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Full Length Research Paper

Customized interface design of the intelligent PDA for e-learning

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The intelligent PDA has gradually come to embody the concept of mobile information and customization, and its functions can be approximated to those of a personal computer (PC). However, most users are used to PC interface, and find it difficult to operate the smaller interface of an intelligent PDA, causing problems in system interface design. This study applies Intelligent PDA to e-learning, and provides a customized, simple, convenient, and intuitive interface design for users. This study conducts cluster analysis to categorize user interface requirements, and then presents a customized interface design based on different user interface requirements. The results of this study can serve as a reference for designers of intelligent-PDA-based interfaces for e-learning.

Key words: Intelligent PDA, e-learning, interface analysis.

INTRODUCTION

With the rapid changes in society and constant innovation and evolution in information technology products, an Intelligent PDA is a more innovative information product than many other products. The Intelligent PDA is a voice-centric mobile phone capable of voice and data communications. The main features of the Intelligent PDA include wireless communication and transmission, notepad, telephone directory, calendar, camera, and video recorder. In addition, the Intelligent PDA has built-in Office Mobile; files from Word, Excel, PowerPoint, etc. can be instantly downloaded and edited. Superior to a conventional PDA, the Intelligent PDA can deal with word processing and can be combined with a mobile phone. As a result, the Intelligent PDA has become one of the most popular electronic products. Its peripheral accessories and applications are diverse and practical. Therefore, the Intelligent PDA deserves to be promoted and investigated (Lo et al., 2004; Lo and Hsu, 2005).

In the current wireless technology boom, information delivery is available everywhere, allowing users to access information anytime and anywhere. Tinker and Vahey (2002) proposed that the application of ubiquitous technologies to education can effectively support student inquiry learning. Furthermore, numerous studies indicate that mobile-learning supports outdoor teaching, helping students reorganize and share data collected in environments (Rieger and Gay, 1997; Rogers et al., 2005; Roschelle and Pea, 2002; Sharples et al., 2002; Soloway et al., 2001). Therefore, this study believes that applying the Intelligent PDA to study and research provides a great teaching medium for people, and can not only improve individuals' learning and performance, but also enhance their knowledge about life.

The rise in technology level results in a close relationship between usage and operation of products, especially in terms of user interface. Technology product functions involve simple and complicated operations, allowing multiple-use products. As a result, operating steps have also become more complicated and cumbersome. An appropriate interface can help users operate device functions correctly. An inappropriate interface design and arrangement may generate error messages, causing operation errors and confusion. Thus, whether or not users can be clearly informed of the device's operational methods and purposes among all functions lies in the interface design. Currently, various combinations of words, pictures, colors, images, and voices

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on the user interface not only improve the interface aesthetics, but also enhance its usability. However, when the interface presentation is too complicated, users are confused about how to operate the system. Besides, the overuse of different colors may distract users as well.

Small-screen web pages, whose interfaces are designed based on small-screen interface design guidelines and which lack a proper layout, are not readable and humanized, thereby hindering mobile commerce development (Su et al., 2007). Rosson and Carroll (2002) indicated that the greatest challenge to mobile usability is related to user interface design. In addition, since the emergence of individualism, users may like to create their own unique mobile device appearances and interface colors to emphasize their personal styles. Chen et al. (2006) indicated that because portable mobile devices are restricted by their screen size, volume, and weight, the presentation of information on the screen and interface color combinations greatly affect readability and user attention. Thus, one of the main purposes of this study is to design a user interface for the Intelligent PDA.

The current Intelligent PDA integrates many functions, and the concepts of mobile information and customization can be gradually implemented in this kind of device (Su et al., 2007). Accordingly, the functions of mobile devices can be approximated to those of a personal computer (PC). However, when users are used to a PC interface, they may find it difficult to operate the smaller Intelligent PDA interface. Thus, the second motivation of this study is to understand whether or not different types of user interface affect the users.

Current research issues on mobile digital systems include e-learning application and cognitive learning (Croop, 2008) and travel positioning technology and navigation application (Ahas et al., 2007; Ahas et al., 2008; Buhalis and Law, 2008). Secondly, issues about mobile digital system interface design include the effect of colors on vision (Chen et al., 2006), user preferences for pictures (Lin and Huang, 2004) and interface design for different subjects based on gender (Passig and Levin, 1999) and age (Tang and Hsiao, 2009). However, little research is related to the e-learning system interface design. Therefore, this study uses user experiences to investigate the e-learning interface design and proposes relevant suggestions as a reference for decision makers.

Literature review

Weiss (2002) proposed four factors related to the small-screen interface design.

Presentation interface

Laurel and Mountford (1990) and Nielsen (2000) proposed a graphic user interface (GUI) design to prevent users from becoming confused. Brinck et al. (2002) thought that an interface presentation using contrasting shapes, colors, sizes, and positions could direct user attention toward internal components on the web page. Christie et al. (2004) arranged a 3 × 3 grid layout for a small screen. Their design yields superior performance to that of a hierarchical layout. Users can also locate required options quickly.

Conversation interface

Westendorp et al. (2000) indicated that when users first use a product, they first understand and learn functions by operating the user interface (using icons and buttons), then by querying (e.g., printing a user manual and using basic online assistance), and finally by employing other information (such as error messages, auxiliary animations, and memo cards). Baecker and Buxton (1987) showed that users can use various ways to talk to and interact with a computer. Kristof and Satran (1995) reported that a user-centered design allows users to have considerable control over the browsing speed and direction and filtering out unfavorable content.

Navigation interface

Preece and Chen (1998); Shneiderman (1997); Chuang and Yang (2006) studied text browse modes common to PDAs, including tip-up, scrolling, leading, and fast-forward modes. Different browsing modes may affect user reading efficiency and preference. Marchionini (1995) indicated that the tip-up mode has the best performance in terms of reading speed, efficiency, and satisfaction, whereas the scrolling mode has the worst. Vora and Helander (1997), who focused on browsing behaviors, proposed that relevant auxiliary tools, including simple paths, user guides, back to previous page, history lists, bookmarks, bookmarking, overview maps, and maps, can also enhance browsing efficiency. Newman and Lamming (1995) proposed that a menu-based user interface can provide users with meaningful options and prevent them from operating the device inappropriately or controlling it ineffectively.

Mousing around interface

Horton (1994); Kristof and Satran (1995); Mok (1996) conducted research on perceptual image preferences for human-machine interfaces on mobile phones. They divided the perceptual image of mobile phones into linguistic expressions, symbolic meanings, and design quality. Norman (1998) proposed that an image subject is the most critical aspect of image design, and especially in the image size category, where a large image receives the most positive response. Lai (2008) summarized four

touch modes of consumer electronics products: touch mode, single-point drag touch mode, multi-point drag touch mode, and text identification touch mode. Hsu (2005) suggested that the touch screen is tangible, institutive, able to reduce the distance between the human and machine, and makes it easy to draw and create handwriting.

MATERIALS AND METHODS

This study analyzed the mobile interface for e-learning using user experiences. Data was collected from users who had experience with the Intelligent PDA for various learning activities. To enhance reliability, this study adopted an interview method for a total of 229 subjects.

The questionnaire questions of this study consisted of five parts. The first part assessed personal variables, including gender, age, and level of education. As for the interface questionnaire, this study adopted the amended questionnaire proposed by Weiss et al. (2002).

The questionnaire includes four portions:

Presentation Interface: describing message control on the interface.
Conversation Interface: describing movement control on the interface.
Navigation Interface: describing movement control on the interface.
Mousing around interface: describing action control between an image and a window.

RESULTS

This study presents statistical analysis for each of the hypotheses, tests them, and discusses the results.

Statistical description

Based on the 229 questionnaires distributed, a table was first constructed based on the individual variables collected. As the following table shows, there were more female respondents than male respondents; subjects who were below 20 years old occupied the largest percentage (41%) while those 21-30 years old and above occupied 37.6%; at level of education, the number of respondents' in universities was greater with 73.8% (Table 1).

Interface analysis

Based on collected data, a descriptive statistical analysis of each question item was performed to identify their characteristics.

Presentation interface

This study adopted the mean value, the standard deviation, and the t-test ($\mu < 2.5$ and $\mu > 3.5$) to investigate the presentation interface. First, users preferred background music when using the e-learning system and favored a commentator's voice explaining how to use the system. Secondly, users preferred short tutorial films and an animated image interface. Thirdly, when using the system, users liked to see a handful of drawings and colors on the screen. Users preferred yellow or red for the screen, and fewer users preferred blue or gray (Table 2).

Conversation interface

This study adopted the mean value, the standard deviation, and the t test ($\mu < 2.5$ and $\mu > 3.5$) to investigate the conversation interface. Users preferred hearing vocal explanations when using some functions of the e-learning system and having their own way to control the whole system. When operating the system incorrectly and provided with various options, users preferred receiving assistance from the system. However, they disliked being asked to input data when using the system (Table 3).

Navigation interface

This study adopted the mean value, the standard deviation, and the t test ($\mu < 2.5$ and $\mu > 3.5$) to investigate the navigation interface. Results show that when using the Intelligent PDA, users liked to know how to operate the device, how to go backwards easily, and how to see navigational buttons at any moment. Secondly, during the process of interface transition, users liked to have surprises and to proceed to the next interface quickly. Thirdly, when a new link on a web page was clicked on, there was no significant difference between opening a new window and changing part of window on the screen. In addition, users liked to watch the animated tutorial displayed in full-screen mode (Table 4).

Mousing around interface

This study adopted the mean value, the standard deviation, and the t test ($\mu < 2.5$ and $\mu > 3.5$) to investigate the mousing around interface. Results show that when using the Intelligent PDA, users preferred large buttons. The most popular button was a round button, followed by one with drawings, a colored button, and a square button. In addition, an arrow button was convenient. Secondly, users thought there should be an exit (logout) button. Thirdly, considering button arrangement, a button at the bottom of the screen was more convenient to click than a button at the top or on the side. However, too many buttons made users feel that the system was confusing (Table 5).

Table 1. Demographic analyses.

Variable		Number	Percentage (%)
Gender	Male	89	38.9
	Female	140	61.1
Age (Years)	Below 20	94	41.0
	21-30	86	37.6
	31-40	27	11.8
	41-50	17	7.4
	Over 51	5	2.2
Level of education	Junior school	9	3.9
	High school	13	5.7
	Junior college	18	7.9
	University	169	73.8
	Institute	20	8.7

Table 2. Presentation interface.

Presentation interface	Mean	Std. deviation	H_1: μ<2.5	H_1: μ>3.5
I like it when music accompanies the whole learning system.	3.60	1.02		
I like it when a commentator's voice explains how to play.	4.02	0.85		Yes
I like seeing a lot of short films.	4.39	0.71		Yes
I like seeing long films.	2.41	1.05	Yes	
I like seeing a lot of drawings on the screen.	3.84	0.98		Yes
I like seeing a lot of color on the screen.	3.72	1.00		Yes
The colors blue and gray are pleasant.	2.79	0.88	Yes	
I like it when there is a lot of green.	3.45	0.93		
Moving drawn images attract me to play.	4.07	0.86		Yes
I like a lot of yellow /red.	3.17	0.91		

Table 3. Conversation interface.

Conversation interface	Mean	Std. deviation	H_1: μ<2.5	H_1: μ>3.5
I like hearing the voice explanation, when I want to….	3.86	1.00		Yes
It is good that I can change my mind and make another move as I wish.	4.47	6.39		Yes
I like it that when I make a mistake the computer helps me understand.	4.37	0.78		Yes
I like it when there is a large choice.	4.35	0.73		Yes
I like it when I am told to write things during e-learning.	2.83	1.00	Yes	

Cluster analyses

This study used the presentation interface, conversation interface, navigation interface, and mousing around interface as input properties for clustering methods and investigated new clusters when users were using the e-learning system on a mobile device. Based on the first-stage results of cluster analysis, only agglomeration coefficients corresponding to Clusters 1 to 10 were listed because agglomeration coefficients were not significantly different for Clusters above 10 (Table 6).

When Cluster 5 jumped to Cluster 4, the incremented coefficient was 243.9, so there exists much difference if Cluster 5 is incorporated into Cluster 4. Therefore, this study concluded that the appropriate number of clusters is 5. In the second stage of cluster analysis, the K mean was used to analyze customized interface requirements for the e-learning system in the Intelligent PDA. Finally,

Table 4. Navigation interface.

Navigation interface	Mean	Std. deviation	H1 :μ<2.5	H1 :μ>3.5
I have to know how to carry on with the learning.	3.91	0.91		Yes
I need it to be easy for me to go backwards in e-learning.	4.32	0.776		Yes
I have to see the navigational buttons all the time.	3.90	0.95		Yes
I like surprises after every click.	3.75	1.02		Yes
I like quick transitions.	4.17	0.98		Yes
I like a slow pace for e-learning.	2.39	1.00	Yes	
I like it when the whole screen changes at once.	3.62	1.02		Yes
I like it when only parts of the screen change.	3.40	1.01		
I am surprised every time animation appears.	3.64	0.95		Yes
I like it when there is animation at the whole of the screen.	4.37	0.76		Yes
I like it when there is animation at the top of the screen.	3.08	1.04		
I like it when there is animation at the bottom of the screen.	2.59	0.86	Yes	

Table 5. Mousing around interface

Mousing around	Mean	Std. deviation	H_1: μ<2.5	H_1: μ>3.5
I like big buttons.	3.94	0.86		Yes
I like colored buttons.	3.36	1.07		
I like round buttons.	3.78	2.74		Yes
I like square buttons.	3.09	0.86		
It is convenient for me when there are arrow buttons.	3.88	0.89		Yes
I like drawings that are buttons.	3.66	0.99		Yes
I like a screen without any buttons at all.	2.31	1.07	Yes	
I like it when there is a button for exiting the learning.	4.14	0.89		Yes
I like it when the cursor changes its shape all the time.	3.32	1.11		
It is convenient when the buttons are arranged at the bottom.	3.57	1.13		Yes
It is convenient when the buttons are arranged at the top.	2.81	1.08	Yes	
It is convenient when the buttons are arranged on the side.	3.04	1.14		
I like it when the buttons change shapes at every stage.	3.14	1.19		
It confuses me when there are a lot of buttons.	4.27	0.92		Yes

Table 6. Agglomeration coefficient

Cluster number	Agglomeration coefficient	Incremented coefficient
10	7349.55	132.78
9	7490.47	140.92
8	7639.13	148.66
7	7795.01	155.88
6	7963.93	168.91
5	8163.15	199.22
4	8407.05	243.90
3	8678.57	271.52
2	9348.00	669.43

PDA. Finally, analysis of variance (ANOVA) was used to analyze any differences existing among different clusters.

Cluster 1

In Cluster 1, users preferred a yellow or red interface for presentation interface. Regarding navigation interface, users preferred a slow pace for the e-learning and liked to browse the animated tutorial displayed at the top of the screen.

Cluster 2

In Cluster 2, when a new link on a web page was clicked on, users preferred to open a new window for the navigation interface. Moreover, users preferred to have a button at the bottom of the screen for the mousing around interface.

Cluster 3

In Cluster 3, users preferred background music and drawings, and preferred green and movable images for the presentation interface. Furthermore, users preferred hearing vocal explanations for the conversation interface. Moreover, for the navigation interface, users liked to actively understand how to use the whole system. They liked the function enabling going backwards, liked to see a navigation button and having surprises and quick interface transitions after clicking, and preferred seeing part of window on the screen being changed after a new website link was clicked on. Finally, for the mousing around interface, users liked to see colored and square buttons or buttons with drawings, and preferred changing a shape of a cursor on the screen at any given moment.

Cluster 4

In Cluster 4, for the conversation interface, users liked to have their own way to use the digital e-learning system, to receive assistance from the system when operating the system incorrectly, and to have various options. Furthermore, for the navigation interface, users liked to watch the animated tutorial displayed in full-screen mode. Finally, for the mousing around interface, users preferred a large button, a round button, and a logout button. However, too many buttons confused users.

Cluster 5

In Cluster 5, for the presentation interface, users liked a commentator's voice explaining how to use the digital e-learning system, preferred short tutorial films, and liked various colors on the screen. Furthermore, for the mousing around interface, an arrow button was convenient, as was a button on the (left or right) side of the screen; also, under different operating situations, users preferred that the button change its shape (Table 7).

Variance analysis among clusters

This study used ANOVA to analyze the interface requirement differences in the Intelligent PDA when users in all clusters used the digital e-learning device. The following section presents the statistical results.

Presentation interface

More users in Cluster 1 than in Cluster 5 liked to watch a long digital animated tutorial. Users in Cluster 1 also liked a moving image for the interface design of the Intelligent PDA more than users in Clusters 2 or 4.

More users in Cluster 3 than in Clusters 1, 2, and 4 liked hearing background music on the Intelligent PDA interface. Furthermore, when using the Intelligent PDA, more users in Cluster 3 than in Cluster 2 liked vocal explanations, lots of drawings and colors, and using the Intelligent PDA when there existed movable images. Moreover, more users in Cluster 3 than in Cluster 4 liked background music, drawings, a green main page, and moving images. Finally, more users in Cluster 3 than in Cluster 5 liked watching a long digital animated tutorial.

More users in Cluster 5 than in Cluster 2 liked colors on the screen.

On yellow or red interfaces, there exist significant differences among all clusters (Table 8).

Conversation interface

More users in Cluster 3 than in Cluster 1 liked hearing vocal explanations. When users operated the device incorrectly, more users in Cluster 5 than in Cluster 3 liked receiving assistance assistance.

Different clusters produced significant differences when users were asked to input some data during the e-learning process (Table 9).

Navigation interface

More users in Cluster 1 than in Cluster 2 liked having surprises after they clicked on the button and when animations appeared. Secondly, when clicking on a new link, users in Cluster 1 liked to see part of the window change more than users in Clusters 2 and 5 did.

When clicking on a new link, users in Cluster 2 liked seeing a new window more than users in Clusters 1 and 4 did.

Compared to users in Cluster 1, users in Cluster 3 preferred seeing a navigation button at any moment, having

Table 7. Interface mean values among all clusters.

		Cluster number				
		1	2	3	4	5
Presentation interface	I like it when music accompanies the whole learning system.	3.30	3.29	3.92	2.75	3.62
	I like it when a commentator's voice explains how to play.	3.90	3.61	4.18	3.75	4.19
	I like seeing a lot of short films.	4.48	4.18	4.36	4.45	4.62
	I like seeing long films.	2.48	2.11	2.65	2.15	1.52
	I like seeing a lot of drawings on the screen.	3.88	3.21	4.06	3.25	3.95
	I like seeing a lot of color on the screen.	3.65	3.11	3.88	3.40	4.05
	The colors blue and gray are pleasant.	2.80	2.61	2.93	2.65	2.38
	I like it when there is a lot of green.	3.58	3.11	3.63	2.90	3.10
	Moving drawn images attract me to play.	4.23	3.46	4.26	3.45	4.05
	I like a lot of yellow /red.	3.35	2.82	3.35	2.75	2.71
Conversation interface	I like hearing the voice talking, when I want to….	3.50	3.50	4.08	3.75	3.90
	It is good that I can change my mind and make another move as I wish.	4.43	4.39	4.49	4.65	4.33
	I like it that when I make a mistake the computer helps me understands.	4.38	4.29	4.44	4.60	3.86
	I like it when there is a large choice.	4.15	4.32	4.42	4.45	4.29
	I like it when I am told to write things during e- learning.	2.48	2.71	3.02	2.75	2.71
Navigation interface	I have to know how to carry on with the learning.	3.70	3.86	4.14	3.40	3.57
	I need it to be easy for me to go backwards in e-learning.	4.05	4.21	4.46	4.35	4.19
	I have to see the navigational buttons all the time.	3.33	3.86	4.14	4.05	3.52
	I like surprises after every click.	3.78	2.50	4.08	3.65	3.52
	I like quick transitions.	4.00	3.46	4.44	4.40	3.67
	I like a slow pace for learning.	2.58	2.14	2.47	1.90	2.38
	I like it when the whole screen changes at once.	3.20	3.96	3.79	2.90	3.71
	I like it when only parts of the screen change.	3.50	2.75	3.64	3.40	2.67
	I am surprised every time animation appears.	3.48	2.79	3.96	3.50	3.38
	I like it when there is animation at the whole of the screen.	4.08	4.18	4.53	4.60	4.05
	I like it when there is animation at the top of the screen.	3.45	2.93	2.97	2.90	3.38
	I like it when there is animation at the bottom of the screen.	2.53	2.18	2.77	2.55	2.24
Mousing around interface	I like big buttons.	3.63	3.93	3.99	4.20	4.00
	I like colored buttons.	3.23	2.68	3.63	3.20	3.24
	I like round buttons.	3.40	3.36	3.70	3.75	3.62
	I like square buttons.	2.83	2.82	3.32	2.85	2.86
	It is convenient for me when there are arrow buttons.	3.85	3.39	3.98	3.80	4.05
	I like drawings that are buttons.	3.65	3.11	3.78	3.60	3.71
	I like a screen without any buttons at all.	2.13	1.96	2.54	2.10	1.95
	I like it when there is a button for exiting the learning.	3.75	4.39	4.11	4.45	4.43
	I like it when the cursor changes its shape all the time.	3.00	2.64	3.64	2.65	3.62
	It is convenient when the buttons are arranged at the bottom.	2.93	4.29	3.86	2.95	2.76
	It is convenient when the buttons are arranged at the top.	3.28	1.93	2.62	3.40	3.67
	It is convenient when the buttons are arranged on the side.	3.08	2.14	3.26	2.70	3.29
	I like it when the buttons change shapes at every stage.	3.48	2.00	3.38	2.20	3.52
	It confuses me when there are a lot of buttons.	4.25	4.46	4.16	4.60	4.33

Table 8. Post tests among all clusters for the presentation interface.

	F	P value	Scheffe
I like it when music accompanies the whole learning system.	8.932	0.000*	Cluster 3 > Clusters 1,2,4
I like it when a commentator's voice explains how to play.	3.731	0.006*	Cluster 3 > Cluster 2
I like seeing a lot of short films.	1.423	0.227	
I like seeing long films.	6.880	0.000*	Clusters1,3 > Cluster 5
I like seeing a lot of drawings on the screen.	6.832	0.000*	Cluster 3 > Clusters 2,4
I like seeing a lot of color on the screen.	4.803	0.001*	Cluster 3,5 > Cluster 2
The colors blue and gray are pleasant.	2.332	0.057	
I like it when there is a lot of green.	5.178	0.001*	Cluster 3 > Cluster 4
Moving drawn images attract me to play.	8.842	0.000*	Clusters 1,3 > Clusters 2,4
I like a lot of yellow /red.	5.346	0.000*	

* P< 0.05.

Table 9. Post tests among all clusters for the conversation interface.

	F	P value	Scheffe
I like hearing the voice explanation, when I want to….	3.914	0.004*	Cluster 3 > Cluster 1
It is good that I can change my mind and make another move as I wish.	0.820	0.513	
I like it that when I make a mistake the computer helps me understands.	3.137	0.015*	Cluster 5 > Cluster 3
I like it when there is a large choice.	1.144	0.337	
I like it when I am told to write things during learning.	2.573	0.039*	

* P< 0.05

a new window after clicking on a new link, and watching the animation displayed in full-screen mode. Secondly, compared to users in Cluster 2, users in Cluster 3 preferred having surprises after clicking on a button, preferred quick interface transitions when browsing the web page, preferred seeing part of window being changed, and preferred animations displayed at the bottom of the screen. Thirdly, compared to users in Cluster 4, users in Cluster 3 preferred understanding how to use a browsing method and preferred having a new window after clicking on a new link. Finally, compared to users in Cluster 5, users in Cluster 3 preferred quick interface transitions when browsing the web page and preferred seeing part of window change after clicking on a new link.

After users clicked on the button and when the animations appeared, users in Cluster 4 preferred having surprises more than users in Cluster 2 did. Further, users in Cluster 4 preferred proceeding to the next interface at a quick pace when browsing web pages.

Users in Cluster 5 liked having surprises more than user in Cluster 2 after clicking on a button or when animations appeared.

Among different clusters, there existed significant differences when users could easily go backwards to a previous step of the system and when the animated tutorial was played at the top of the screen (Table 10).

Mousing around interface

Compared to users in Cluster 2, users in Cluster 1 preferred buttons at the top or on the (left or right) side and buttons with various shapes at every stage. Secondly, more users in Cluster 1 than in Cluster 3 preferred buttons at the top of the screen. Finally, users in Cluster 1 preferred buttons with various shapes at every stage more than users in Cluster 4 did.

Users in Cluster 2 preferred buttons at the bottom more than users in Clusters 1, 4, and 5 did.

Compared to users in Cluster 1, users in Cluster 3 preferred square buttons, preferred the cursor changing its shape at all time, and felt the convenience of buttons at the bottom. Secondly, compared to users in Cluster 2, users in Cluster 3 preferred colored buttons, arrow buttons, and buttons with drawings, felt the convenience of buttons on the (left or right) side, preferred buttons with various shapes at every stage, and preferred the cursor changing its shape at all time. Thirdly, compared to users in Cluster 4, users in Cluster 3 thought that buttons at the bottom of the screen were convenient, and preferred buttons with various shapes at every stage and the cursor changing its shape at all time. Finally, more users in Cluster 3 than in Cluster 5 thought buttons at the bottom were convenient.

Users in Cluster 4 preferred buttons at the top of the

Table 10. Post tests among all clusters for the navigation interface.

	F	P value	Scheffe
I have to know how to carry on with the learning.	5.103	0.001*	Cluster 3 > Cluster 4
I need it to be easy for me to go backwards in e-learning.	2.657	0.034*	
I have to see the navigational buttons all the time.	7.335	0.000*	Cluster 3 > Cluster 1
I like surprises after every click.	18.069	0.000*	Clusters 1,3,4,5 > Cluster 2
I like quick transitions.	8.940	0.000*	Cluster 3 > Clusters 2,5; 4>2
I like a slow pace for e-learning.	2.168	0.073	
I like it when the whole screen changes at once.	6.424	0.000*	Clusters 2,3 > Clusters1,4
I like it when only parts of the screen change.	8.451	0.000*	Clusters 1,3 > Clusters 2,5
I am surprised every time animation appears.	11.591	0.000*	Clusters 1,3 > Cluster 2
I like it when there is animation at the whole of the screen.	4.856	0.001*	Cluster 3 > Cluster 1
I like it when there is animation at the top of the screen.	2.439	0.048*	

Table 11. Post tests among all clusters for the mousing around interface.

	F	P value	Scheffe
I like big buttons.	1.960	0.102	
I like colored buttons.	5.400	0.000*	Cluster 3 > Cluster 2
I like round buttons.	1.676	0.156	
I like square buttons.	4.739	0.001*	Cluster 3 > Cluster 1
It is convenient for me when there are arrow buttons.	2.861	0.024*	Cluster 3 > Cluster 2
I like drawings that are buttons.	2.762	0.029*	Cluster 3 > Cluster 2
I like a screen without any buttons at all.	3.380	0.010*	
I like it when there is a button for exiting the learning.	3.892	0.004*	
I like it when the cursor changes its shape all the time.	9.322	0.000*	Cluster 3 > Clusters 1,2,4 Cluster 5 > Cluster 2
It is convenient when the buttons are arranged at the bottom.	15.327	0.000*	Clusters 2,3 > Clusters 1,4,5
It is convenient when the buttons are arranged at the top.	15.294	0.000*	Clusters 1,4,5 > Clusters 2,3
It is convenient when the buttons are arranged on the side.	6.720	0.000*	Clusters 1,3,5 > Cluster 2
I like it when the buttons change shapes at every stage.	15.111	0.000*	Clusters 1,3,5 > Clusters 2,4
It confuses me when there are a lot of buttons.	1.424	0.227	

screen more than users in Clusters 2 and 3 did.

Compared to users in Cluster 2, users in Cluster 5 preferred buttons with various shapes at every stage, the cursor changing its shape at all time, and buttons at the top or on the (left or right) side of the screen. Secondly, users in Cluster 5 preferred having buttons at the top of the screen more than users in Cluster 3 did. Finally, users in Cluster 5 preferred buttons with various shapes at every stage more than users in Cluster 4 did.

Among different clusters, there existed significant differences when the screen did not have any button and when the screen had an exit (logout) button (Table 11).

DISCUSSION

This study investigates the relationship between users and the Intelligent PDA user interface, and used personal variables to determine the effects of the user interface. Five clusters were obtained through two-stage cluster analysis, and the t test was used to obtain question items of $\mu < 2.5$ and $\mu > 3.5$. $\mu > 3.5$ means that users required basic interface functions. Further, $\mu < 2.5$ means that users did not require basic interface functions, while $2.5 < \mu < 3.5$ means that users liked to have more options. The clusters were compared using the Scheffe post comparison test. These research results can help practitioners design an Intelligent-PDA-based user interface for e-learning.

For functions that users deemed necessary, users thought that the Intelligent PDA should have a commentator's voice explaining how to use the system and employ shorter films, various pictures and colors, and animated image interface, etc., to attract their attention. Secondly, when using the Intelligent PDA, users liked learning how to use and have their own way to use the

system; when operating the device incorrectly, users liked to receive assistance; when using the system, users liked to have numerous operating options. Thirdly, when browsing web pages, users liked to go backwards easily, liked to see a navigation button at any given moment, enjoyed surprises during interface transitions, liked quick interface transitions, liked to see a new window after clicking on a new link, and liked to play animations in full-screen mode. Finally, as for the mousing around interface, users liked big buttons, and round buttons were the most popular. Users also liked arrow and exit (logout) buttons and liked buttons at the bottom of the screen, which was more convenient. However, too many buttons confused users. Therefore, the functional design of the interface on the Intelligent PDA should be simple and convenient enough that users can intuitively operate it. This will likely become a key design point in the future.

For functions that users deemed unnecessary, users generally disliked long tutorial films, and blue and gray colors did not make users feel happy. When operating the system, users disliked being asked to input data, and disliked the low-paced Intelligent PDA. When using the Intelligent PDA to play animations, users disliked the animations to be displayed at the bottom, and did not like a screen without button or buttons at the top of the screen.

Furthermore, the functions that users thought should include multiple options include the presence of background music and interface with different colors (e.g., green, yellow, red, etc.). After clicking on a new link on a web page, users liked choosing whether to change part of the window. Users also liked the ability to move the animations. As for the button design, users preferred many button options, and liked changing the shape of a cursor on the screen, changing button locations and settings, and changing button shapes at every stage.

This study suggests that various customized interfaces can be designed for different groups of customers when using the Intelligent PDA for e-learning. The main design should be simple, convenient, and intuitive. In addition, regarding user preferences, the interface design should provide more options to satisfy operating requirements. In future e-learning applications, users can change window sizes and the shape, color, and location of a button, share knowledge with peers, and search for links to supplementary course material using the interface.

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