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The Interface Design of Electronic Journals via Mobile Devices: A Cognitive styles Perspective

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Abstract: With the advancement of information technology, combining with electronic journals and mobile devices would produce ubiquitous electronic journals. However, there is a need to consider the usability evaluation because usability is a strong predictor of design issues. To satisfy individual needs, the effects of cognitive styles on usability inspection are investigated in this study. To this end, this study aimed to examine how different cognitive style groups perceive the interface design of an electronic journal. More specifically, Nielsen's ten heuristics (Hs) were applied to investigate user' perceptions. The results show that H8 was considered the most important heuristic by all users. The results also demonstrate that Holists who perceive excessive advertising may strongly need previous/next buttons while Serialists who feel this electronic journal provides too many advertising may consider that too much information is presented in the home page. The findings can be applied to support the development of individualized mobile electronic journals.

Keywords: Electronic journals, Mobile devices, Cognitive styles, usability, Nielsen's heuristics

1. Introduction

Digital learning refers to utilize digital technologies to support student learning (Chan, et. al., 2006). Among a variety of digital technologies which can be applied to implement learning materials, mobile devices particularly offer many advantages, e.g., convenience, flexibility and ubiquitous information access (Jacob & Issac, 2008). Among these advantages, the portability is a major advantage that leads to the other two. Regarding flexibility, portability can facilitate users to access information anytime (Liu and Carlsson, 2010). Regarding ubiquity, portability removes geographic boundaries so users can locate information at any locations (Looney et al., 2004). Due to these advantages, there are on-going interests to use mobile devices to support teaching and learning recently (Morris, 2010; Petrova and Li, 2009). For instance, Wurst, Smarkola and Gaffney (2008) compared ubiquitous mobile learning with a traditional lecture-based course in higher education. The results from their study suggested users with mobile learning showed significantly more satisfaction than those in traditional classrooms. More recently, Cavus and Uzunboylu (2009) used the mobile devices to develop a mobile learning system and they found both users' attitudes toward the mobile devices and their creativity were improved significantly at the end. In summary, mobile learning does indeed become a mainstream method of education in 21st Century (Peters, 2007).

Further to mobile devices, electronic journals are another useful digital technology widely used in educational settings because they can facilitate to disseminate scientific information (Ollé and Borrego, 2010). By doing so, students can effectively acquire new information to enhance their understandings. In addition to disseminating scientific information, the electronic journals also provide other benefits, including the speed of access and the ability to download, print, and send articles (Tyagi, 2011). Due to the widespread use of electronic journals, research into this issue has mushroomed. In an early period, Bar-Ilan and Fink (2005) conducted a study to examine the use of printed and electronic journals in a science library. The results showed more than 80% of the respondents frequently used and preferred an electronic format. Later on, Prabha (2007) tracked journal subscription and format data for 515 journals in the Association of Research Libraries (ARL) university member libraries. The findings showed journals subscribed in print only decreased to one-third of the journal collections while, concurrently, access to electronic journals increased to one-third of the collections.

The aforementioned studies demonstrated electronic journals played an important role in scholarly communication. Such importance increases the use of electronic journals in various countries. For instance, Kurata et al., (2007) examined the position of electronic journals in scholarly communication based on Japanese researchers' information behavior. The results showed Japanese researchers used electronic journals for information access as a matter of course. Recently, Bravo and Díez (2011) examined the models of consumption of the academic communities of five Spanish universities. Their study revealed the overall totals for downloads at the universities showed constant growth from 2002 onward. In other words, there was an upward trend in the consumption of scholarly information in electronic formats in the Spanish academic communities.

The aforesaid results demonstrated electronic journals are popular academic tools. In other words, there are an increasing number of users to access electronic journals. On the other hand, great diversities exist among such users, who may have heterogeneous backgrounds, in terms of their knowledge, skills and needs (Chen and Macredie, 2010). Thus, it is necessary to examine relationships between individual differences and the use of electronic journals. Among various individual differences, previous studies mainly focused on examining how users' subject background affected their information seeking behavior (Talja and Maula, 2003). In addition to subject background, other human factors are also essential, e.g., cognitive styles, which refer to a person's information processing habits, capturing an individual's preferred mode of perceiving, thinking, remembering, and problem solving (Messick, 1976). Previous research found cognitive styles are key determinants to affect users' information seeking (Clewley et al., 2010). Thus, it is necessary to examine how different cognitive style groups react to the use of electronic journals.

Among various dimensions of cognitive styles, Pask's Holism/Serialism has been received attention recently. Jonassen and Grabowski (2012) describe Holists as preferring to process information in a 'whole-to-part' sequence. In contrast, Serialists are described as preferring a 'part-to-whole' processing of information. Holists and Serialists have different characteristics. Due to such differences, recent works examined how Holists and Serialists behave differently. For instance, Clewley et al., (2011) found Serialists and Holists have different preferences for their navigational styles. The former prefer to follow a linear pattern by having a suggested route or looking at the subject content step-by step with back/forward buttons. Conversely, the latter tend to take a non-linear pattern by 'jumping' between different levels of subject contents with hypertext links. Furthermore, Chen and Chang (2014) investigated how member grouping affects users' reactions to mobile collaborative learning from a cognitive style perspective. The results suggest there is a need to provide Serialists with additional help when they use mobile collaborative learning.

In addition to the effect of the cognitive styles, the interface design of the electronic journals is also important because user interface may be thought of as a 'window' through which users interact with electronic journals so the design of user interface may affect how users access electronic journals. In other words, the user interface formulates the working environment of electronic journals so it is critical that the working environment is friendly enough to accommodate users' different preferences. As such, the usability evaluation of electronic journals becomes paramount because it can provide concrete prescriptions for developing electronic journals that are able to align to diverse users' needs. A number of methods can be used to evaluate usability. Among them, Nielsen's heuristic approach is most commonly used because it can be used effectively by novices and experts alike and can be performed at any stages of the development lifecycle (Nielsen, 1994a). Nielsen's Heuristics were first formally described in presentations in the Human–Computer Interaction conference through papers published by Nielson and Molich (1990). Since then, they have refined the heuristics based on a factor analysis of 249 usability problems to derive a revised set of heuristics with maximum explanatory power. Table 1 presents the detail of the revised set of 10 heuristics (H).

These ten heuristics are concise and simple to learn so they are widely applied to evaluate the user interface of a variety of applications. Petrie and Power (2012) assessed the usability of six complex, highly interactive websites based on Nielsen's heuristics. The results of their study showed there were 935 usability problems found in the evaluation. Recently, Hsieh, Su, Chen and Chen (in press) also used Nielsen's ten heuristics to assess the usability of a robot-based learning companion. Based on the results of the assessment, they developed three versions of robot-based learning companion. Due to such popularity, the study presented in this paper also assesses the usability of a game-based learning system with Nielsen's ten heuristics.

Table 1: Nielsen's ten heuristics (1994b).

Heuristics	Explanations
H1:Visibility of system status	The system should always keep user informed about what is going on by providing appropriate feedback within reasonable time
H2:Match between system and the real world	The system should speak the user's language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order
H3:User control and freedom	Users should be free to develop their own strategies, select and sequence tasks, and undo and redo activities that they have done, rather than having the system do these for them
H4:Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing and the system should follow platform conventions.
H5:Error prevention	Even better than good error messages is a careful design, which prevents a problem from occurring in the first place.
H6:Recognition rather than recall	Make objects, actions, and options visible. The users should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
H7:Flexibility and efficiency of use	Allow users to tailor frequent actions. Provide alternative means of access and operation for users who differ from the ''average'' user (e.g., physical or cognitive ability, culture, language, etc.)
H8:Aesthetic and minimalist design	Dialogues should not contain information that is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
H9:Help users recognise, diagnose and recover from errors	Error messages should precisely indicate the problem and constructively suggest a solution. They should be expressed in plain language.
H10:Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

The aforementioned studies demonstrate the usefulness of Nielsen's heuristic evaluation. However, paucity of studies uses Nielsen's heuristics to assess the user interface of electronic journals, i.e., the ScienceDirect. In particular, there is a lack of studies to investigate Holists and Serialists' reactions to electronic journals in the context of mobile devices. To this end, we address this issue. In brief, the aim of this study is to examine how different cognitive style groups perceive the interface design of an electronic journal.

2. **Methodology**

2.1 Participants

As indicated by Nicholas et al. (2009), the majority users of digital resources were students. Thus, the participants (N=23) were recruited from master students from the Department of Computer Science and Information Engineering at National Central University in Taiwan. In other words, the participants had a similar subject background so that the effects of prior knowledge could be minimized. In addition, a request was issued to students in lectures, and further by email, making clear the nature of the study and their participation. All participants had the basic computer and Internet skills necessary to use the electronic journals.

2.2 ScienceDirect

Among various electronic journals, this study adopted the ScienceDirect (Figure 1) to reach the aim described in Section 1. This is because the ScienceDirect covers various topics, such as life sciences, chemistry, and physics. Furthermore, the ScienceDirect also provides multiple search mechanisms: (1) Basic Search, (2) Advanced Search and (3) Expert Search, which differ with respect to the complexity of their interface design and search mechanisms. More specifically, the Expert Search and Advanced Search were considered as an example of complex search design whereas the Basic Search was appreciated by its simplicity. Having such varieties in interface design and search mechanisms provides a wider range of choices, which can help to identify users' preferences.

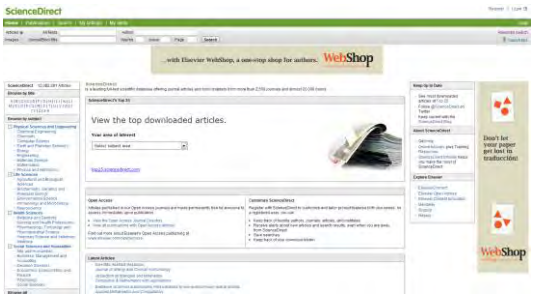

Figure 1. The homepage of the ScienceDirect.

2.3 Questionnaire

To investigate how users with different cognitive styles perceived the interface design of the ScienceDirect. A paper-based questionnaire was developed and it included two parts. In the first part, which included 10 three-point Likert-scale questions ("disagree", "general" and "agree"), users were asked to describe the degree of their satisfaction with the ScienceDirect on the basis of each heuristic. The internal consistency for the overall scale is 0.58 by Cronbach's alpha, which indicates an adequate satisfaction of the questionnaire. In the second part, which consisted of 30 questions, users were requested to check whether the interface design of the ScienceDirect met the criteria of each heuristic.

2.4 Experimental Procedures

To achieve the aim of this study, the procedure included three steps (Figure 2). Initially, all participants were required to fill out their personal information and the SPQ. According to the results of the SPQ, our participants consisted of 12 Holists and 11 Serialists. Subsequently, all of the participants were trained to learn the principles of Nielsen's heuristics so that all of the participants had the understandings of how to conduct the usability assessment. Then, they were required to interact with the ScienceDirect via tablet PCs. Finally, the participants needed to evaluate the usability of the ScienceDirect based on Neilson's ten heuristics. Such evaluation was conducted via the questionnaire described in Section.

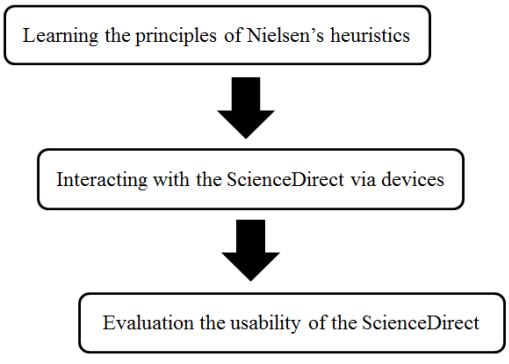

Figure 2. The Experimental Procedure.

2.5 Data Analyses

Traditional statistics were applied to conduct data analyses from both macro and micro views in Study Two. The macro view covers two aspects: (a) relationships between the satisfaction of each heuristic and (b) relationships between each criterion in all heuristics. The micro view is obtained by further examining the aforementioned relationships. Spearman's correlations, which could be used to interpret the strengths of a statistical relationship between two random variables (Stuart et. al, 1991), were applied to find the aforesaid macro view and micro view. Such analyses were undertaken by using Statistical Package for the Social Sciences (SPSS) for Windows (release 18.0). A significance level of $p<0.05$ was adopted for this study.

3. Results and Discussions

3.1 Overall

The satisfaction of H8 is negativity related to that of H1($r=-.458$, $p<.05$) and positively related to H3($r=.492$, $p<.05$) and H6 ($r=.492$, $p<.05$). The results indicated users with high satisfaction with H8 would show low satisfaction with H1 whereas they would show high satisfaction with H3 and H6. In other words, the users' satisfaction with H8 plays an important role. Thus, this study also conducted detailed analyses for questions related to H8, H1, H3 and H6. As displayed in Table 2, H8 includes three items, i.e., Q24, Q25 and Q26. Q24 is associated with Q18 belonged to H6. Q25 is linked with Q3 and Q8, which are belonged to H1 and H3, respectively. Q26 is connected with Q18 belonged to H6. These findings suggest Q25 is an important issue, which is related to Q3 and Q8. More specifically, too many advertisements may let users feel that it is difficult to identify where the Expert Search is and that there is a need to provide previous/next buttons. The other important issue is Q18, which is related to Q24 and Q26. In other words, presenting too much information in the home page may also make users feel that this electronic journal provides too many functions and too much information. This finding suggests displaying too much information in the home page may cause users' cognitive overload so they cannot appreciate the value of information and function provided by the electronic journal. In brief, there is a need to pay enough attention to Q18 and Q25, which are essential for the interface design of electronic journals.

Table 2: The variables of Nielsen's Heuristics (The whole sample).

		H8		
		Excessive functions (Q24)	Excessive advertising(Q25)	Overall Excessive information(Q26)
H1	Highlighted Keywords(Q1)	.233	.042	.215
	Lack of detailed instruction (Q2)	-.094	-.094	-.210
	Hard to find the location of the Expert Search (Q3)	-.342	**-.533****	-.151
H3	Lack of undo/redo functions (Q7)	.279	.058	.128
	Lack of previous/next buttons (Q8)	-.086	**.509***	-.066
	Provisions of multiple search.(Q9)	-.350	-.163	-.302
H6	Too many subject categories (Q17)	.387	.147	.250
	Excessive information in the Home page (Q18)	**.707****	.311	**.691****
	Clear text icons (Q19)	.042	.042	.032

Keys: * $p < .05$, ** $p < .01$

3.2 Cognitive styles

Further to the aforesaid findings for the whole sample, how each cognitive style group reacted to each Nielsen's heuristic is also analyzed. Holists and Serialists share some similarities but several differences also exist between them.

3.2.1 Similarities

The satisfaction of H8 was positively related to H3 for Holists($r=.622$, $p<.05$). On the other hand, the satisfaction of H8 was positively related to H6 ($r=.777$, $p<.01$) and negativity related to H1 ($r=-.712$, $p<.05$) for Serialists. These results indicated Holists and Serialists who showed high satisfaction with H8 would show high satisfaction with H3 and H6, respectively but Serialists would also show low satisfaction with H1. In other words, the satisfaction with H8 plays an important role for both Holists and Serialists. Thus, this study also conducted detailed analyses for questions related to H8, H1, H3 and H6. As displayed in Table 3, H8 includes three items, i.e., Q24, Q25 and Q26. Regarding Holists, Q24 and Q25 are associated with Q9 and Q8 belonged to H3. The findings from Holists are similar to those from the whole sample. More specifically, Holists who perceived excessive advertising may strongly need to use previous/next buttons. Additionally, Holists who perceived excessive functions may not need the provision of multiple search. This may be due to the fact excessive advertising and functions increase their cognitive overload already so they do not need multiple search but they need previous/next buttons to facilitate their navigation in hyperspace.

Regarding Serialists, Q25 is related to Q18 belonged to H6 and Q26 is connected with Q1 and Q18 belonged to H1 and H6, respectively. These findings suggest Q26 and Q18 are important issues. Regarding Q26, highlighted Keywords in search results and too much information displayed in the home page may let Serialists feel overwhelmed. Regarding Q18, presenting too much information in the home page may also make Serialists feel this electronic journal provides too many advertising and information. This finding is consistent with the results from 3.1 which claim too much information displayed in the home page may cause users' cognitive overload. Such a problem may be more serious to Serialists because they only use the options that are relevant to their current tasks (Clewley et al., 2010), which, in turn, they cannot appreciate the value of rich information provided by the electronic journal. In brief, Q18 and Q26 are essential factors for designing the interface of electronic journals for Serialists.

3.2.2 Differences

Regarding Serialists, the satisfaction of H1 was negatively related to H6 ($r=-.969$, $p<.05$). Regarding Holists, the satisfaction of H8 was negatively related to H5 ($r=-.32$, $p<.05$) and the satisfaction of H1 was positively related to H7 ($r=.853$, $p<.01$). In other words, the users' satisfaction with H1 plays an important role. Thus, this study also conducted detailed analyses for relationships between questions belonged to H1 and those belonged to H6 and H7. However, no significant relationships were found for Serialists. Conversely, some significant relationships were discovered for Holists. As displayed in Table 4, H1 includes three items, among which both Q1 and Q3 are associated with Q22 belonged to H7. In other words, Q22 is an important issue. Regarding Q1, the highlighted keywords in search results may be enough for Holists so that they do not need different types of font size to enhance the visual clue. Regarding Q3, it is difficult to find the location of the Expert Search for Holists so they may need to change the font size to help them find where the Expert Search is

Table 3: Findings similar to the whole sample.

		H8		
		Excessive functions (Q24)	Excessive advertising(Q25)	Overall Excessive information(Q26)
Holists				
H3	Lack of undo/redo functions (Q7)	.529	-.316	.447
	Lack of previous/next buttons (Q8)	-.239	**.625***	-.354
	Provisions of multiple search.(Q9)	**-.657***	-.120	-.507
Serialists				
H1	Highlighted Keywords(Q1)	.542	-.039	**.671***
	Lack of detailed instruction (Q2)	-.194	.418	-.289
	Hard to find the location of the Expert Search (Q3)	-.463	-.571	-.311
H6	Too many subject categories (Q17)	.542	.386	.261
	Excessive information in the	.542	**.810****	**.671***

	Home page (Q18)			
	Clear text icons (Q19)	-.149	-.311	-.467

*Keys: * p < .05, ** p < .01*

Table 4: Findings different from the Whole sample.

		H1		
		Highlighted Keywords(Q1)	Lack of detailed instruction (Q2)	Hard to find the location of the Expert Search (Q3)
Holists				
H7	Only English version(Q20)	-.029	-.239	-.169
	Provision of three different search mechanisms(Q21)	.507	-.354	1.0
	Provision of three different types of font size (Q22)	**-.598***	.250	**.625***
Serialists				
H6	Too many subject categories (Q17)	.542	.516	-.463
	Excessive information in the Home page (Q18)	.083	-.194	-.463
	Clear text icons (Q19)	-.559	-.289	.069

Keys: * p < .05, ** p < .01

4. Conclusion

This study aims to examine how different cognitive style users response differently to the interface design of the electronic journal. The major results of our research showed most of the students thought H8 was the most important heuristic. However, there are some differences between Holists and Serialists. More specifically, Holists who perceive excessive advertising may strongly need previous/next buttons while Serialists who feel this electronic journal provides too many advertising may feel too much information presented in the home page. Such differences between Holists and Serialists reveal that cognitive styles do play an important role. Accordingly, cognitive styles should be considered for the development of individualized mobile electronic journals. However, this study has several limitations. Firstly, the sample is small so further works need to use a larger sample to verify the findings presented in this study. Additionally, there is also a need to conduct further research to examine how other human factors, such as gender differences or prior knowledge, influence learners' responses to the usability inspection of the electronic journals in the mobile context.

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