Tan, S. C. et al. (Eds.) (2013). Workshop Proceedings of the 21st International Conference on Computers in Education. Indonesia: Asia-Pacific Society for Computers in Education

Cognitive Styles and Hybrid Mobile Systems

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Abstract: Mobile learning, which has become widespread in educational settings, faces students with diverse background, in terms of knowledge, skills and needs. Two approaches, i.e., Customization and Personalization, can be applied to sort out diversity. However, these two approaches have different advantages and disadvantages. Thus, this study tends to make best use of the advantages of personalization and customization to modeling a Hybrid Mobile Learning System (HMLS). In addition, Cognitive styles were considered as targets to investigate how cognitive styles affect students' reactions to the HMLS. The results show that the Holists attempted to use multiple tools, and the Serialists prefer to focus on a single item at a time. In addition, customization was helpful for Holists, while the personalization were useful for Serialists. The implications of these results for the design of Hybrid mobile learning system are discussed.

Keywords: Guidelines, formatting instructions, author's kit, conference publications

1. Introduction

Mobile learning has become increasingly popular in educational settings. The major reason for such popularity is that mobile learning systems offer many advantages, e.g., portable size of mobile tools, blended, private, interactive, collaborative, and instant information (Ozdamli & Cavus, 2011). Thus, mobile learning was generally considered as a useful tool, which can improve learners' performance (Yi, Liao, Huang & Hwang, 2009). However, there is a great diversity among learners, who may have heterogeneous backgrounds, in terms of their knowledge, skills and needs (Chen & Macredie, 2010). Thus, individual differences are essential issues.

There are two approaches to accommodate students' individual differences. One is to provide adaptability while the other is to offer adaptivity. The main difference between adaptability and adaptivity is that the former provides a customized program where learners are allowed to modify the content presentation and navigation facilities by themselves while the latter offers a personalized program where a system automatically adapts to learners based on observed behaviors (Stephanidis, Savidis & Akoumianakis, 1995). These two approaches differ with respect to who takes the initiative: the learner or the system (Kay, 2001). Customized systems are learner-controlled while personalized systems are system-controlled (Finlater & McGrenere, 2004). Giving the control to the learners can reduce the effect of incorrect adaptation. However, the cost of the increased controllability is the additional effort required from the learners. The learners may need to learn the adaptation component before being able to manipulate it (Tsandilas & Schraefel, 2004). In brief, these two approaches have different advantages and disadvantages. Thus, this study tends to make best use of the advantages of personalization and customization to modeling a Hybrid Mobile Learning System (HMLS).

Furthermore, an empirical study was conducted to investigate how cognitive styles affected students' reactions to the HMLS. Cognitive style refers to an individual preferred and habitual approach to organizing and representing information (Riding & Rayner, 1998). Cognitive styles were considered as targets because they have been recognized as being an important human factor affecting student learning. For example, Clewley, Chen and Liu (2011) found that Serialists and Holists had 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. In brief, the ultimate aim of this study is not only to develop the HMLS, but also to get a complete understanding of how cognitive styles affect students' reactions to HMLS.

2. Methodology Design

To effectively achieve the aforementioned aim, an empirical study was conducted. This section describes the methodology design of the empirical study, including participants, research instruments, experimental procedures and data analyses.

2.1 Participants

30 undergraduate and postgraduate students from some universities in Taiwan participated in our study voluntarily. A request was issued to students in lectures, and further by email, making clear the nature of the studies and their participation. All participants had the basic computer and Internet skills necessary to use a Hybrid Mobile Learning System (HMLS) described in Section 2.2.1 but they do not any understanding of the subject content of the HMLS.

2.2 Hybrid Mobile Learning System

Table 1 summarizes the different preferences of Holists and Serialists based on the results obtained in our previous study (Hsieh and Chen, 2013). This table was further applied to develop the HMLS, which included two versions. Figure 1 illustrates the design layout of the Serialist version, in which major navigation tools are the main menu and keyword search and the reading tools are located on the right side and the searching tools on the left side. Conversely, Figure 2 illustrates the design layout of the Holist version, in which major navigation tools are the main menu and previous/next buttons and the reading tools are located on the left side and the searching tools on the right side. The same content was used for both Holist and Serialist Versions without incurring the practice and fatigue effects in the study.

Table 1: Summary of Preferences of Holists and Serialists

	Serialists	**Holists**
Navigation Tools	The main menu and keyword search.	The main menu and previous/ next buttons.
Display Formats	The reading tools on the right side and the searching tools on the left side.	The searching tools on the right side and the reading tools on the left side.

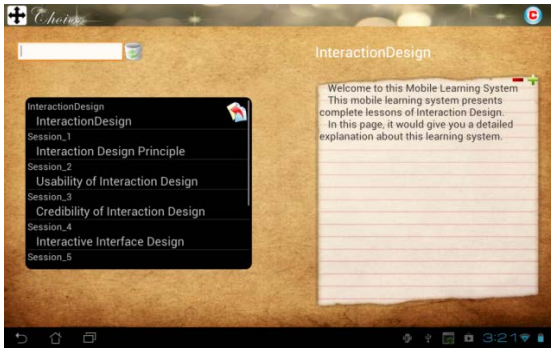

Figure 1. Serialist Version of HMLS (Initial Layout)

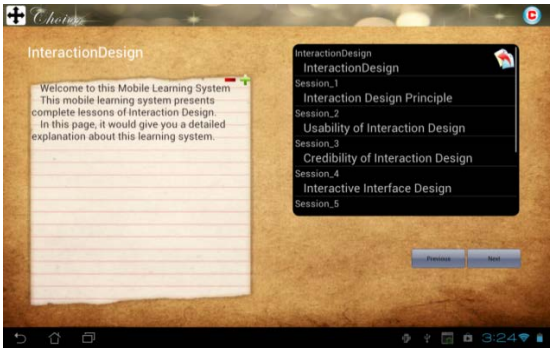

Figure 2. Holist Version of HMLS (Initial Layout)

In addition, learners were allowed to customize the look and toolbar based on their particular needs. The HMLS provides 10 kinds of tools, including Keyword, Main menu, Alphabetical Index, Topic, Content, Image, Route, History, Next & Previous, and Undo & Redo. In other words this system also allows learners to change the display formats and choose the navigation tools based on their particular needs. On the other hand, learners can also go back to use the navigation tools and display format provided in the Serialist version (Figure 3) or Holist version (Figure 4).

Figure 3. Serialist Version of the HMLS (Customized Layout)

Figure 4. Holist Version of HMLS (Customized Layout)

2.3 Task Sheet

When interacting with the HMLS, the participants were given a task sheet, which described the tasks that learners needed to perform. The range of tasks aimed to: (i) maintain the learners' motivation (Scanlon, 2000) and (ii) guide learners to search keyword to find information from the HMLS. Moreover, these tasks were used to assess learning performance. More specifically, how much time the participants spent for completing the tasks was applied to measure their learning performance.

2.4 Pre-test and Post-test

The pre-test and post-test were conducted to assess participants' levels of knowledge of the subject domain both before and after using the systems. The pre-test gave an objective assessment of the participants' prior knowledge of the subject domain. It included 20 multiple-choice questions, each with three different answers and an "I don't know" option. The post-test was designed to assess how much they have learnt from the HMLS. The post-test was presented in a computer-based format and included 20 multiple-choice questions. Each question included three different answers and an "I don't know" option but there was only one right answer. The questions covered all eight sections of the HMLS from basic concepts to advance topics.

2.5 Experimental Procedures

There were two scenarios and four stages in this Study. In order to identify students' reactions to the HMLS, a between-subjects design was used. In other words, each student used either the Holist Version or the Serialist Version based on their cognitive styles. Thus, each participant was initially provided with the SPQ to determine whether s/he was Holists or Serialists.

The participants were then asked to, carefully; go through a pre-test to measure their initial levels of knowledge. In the next stage, all participants were initially instructed how to use the tools provided by the HMLS. After they finished the pre-test, they were required to interact with the HMLS. At the same time, the participants needed to complete the practical tasks based on each question described in a task sheet. The time that they spent for completing the task was recorded in a log file. Then, learners needed to take a post-test, which was used to evaluate their learning performance based on the differences between the scores of post-test and the scores of pre-test. Finally, the participants were provided with a questionnaire to express their opinions to the use of the HMLS.

2.6 Questionnaire

The questionnaire was divided into two parts in this research. The first part focused on background information, such as age, gender, academic background, and the frequencies of mobile device/Internet usage, etc. In particular, it focused on their system experience, and enjoyment of using mobile device, and mobile learning programs, for example, how frequently they used mobile device and mobile learning and how much they enjoyed using the mobile device and mobile learning. The second part was committed to realize students' reactions to the HMLS. The questionnaire in this study included 40 questions. All of questions were designed based on five Likert Scale, which consisted of: "strongly agree", "agree", "neutral,", "disagree" and "strongly disagree". Students were required to indicate agreement or disagreement with each question that most closely reflected their opinions. To reduce the bias of this research, there are an almost equal number of positive statements and negative statements.

3. Results and Discussions

3.1 Holists

3.1.1 Learning Behavior

As shown in Figure 5, most of Holists (78%, N=14) changed the original layout while only few of Holists (22%, N=4) unchanged the original layout. We further compare the participants who change the display formats with those who change navigation tools. More specifically, the results indicated that a great number of Holists (N=14) changed their navigation tools while only a few number of leaners changed their display formats (N=3). It implies that the display formats originally provided by the Holists version in which the searching tools were put on the right side and the reading tools on the left side was suitable for their learning. On the other hand, navigation tools originally provided by the Holists version may not be helpful enough for them. One possible interpretation is that Holists tend to use additional materials to help them generate hypotheses and make inferences. Thus, they may expect to use a variety of navigation tools to make analogies, illustration and anecdote.

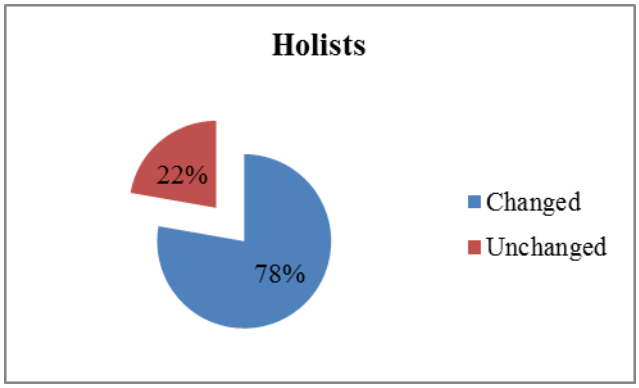

Figure 5. The Distribution of Layout Changed (Holists).

To further investigate how the Holists changed the original layout, the changed and unchanged navigation tools are discussed in this section. As shown in Figure 6 and Figure 7, in general, Holists frequently used the Main Menu and Previous & Next buttons. After comparing Figure 6 and Figure 7 in details, an interesting difference, however, was found. More specifically, Holists who changed the navigation tools and those who unchanged the navigation tools demonstrate different navigation behavior. The frequencies of using the Main menu in the former (54%) is high than those in the latter (35%). Conversely, Holists who changed the navigation tools less frequently used the Previous & Next buttons (37%) than those who unchanged the navigation tools (65%).

More specifically, Holists may prefer to use the Main menu, rather than the Previous & Next buttons. This is probably because that the Main menu allows learners to locate the information with "topic" based learning, which help Holists easily get a global picture and jump from one point to another in pursuit of their goals. These finding echoes that showed in Ford et al. (2002), which Holists

feel more comfortable with “topic” based learning. In brief, Holists attempted to use multiple tools to build their own navigation strategies instead of putting an emphasis on the particular navigation tools.

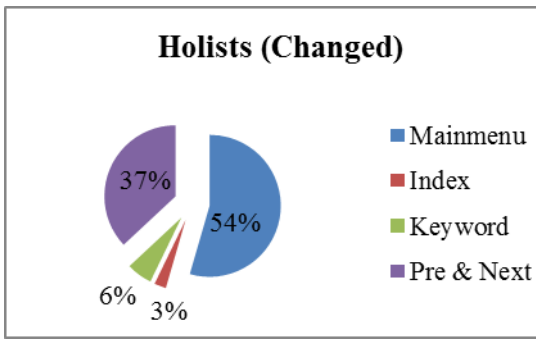

Figure 6. The Distribution of Navigation Tools

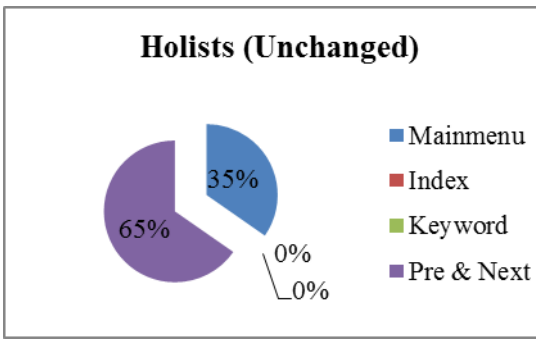

Figure 7. The Distribution of Navigation Tools

3.1.2 Learning Performance

As showed in Table 2, Holists who changed the navigation tools and those who unchanged the navigation tools have similar pre-test scores and obtained similar post-test scores and gain score. However, the former obtained the higher task scores but they spent more amount of task time than the latter. In other words, a huge amount of time that they spent for completing tasks is meaningful to them. This may be because Holists tend to spent more time exploring the learning environments and use additional supports to re-organize information to locate relevant information. Such finding also echoes the one described Section 3.1.1, which indicated Holists prefer to use additional material to help them generate hypotheses and make inferences. In other words, the HMLS was helpful for Holists to make best use of learning strategies to complete the tasks.

Table 2: Learning Performance of Changed and Unchanged

Attributes	Changed (N = 15)	Unchanged (N = 3)
Pre-test Scores		
Mean (SD)	9.8 (2.38)	10.67 (2.21)
Task Scores		
Mean (SD)	20.4 (1.44)	18.33 (1.33)
Post-test Scores		
Mean (SD)	14.33 (1.13)	14.67 (1.52)
Gain Scores		
Mean (SD)	4.53 (2.77)	4 (1)
Task Time		
Mean (SD)	62.27 (5.97)	56 (4)

3.1.3 Learning Perception

As shown in Table 3, positive perceptions and negative attitudes were measured based on the favored statements and the non-favored statements, respectively. After comparing the perceptions of the Holists who changed the navigation tools with those who unchanged the navigation tools, we found that the former obtained higher scores for both the favored statements and non-favored statements than the latter. One possible reason is that HMLS allowed learners to modify the content presentation and navigation facilities by themselves. Such a way matches with characteristics of Holists, who attempted to use multiple tools to build their own navigation strategies, instead of putting an emphasis on the particular navigation tools (Section 3.1.1). In other words, default tools originally displayed in the HMLS were not so helpless for them, who were not satisfied with such a scenario.

Table 3: Learning Perception of Changed and Unchanged

	Changed	Unchanged
	(N = 15)	(N = 3)
Positive Perceptions		
Mean (SD)	3.99 (0.75)	3.70 (0.73)
Negative Attitudes		
Mean	2.9 (1.11)	2.44 (1.16)

3.2 Serialists

3.2.1 Learning Behavior

Unlike Holists' navigation behavior, most of Serialists (75%, N=9) prefer to use the navigation tools and display formats originally provided by the Serialist version (Figure 8). In other words, only a few number of Serialists (25%, N=3) changed the layout of the Serialist version. This may be because Serialists tended to focus on one thing at a time (Pask, 1976). Thus, Serialists may pay more attention to examining the subject content and ignore the layout of the HMLS.

It is also interesting to note that all of them change the navigation tools and nobody modifies the display formats. These findings suggest that the display format originally provided by the Serialist version is suitable for their learning. This may be because Serialists prefer to take restricted navigation (Ford and Chen, 2000). Thus, they tend to use a static learning environment, instead of a dynamic a learning environment where navigation tools and display formats can be changed.

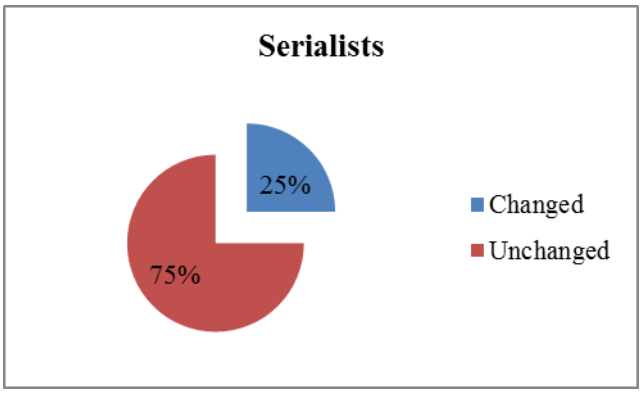

Figure 8. The Distribution of Layout Changed (Serialists).

To further investigate how these three Serialists changed the original layout, the navigation tools used by them were examined. As shown in Figure 9 and Figure 10, Serialists prefer to use the Main menu and Keyword search. Moreover, it was also found that Serialists used the Main menu more often than the Keyword search. More specifically, the main menu is useful for them to browse the subject content page by page while the keyword search can help them find specific information for their particular needs. This may be because Serialists tend to take a sequential approach so they need to rely on the main menu to examine the content step by step. On the other hand, they emphasized on procedural details (Pask, 1976) so it is necessary for them to acquire the details with the keyword search.

Additionally, Serialists only used the Previous & Next buttons (5% and 0%), Index (1% and 0%) and Keyword search (12% and 11%) a few times, but they used the Main menu (82% and 89%) many times. This finding implies that Serialists mainly use the Main menu, regardless of those who changed the navigation tools and those who unchanged the navigation tools. This may be due to the fact that Serialists prefer to focus on a single item at a time. In summary, Serialists not only use the navigation tools that can match with their characteristics, but also tend to rely on a single navigation tools at a time.

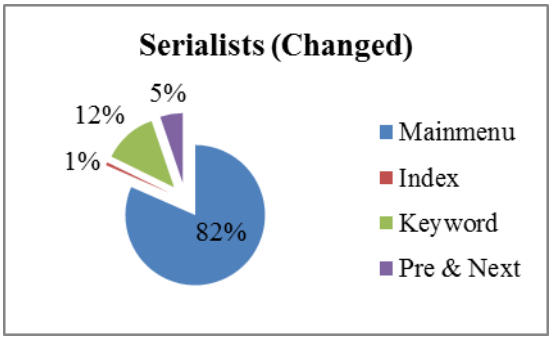

Figure 9. The Distribution of Navigation Tools

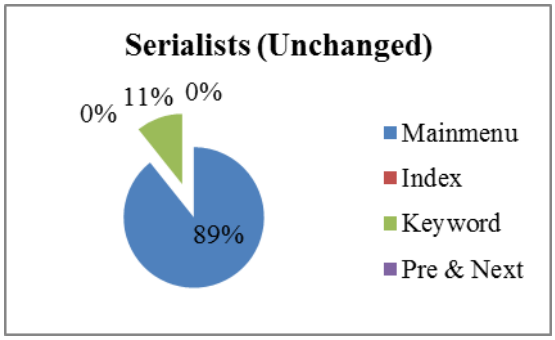

Figure 10. The Distribution of Navigation Tools

3.2.2 Learning Performance

Table 4: Learning Performance of Changed and Unchanged

Attributes	Changed (N = 3)	Unchanged (N = 9)
Pre-test Scores		
Mean (SD)	10.00 (1.68)	10.22 (1.39)
Task Scores		
Mean (SD)	19.67 (1.47)	19.22 (1.41)
Post-test Scores		
Mean (SD)	13 (1.6)	13.67 (1.41)
Gain Scores		
Mean (SD)	3 (1.00)	3.44 (0.94)
Task Time		
Mean(SD)	57.33 (4.08)	57.78 (3.62)

As showed in Table 4, Serialists who changed the navigation tools and those who unchanged the navigation tools obtained similar pre-test scores and similar task Scores, post-test scores and gain scores. Furthermore, they also spent a similar amount of time completing the tasks. It may be because Serialists who changed the layout did not spend too much time to select additional navigation tools and arrange the display formats in the HMLS. One possible interpretation is that navigation tools and display format provided in the Serialist version was suitable for them. Such finding also echoes the one described Section 3.2.1, which indicated that Serialists tend to take restricted navigation within a static learning environment.

3.2.3 Learning Perception

As shown in Table 5, positive perceptions and negative attitudes were measured based on the favored statements and the non-favored statements, respectively. After comparing the perceptions of the Serialists who changed the navigation tools with those who unchanged the navigation tools, we found that the both of them obtained similar scores for the favored statements and non-favored statements. In other words, they showed similar perceptions. As described in Section 3.2.2, Serialist version was suitable for them and they did not make too changes for the layout. This may be the reason why Serialists who changed the navigation tools and those who unchanged the navigation tools had similar perceptions.

Table 5: Learning Perception of Changed and Unchanged

	Changed	Unchanged

	(N = 3)	(N = 9)
Positive Perceptions		
Mean (SD)	3.75 (0.52)	3.60 (0.84)
Negative Attitudes		
Mean	2.78 (0.76)	2.79 (0.88)

4. Conclusions

This study developed a HMLS, with which we examined how cognitive styles affects learners' reactions to mobile learning. In general, the results demonstrated that Holists attempted to use multiple tools to build their own navigation strategies, instead of putting an emphasis on the particular navigation tools. Conversely, Serialists tended to rely on a single navigation tools at a time. In addition, the results also demonstrated that customization was helpful for Holists while personalization was useful for Serialists.

These experimental results can be used to construct robust user models, which can be used to describe the requirements of different cognitive style groups. In brief, the present study shows fruitful results but there are several limitations. Firstly, the present study only incorporates a small-scale sample and limited navigation tools. Hence, it is recommended that further studies should be undertaken with a larger sample, so that additional evidence can be obtained.

Acknowledgements

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