Mobile Collaborative Learning and Cognitive Style Grouping

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Abstract

Mobile devices are widely applied to support learning. Student learning is being shifted from individual learning to collaborative learning. In other words, mobile collaborative learning is a current trend in educational settings. On the other hand, students have various characteristics, among which cognitive styles play an important role. This study aims to investigate how member grouping affects students' reactions to mobile collaborative learning from a cognitive style perspective. The results suggest that there is a need to provide Serialists with additional help when they use mobile collaborative learning. Furthermore, the findings indicate that the heterogeneous groups show more positive reactions to the mobile collaborative learning, demonstrate better learning performance and use more effective learning strategies than the homogeneous groups. The students' learning performance is consistent with their behavior and perceptions.

1. Introduction

With the advancement of information technology, a growing number of technology-based educational tools currently exist, including the Internet, intranets, mobile devices, multimedia and webcasts. Among them, mobile devices are growing both in and out of classrooms and laboratories [26]. This is because mobile devices offer many advantages, e.g., flexibility, convenience and ubiquitous information access [4]. Due to such advantages, today's education can take place at any locations [15]. In other words, mobile devices offer exciting possibilities for overcoming geographical access barriers [21]. Thus, the mobile devices are widely employed to support student learning [11].

On the other hand, student learning is being gradually shifted from individual learning to collaborative learning. The differences between individual learning and collaborative learning lie within the fact that the former is the one in which a student work individually to reach his/her own objectives while the latter is an instruction method where more than an individual work together to reach their common objectives [5]. Collaborative learning can lead to deep information processing [9] and stimulate and enable students to engage in activities that are valuable for learning [10]. Furthermore, collaborative learning enables students to share knowledge and social involvement [12].

In brief, both mobile devices and collaborative learning provide new opportunities for students. Therefore, a current trend in educational settings is mobile collaborative learning where mobile devices were integrated into collaborative learning [1]. However, students have various characteristics. Based on students' characteristics, there are two grouping ways: homogeneous grouping and heterogeneous grouping. With the homogeneous grouping, students in a same group have similar characteristics. With the heterogeneous grouping, students in a same group have different characteristics. Previous research found that the heterogeneous grouping can demonstrate better performance than the homogeneous grouping. It may be due to the fact that high prior knowledge students can support low prior knowledge students [20]. This suggests that the grouping of mobile collaborative learning should consider students' individual differences. However, previous studies mainly emphasize on prior knowledge, ignoring other human factors, especially cognitive styles, which affected how students used technology-based educational tools [25]. In other words, the effectiveness of mobile collaborative learning may be affected by cognitive style grouping.

To this end, the study presented in this paper aims to investigate how member grouping affect students' reactions to mobile collaborative learning from the aspect of cognitive styles. In summary, this study attempts to find answers for the following the two research questions: (1) how cognitive styles affect students' reactions to mobile collaborative learning, and (2) how homogeneous groups and heterogeneous groups react differently to mobile collaborative learning.

This paper is organized as follows. Section 2 describes methodology used to find answers for the aforementioned research questions. Subsequently, Section 3 presents and discusses the results of this study, which include (a) the differences between Holists and Serialists and (b) the differences between homogeneous grouping and heterogeneous grouping. Finally, conclusions are drawn and future work is identified in Section 4.

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2. Methodology design

To effectively find answers for the research questions described in Section 1, an empirical study was conducted. This section describes the methodology design, including participants, research instruments, and experimental procedures.

2.1. Participants

36 postgraduate students voluntarily took part in our empirical study, and they were 20 females and 16 males. All of the participants did not have any understandings of the subject content of the Web-based learning system described in Section 2.2.1. On the other hand, they had the basic computer and Internet skills necessary to use a Web-based learning system. To recruit these participants, a request was issued to students in lectures and further by email, making clear the nature of the study and their participation.

2.2. Research instruments

2.2.1. Web-based learning systems. We developed a Web-based learning system to support mobile collaborative learning. In other words, the students had to access this Web-based learning system via the mobile device, i.e., a tablet PC. The Web-based learning system gives the lecture of "Interaction Design". Due to the fact that the screen size of the tablet PC is small, there is a need to provide effective navigation tools for students to locate information. The Web-based learning system provides two kinds of navigation tools. One is Keyword Search (Figure 1), which allows students to locate specific information based on their particular needs. The other one is Hierarchical Map (Figure 2), which provides a global picture of the subject content. These two navigation tools are selected because they serve different purposes and are complementary to each other. By doing so, the system offers flexibility to let students choose a navigation tool based on their requirements.

In addition to providing effective navigation tools, the Web-based learning system also includes some visual cues to help students look for relevant information with a small screen provided by the mobile device. For example, keywords are highlighted with yellow color in the display of the results so that students can easily identify whether results are relevant to their needs (Figure 3).

Figure 1. Keyword search

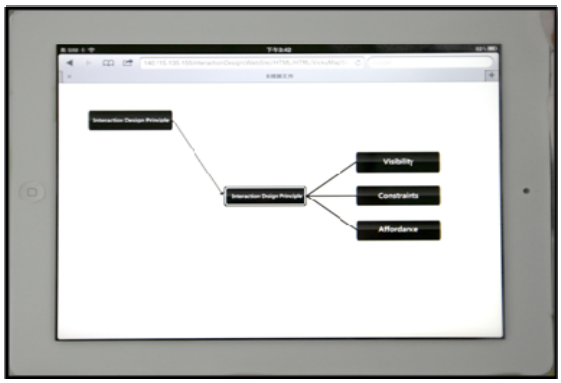

Figure 2. Hierarchical map

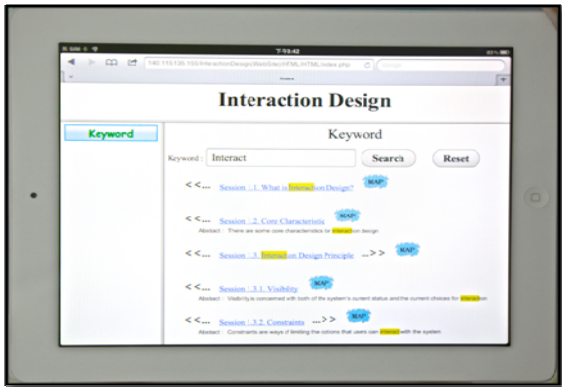

Figure 3. The display of the results

2.2.2. Study Preferences Questionnaire. Several dimensions of cognitive styles have been studied in the area of learning technology. Among them, Witkin's Field-Dependence/Field-Independence has emerged as the most widely studied [23]. The other dimension of cognitive style, i.e., Pask's Holist-Serialist [6], has a conceptual link with Field-Dependence/ Field-Independence [24]. However, this dimension of cognitive style was ignored by past research. To fill this gap, this study emphasizes on Pask's Holist-Serialist, instead of Witkin's Field-Dependence/ Field-Independence. As suggested by Ford [16], the

Holist/Serialist dimension has potential for adapting computing-based systems to the needs of each student.

In an attempt to devise a relatively quick and easy measure of Holist and Serialist biases, Ford [17] developed the Study Preferences Questionnaire (SPQ) for categorizing students as Holists or Serialists. In this vein, students were provided with two sets of statements. They were asked to indicate their degree of agreement with either statement or to indicate no preferences [17]. As the SPQ has been used in several studies [2] [13] [14] [18], it was chosen for this study, which identified Holists and Serialists by using criteria suggested by the original producer [17]: (a) if users agree with over half of the statements related to Holists, they are identified as Holists; (b) if users agree with over half of the statements related to Serialists, they are then considered as Serialists.

2.2.3. Task sheet. When interacting with the Web-based learning systems, the groups were given a task sheet, which described the tasks that students needed to perform. The task sheet lists 15 factual questions, which focuses on a single concept so there is only one standard answer for the question. The participants were requested to find answers with the Web-based learning system via a tablet PC. The starting time and the end time for each group were recorded.

2.2.4. Questionnaire. In this study, the questionnaire consisted of 15 four Likert scale questions, which were applied to examine students' perception for mobile collaborative learning. All questions consisted of: "strongly agree", "agree", "disagree" and "strongly disagree". Students were required to indicate agreement or disagreement with each statement that most closely reflected their opinions. To reduce the bias of this study, there are an almost equal number of positive statements (N=6) and negative statements (N=9).

2.2.5. Pre-test and post-test. The pre-test and post-test were designed to assess the participants' levels of knowledge of the subject domain both before and after interacting with the mobile collaborative learning. Both tests included 20 multiple-choice questions about the principles of "Interaction Design", each with three different answers and an "I don't know" option. The participants' learning performance was measured based on gain scores, i.e., the post-test score minus the pre-test score.

2.3. Experimental procedures

36 students voluntarily took part in our empirical study, of which included two stages. Firstly, all of the participants were required to take the SPQ. According to the results of the SPQ, there were 18 Holists and 18 Serialists. Such results were applied to assign students into three kinds of cognitive style combinations, i.e., "Serialist and Serialist" (S/S), "Serialist and Holist" (S/H), and "Holist and Holist" (H/H). Furthermore, each kind of combinations also included six groups to reduce the bias of this study. In the end of the first stage, the participants needed to take the pre-test to identify their preliminary understanding of the subject content.

In the next stage, all participants were initially instructed how to use a tablet PC and the tools provided by the Web-based learning system. This instruction was meant to minimize the gap between diverse experiences of participants using the tablet PC. Subsequently, each group was given a task sheet, which describes 15 factual questions. Each group needed to use one Tablet PC to find answers for the 15 factual questions with the Web-based learning system (Figure 4). After completing the tasks, the participants needed to take the post-test to identify how much they had learnt. Finally, each participant separately filled out the questionnaire, which consisted of 15 closed questions to identify students' perception for mobile collaborative learning.

Figure 4. The experimental scenario

3. Results and discussion

This study examines how cognitive style grouping affects students' reactions to mobile collaborative learning. The independent variable of this study is three kinds of cognitive style combinations, i.e., "Serialist and Serialist" (S/S), "Serialist and Holist" (S/H), and "Holist and Holist" (H/H). The dependent variables include learning performance, learning behavior and learning perception. More specifically, learning performance was measured based on the gain score that each group obtained and the task time that each group spent for completing the tasks. Learning behavior was investigated based on the frequencies of using the Keyword Search and the total number of repeated visits. Learning perception was examined according to the participants' responses to the questionnaire.

3.1. Holists vs. Serialists

As showed in Figure 5, the H/H groups more frequently used the Keyword Search than the S/S groups. As described by Ford, Wilson, Foster, Ellis, Spink [19], Holists prefer to use a global way for their learning. They firstly tend to explore various types of concepts and continue to build an overall picture of the subject content. Then, they continue to understand every concept in details. Therefore, they used a large amount of the Keyword Search to explore a variety of concepts. By doing so, they could obtain the whole picture of the subject content.

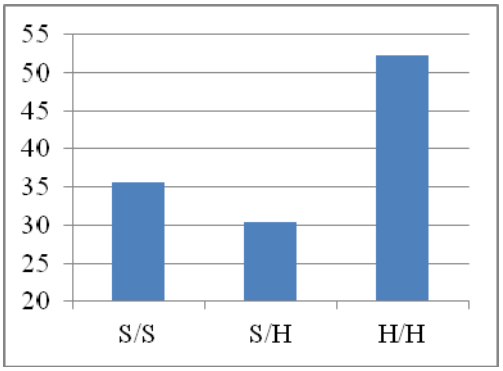

Figure 5. The total number of keyword searching

On the other hand, Serialists process information in a 'part-to-whole' sequence [6]. Thus, Serialists may have to return pages previously read to link different concepts to get a whole picture in the end. This may be a reason why the S/S groups in our study made the most repeated visits (Figure 6). Due to such repeated visits, the S/S groups also spent much more time for completing the tasks than the H/H groups (Figure 7). In other words, they might have used an ineffective learning strategy. Such an ineffective learning strategy might also have negative influences on their learning performance. Thus, the S/S groups also obtained lower gain score than the H/H groups (Figure 8).

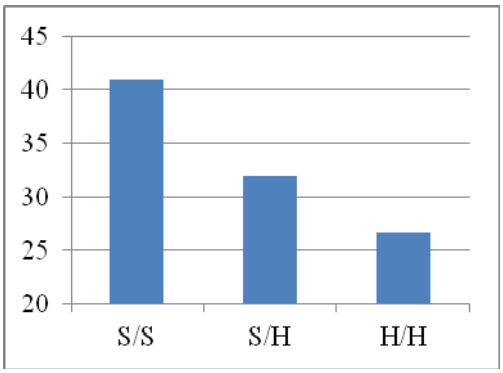

Figure 6. The total number of visited repeats

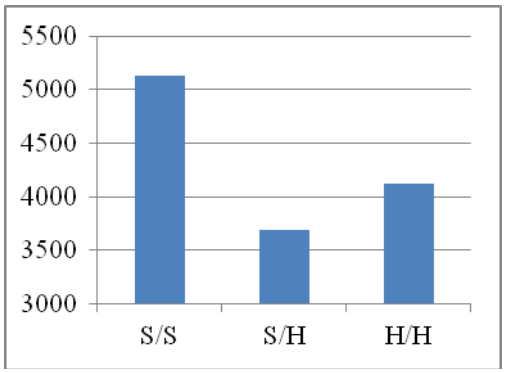

Figure 7. The total time for completing the tasks

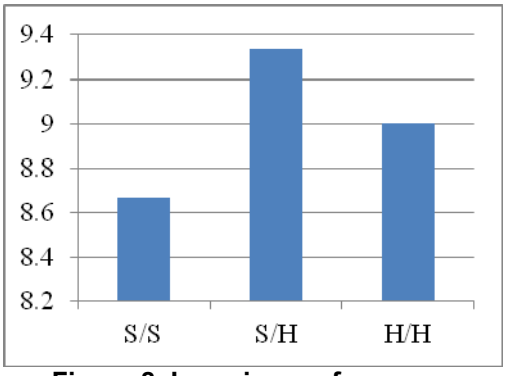

Figure 8. Learning performance

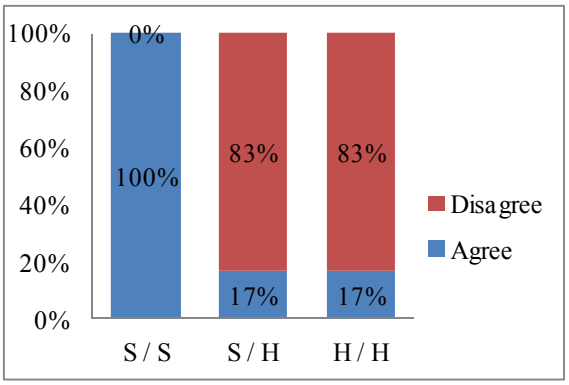

Figure 9. Students' responses to Q15

Figure 9 illustrates students' responses to Q15, "*I prefer to learn with teacher rather than to learn with the mobile device*". The reactions of the S/S groups were different from the reaction of the H/H groups. The former preferred to learn from teachers, rather than to learn with mobile devices. Conversely, the H/H groups disagreed with this statement. This might be due to the fact that the learning system was presented on the Web though the students had to use the mobile devices to access this Web-based learning system. The Web presents information in non-linear formats so students have to decide their learning paths by themselves. On the other hand, Serialists tend to take a sequential approach for their learning. In other words, the S/S groups might be

used to achieving their learning objectives step by step. Therefore, they might feel comfortable to follow a fixed learning path based on teachers' instruction, instead of having freedom to decide how to access the Web-based learning system with the mobile devices by themselves. These findings imply that there is a need to provide Serialists with additional help when the mobile collaborative learning was conducted with Web-based learning systems.

Table 1. Students' responses to Q1 and Q8

	S / S		S / H		H / H	
	Agree	*Disagree*	*Agree*	*Disagree*	*Agree*	*Disagree*
Q1: I do not think that the mobile device is beneficial to my learning.	67%	33%	33%	67%	67%	33%
Q8: I will be happy to consider the mobile device as a learning tool.	17%	83%	67%	33%	33%	67%

3.2. Homogeneous groups vs. Heterogeneous groups

The results presented in the previous section suggest that the mobile collaborative learning is more unsuitable to the S/S groups than the H/H groups. Both of the S/S groups and the H/H groups belong to the homogeneous groups. In addition to the homogeneous groups, there is also heterogeneous groups (i.e., the S/H groups). This section compares the differences between the heterogeneous groups and the homogeneous groups. As showed in Figure 7, the heterogeneous groups obtained the highest gain score. Likewise, the heterogeneous groups also spent less time for completing the tasks than the homogeneous groups. These findings suggest that the heterogeneous groups demonstrated the best learning performance. This finding supports the claim made by Hooper and Hannafin [22], which indicated that collaborative learning has the best performance with heterogeneous grouping.

Further to learning performance, the results from the questionnaire also indicated that the heterogeneous groups and the homogeneous groups also showed different learning perception for the mobile collaborative learning (Table 1). The former showed more positive attitudes toward mobile collaborative learning than the latter. The heterogeneous group could appreciate the advantages provided by the mobile devices and were happy to accept mobile devices as a new learning instrument. Conversely, the homogeneous groups demonstrated negative reactions to the mobile devices. A possible reason is that students in the homogeneous groups own a same cognitive style and use a same way to process information. In other words, they might use a same learning approach. On the other hand, students in the heterogeneous groups had different cognitive styles so each of them process information differently. Thus, diverse views exist among the students in the heterogeneous groups so they can exchange ideas with each other [7]. In other words, the heterogeneous groups can overcome the bias of a particular cognitive style.

Likewise, the heterogeneous groups and the homogeneous groups also demonstrate different learning behavior. As showed in Figure 4, the heterogeneous groups less frequently used the Keyword Search than the homogeneous groups. As previously described, the heterogeneous groups demonstrated the best learning performance. As mentioned before, students in the heterogeneous groups have different cognitive styles and each of them process information differently so they can be influenced by each other. On the one hand, they can behave like Holists, who emphasize on the whole picture of the subject content. On the other hand, their behavior is also similar to Serialists, who focus on procedural details [3]. This is probably the reason why they could use the fewest frequencies of the Keyword Search to obtain the best learning performance. In other words, the heterogeneous groups used the most effective learning strategy.

In summary, the results presented in these two sections demonstrate that the heterogeneous groups not only showed the best learning performance, but also have the most positive reactions and use the most effective learning strategy. Conversely, the S/S groups not only showed the worst learning performance, but also have the most negative reactions and use the most ineffective learning strategy. These findings are in accordance with those obtained from Frias-Martinez, Chen and Liu [8], which highlighted that there are close links among learning performance, learning perception and learning behavior.

4. Conclusions

This study examined two research questions. The answer to the first research question is Serialists more negatively reacted to the mobile collaborative learning, demonstrated worse learning performance and used more ineffective learning strategies than Holists. The answer to

the second research question is that the heterogeneous groups showed more positive reactions to the mobile collaborative learning, demonstrated better learning performance and used more effective learning strategies than the homogeneous groups. In addition, there are closed links among students' learning performance, learning behavior and learning perception.

The present study shows fruitful results but there are several limitations. Firstly, this study was only a small-scale sample. Further work needs to be undertaken with a larger sample to provide additional evidence. Another limitation of this study is that only cognitive styles were investigated. Thus, it is necessary to consider other human factors, such as gender differences and culture differences, in our future research. Such evidence can not only be helpful to promote mobile collaborative learning, but also is useful to develop personalized mobile collaborative learning.

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