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Effects of Touch Technology-based Concept Mapping on Students' Learning Attitudes and Perceptions

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ABSTRACT

Concept maps have become a widely used educational tool around the globe. The advancements in computerized interface technologies have enabled even more alternatives for using concept maps in teaching and learning. This study investigates the effects of two different touch technology-based concept mapping interaction modes on students' learning achievements and learning attitudes in a natural science course, as well as their degree of acceptance of using concept maps to learn. Ninety two sixth graders were randomly divided into three groups. Experimental Group One was taught using the Interactive Whiteboard (IWB)-based concept mapping approach, Experimental Group Two learned with the touchscreen-based concept mapping approach, while the control group learned with the traditional paper-and-pencil-based concept mapping approach. The experimental results show that, in terms of learning attitudes toward the natural science course and the degree of acceptance of using concept maps to learn, the students were significantly more positive about the two touch technology-based interaction modes than they were about the traditional paper-and-pencil mode.

Keywords

Concept map, Interactive whiteboard, Touch technology, Learning attitude, Technology acceptance model

Introduction

This study investigates the effects of using two different touch technology-based interaction modes of computerized concept mapping on students' learning performance. A concept map is a diagram showing the relationships among concepts. It is a graphical tool proposed by Novak and Gowin (1984) for organizing and representing knowledge (Ruiz-Primo, Shavelson & Schultz, 1997). It has also been recognized as a meta-cognitive tool which can empower learners to monitor and control their cognitive progress (Novak, Gowin & Johansen, 1983; Novak, 1990).

With the rapid development of information technology, concept mapping is no longer confined to the production of paper-based drawings. Instead, students are able to modify their own concept maps conveniently via computerized concept mapping tools. The advancement of touch technologies has further enhanced the process by offering easier-to-use interfaces that facilitate the use of concept maps in teaching and learning. For example, Interactive Whiteboards (IWBs) allow instructors to show a variety of content to students which can promote their interest in inquiring into proposed questions (Hwang, 2003; Hung, Lin & Hwang, 2010). Research by Smith (2000) indicated that IWBs are appropriate for any curriculum and for all ages, and can present visualized materials such as text annotation, hidden objects, fast-moving objects and image scaling, etc. It has been found that use of these features can increase teachers' autonomy and flexibility (Kennewell, 2005; Xu & Moloney, 2011).

Based on the aforementioned motivation, this study investigates the effects of different touch technology-based concept mapping approaches on both students' learning attitudes toward a natural science course and their degree of acceptance of the learning approaches. Two experimental groups and one control group were assigned to the three different strategies, that is, the IWB-based concept mapping approach, the touchscreen-based concept mapping approach, and the paper-and-pencil-based concept mapping approach. The proposed research questions are as follows:

- Do the students who learn with the touch technology-based concept mapping approaches show significantly better attitudes toward natural science in comparison with those who learn with the traditional approach?
- Do the students who learn with the touch technology-based approaches show significantly better acceptance of use of the concept maps for learning in comparison with those who learn with the traditional approach?

Literature review

Computerized concept maps

Concept mapping for meaningful learning as proposed by Novak and Gowan (1984) is a theory of instruction based on the meaningful learning principles proposed by Ausubel (1963). Novak and Gowan (1984) aimed to utilize "concept maps" to represent meaningful relationships between concepts and propositions. A concept map can be regarded as a "visual road map" showing the pathways connecting the meanings of concepts (Novak, 1996).

In the past decades, concept maps have been used to help learners reflect on, organize and adjust their given or learned concepts in specific domains (Roth & Roychoudhury, 1994). They have also served as a form of measurement for assessing students' learning achievements (Markham, Mintzes, & Jones, 1994; Schmid & Telaro, 1990). Some previous studies have shown that concept map-based approaches can be used to diagnose learners' knowledge structures and misconceptions (Hwang, 2003; Novak, 1990; Panjaburee, Hwang, Triampo & Shih, 2010). McClure, Sonak and Suen (1999) further summarized concept maps as having four potential applications in science education: (a) as a learning strategy, (b) as an instructional strategy, (c) as a strategy for planning curricula, and (d) as a means of assessing students' understanding of science concepts.

The traditional pen-and-paper-oriented approach to concept mapping has several drawbacks, the foremost among which is that concept maps produced in this way are difficult for students to modify and for teachers to evaluate, which often reduces their effectiveness. Moreover, with the paper-and-pencil approach, the development process of the concept maps cannot be recorded, and hence the teachers can only evaluate students' learning performance based on their final outcomes. Therefore, researchers have developed computerized concept mapping tools to cope with these problems; one example of such a tool is CmapTools, developed by the Institute for Human and Machine Cognition (IHMC) of the Florida University System (Novak & Cañas, 2006). In addition, researchers have created more facilities to aid students in developing quality concept maps; for example, Wu, Hwang, Milrad, Ke and Huang (2012) developed a mechanism for evaluating students' concept maps and giving them instant feedback to help them make improvements.

Owing to the popularity of computer networks, some researchers have developed computerized concept mapping systems in web-based environments, which allow learners to collaboratively develop concept maps via network communications. The study of Khamesan and Hammond (2004) showed that students who learned with web-based concept mapping systems learned as effectively as those who learned with the face-to-face collaborative concept mapping approach. Kwon and Cifuentes (2009) further reported that computerized collaborative and individual concept mapping approaches had equally positive effects on students' learning achievements; however, students who learned collaboratively created significantly higher quality concept maps than those who learned individually, indicating that deeper conceptual understanding could be gained via collaborative learning.

In recent years, the advancement of mobile technologies has further engaged researchers in developing concept map-oriented mobile learning systems (Hung, Hwang, Su, & Lin, 2012). For example, Hwang, Wu and Ke (2011) proposed an interactive concept map-oriented approach for supporting mobile learning activities in the field for an elementary school natural science course. Their experimental results showed that the proposed approach not only enhanced learning attitudes, but also improved the learning achievements of the students. From the literature, it can be found that concept mapping approaches have not only been widely adopted by educators and researchers, but have also been implemented on different learning platforms, implying the potential of such approaches.

Currently, computerized concept mapping tools such as MindManager, Inspiration or FreeMind can be used to create concept maps with a keyboard and mouse. However, researchers have indicated that this approach suffers from two problems: first, it usually requires users to follow particular task structures (e.g., two concept nodes must be created before a proposition can be made), which could distract users from their primary tasks; second, it becomes inefficient and ineffective to use a keyboard and mouse on specific devices that support more direct interaction, such as touch-based computers, because such devices only offer a virtual keyboard and gesture-based interaction that differs from mouse behaviors (Morgan & Butler, 2009; Rick & Rogers, 2008; Ruiz-Primo, Shavelson & Schultz, 1997).
Accordingly, touch technologies provide flexible ways for learners to interact with instructional contents, and thus support free and enjoyable interactions that contrast with the well-established practices of paper-and-pen-based

interaction (Hollan & Hutchins, 2010). That is, those new technologies have the potential of benefiting learners in allowing them to discuss, annotate, and manipulate shared digital artifacts in a more direct and enjoyable way.

Touch technologies for computers

The term “touch technology” refers to the development of digitalized interfaces that are able to detect the presence and location of a touch within a display area; examples of such interfaces are touchpads, touchscreens, and Interactive WhiteBoards (IWBs). Touchscreens enable people to interact directly with what is displayed rather than indirectly with a mouse or touchpad. They have played a prominent role in the design of digital appliances such as personal digital assistants (PDAs), satellite navigation devices, mobile phones, and video games (Hwang, Tsai, Chu, Kinshuk, & Chen, 2012; Wu, Hwang, Su, & Huang, 2012).

Researchers have indicated that touch technologies allow users to operate computer systems more easily than ever before, making them highly attractive to teachers and students (Romeo, Edwards, McNamara, Walker, & Ziguras, 2003; Yu, Zhang, Ren, Zhao, & Zhu, 2010). For example, the British government not only invested a considerable sum in installing Interactive WhiteBoards (IWBs) in elementary and junior high schools from 2002 to 2004, but also initiated the "National Whiteboard Network" project. In a similar move, the Hong Kong Education and Manpower Bureau started promoting the use of IWBs in elementary and junior high schools in 2004.

The study of the implementation and impact of these projects has found that in certain subjects, the more experience the teacher has of using the interactive whiteboard, the greater the likelihood of positive attainment gains in mathematics and natural science courses for the students (Somekh et al., 2007). Goodison (2002) investigated primary schoolchildren's awareness of the linkage between ICT and the way they learn within the context of a school that has been particularly successful in integrating IWB into its curriculum. He also stressed the need to meet the mission requirements with appropriate software. The studies of Wood and Ashfield (2008), and Dhindsa and Emran (2006) both found that in an IWB learning environment combined with collaborative learning activities, teachers should offer students more opportunities for communication, interaction and cooperation to construct and rework their knowledge structures.

To sum up, touch technology has potential in educational applications; therefore, it is worth studying the effects of different forms of touch technology used as educational tools on the learning performance of students.

Research design

The purpose of the current study is to investigate the effects of different touch technology-based concept mapping strategies on the learning attitudes and learning achievements of elementary school students in a natural science course. To obtain accurate research results, three variables which could affect the experiment needed to be controlled, namely the instructor, learning time and learning content, as shown in Figure 1.

Participants

The study was conducted in an elementary school in southern Taiwan. A total of 92 sixth-grade students (12-13 year olds) from three classes participated in the experiment. Two of the classes were assigned to be the experimental groups, and the other was the control group. Experimental Group One, consisting of 31 students, learned with the IWB-based concept mapping approach. Experimental Group Two, also with 31 students, was assigned to learn with the touchscreen-based concept mapping approach, while the control group, made up of 30 students, was arranged to learn with the paper-and-pencil-based concept mapping approach.

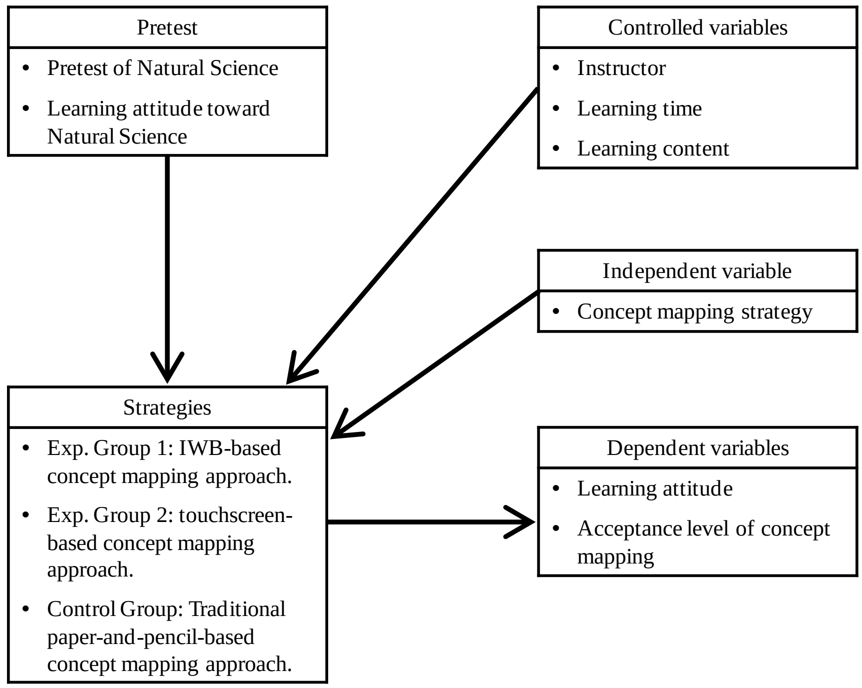

Figure 1. Research structure of the study

Measuring tools

The measuring tools utilized in this study included a scale for measuring the students' attitudes toward the natural science course, and a questionnaire of the students' acceptance of the concept mapping approach.

The learning attitude questionnaire was adapted from the learning attitude scale developed by Crawley and Koballa Jr. (1994). It consisted of twenty-five items (as shown in the appendix) with a five-point Likert rating scheme, where 5 represented "strongly agree" and 1 represented "strongly disagree." The Cronbach's α of this questionnaire was 0.862, showing high internal consistency and reliability (Cohen, 1988).

The acceptance questionnaire of concept mapping originated from the questionnaire developed by Chu, Hwang, Tsai, and Tseng (2010). It consisted of 31 items with a five-point Likert rating scheme, including 14 items for "Perceived usefulness" and 17 items for "Perceived ease of use." The Cronbach's alpha scores of the two dimensions were 0.90 and 0.91, respectively, showing the high internal consistency and reliability of the scale (Cohen, 1988).

Experimental procedure

The experimental procedure of the study is depicted in Figure 2. The students were also asked to complete the learning attitude questionnaire prior to the activity.

During the learning activity, the students in the two experimental groups were given an introduction to the computerized concept mapping tools, while the control group was guided to learn the concept mapping development procedure with paper and pencil. Following the introduction to the concept mapping tool/development procedure, the three groups learned with the different concept mapping approaches.

The students in Experimental Group One were instructed by the teacher via the IWB-based concept mapping approach; that is, concept maps were mainly used as an interactive instructional tool via an IWB. The students in this group were asked to practice following the teacher's demonstration during the instruction process. The teacher first presented the concept mapping tool and some incomplete concept maps to the students on the IWB and asked them to consider how to complete the maps. The teacher then asked some volunteers to come forward to fill in the missing parts (concepts or relationships between concepts) on the IWB. A discussion session was then conducted to allow all of the students to raise their hands and provide different opinions about the answers; that is, other students could also come forward to modify the concept maps on the IWB and explain why the modifications were needed. Finally, the teacher gave feedback to the students by showing the completed concept maps, and answered the questions raised by the students. Such an approach to conducting IWB-based instruction is commonly used in elementary schools in Taiwan.

The students in Experimental Group Two learned with the touchscreen-based concept mapping approach; that is, concept maps were used as a knowledge construction tool via computers equipped with touchscreens. The teachers first presented the concept mapping tool and the learning tasks, and then asked the students to develop their own concept maps using the tool. After the concept map development process, the teacher gave feedback to the students by showing the completed concept maps and answering the questions raised by the students.

In contrast to the two experimental groups, the students in the control group were guided to learn with the traditional concept mapping approach; that is, concept maps were used as a knowledge construction tool via paper and pencil. After the concept map development process, the teacher gave feedback to the students by showing the completed concept maps and answering the questions raised by the students.

After the learning activity, all of the students were asked to complete the questionnaires of learning attitude toward science learning and acceptance of using concept maps.

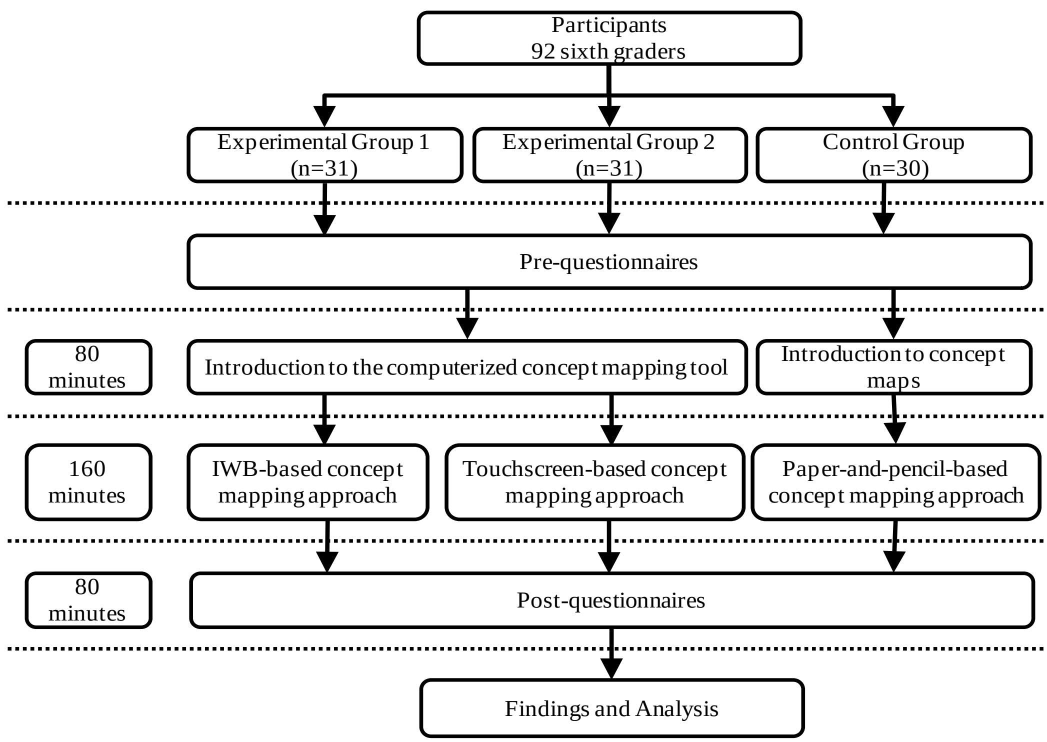

Figure 2. Experimental procedure of the study

Results

Analysis of learning attitudes toward the natural science course

To explore the effects of the different concept mapping approaches on the students' learning attitudes toward the natural science course, a paired-sample t-test was employed to compare their attitudes before and after the learning activity, as shown in Table 1.

It is found that the learning attitudes of the students in Experimental Group One showed significant improvement after participating in the learning activity (t = -2.88, $p < .01$), indicating that the IWB-based instructional mode could promote the students' learning attitude; in contrast, the students in Experimental Group Two showed no significant difference in their attitudes after the learning activity (t = 0.70, $p > .05$), indicating that the touchscreen-based learning mode had no significant effect on their learning attitudes towards the natural science course.

The analysis result of the control group was quite different from that of the two experimental groups as it actually showed a significant deterioration in attitudes after the learning activity (t = 3.34, $p < .01$), indicating that the paper-and-pencil-based concept mapping mode could have significantly negative effects on students' learning attitudes.

Table 1. Paired sample t-test of students' learning attitudes toward the natural science course for the three groups

Group	Test	N	Mean	SD	*t*
Exp. Group 1	Pre-test	31	3.29	0.62	-2.88**
	Post-test	31	3.47	0.66	
Exp. Group 2	Pre-test	31	3.76	0.54	0.70
	Post-test	31	3.69	0.63	
Control Group	Pre-test	30	3.39	0.61	3.34**
	Post-test	30	3.05	0.57	

$^{**}p < .01$

Analysis of acceptance of concept mapping in the natural science course

To further explore the students' perceptions of using the different concept mapping approaches to learn natural science, one-way ANOVA was used to compare the students' ratings on the acceptance questionnaire items from two angles, that is, perceived usefulness and perceived ease of use, as shown in Table 2. The ANOVA result shows that Experimental Groups One and Two had significantly more positive perceptions of the usefulness of concept maps for learning than the control group (F = 6.37, $p < .01$), indicating that the students highly accepted the computerized concept mapping approaches in terms of perceived usefulness, while the paper-and-pencil-based concept mapping strategy was perceived as being less effective.

Table 2. ANOVA of perceived usefulness of concept mapping among the three groups

Group	N	Mean	SD	*F*	Post hoc
(1) Exp. Group 1	31	3.70	0.67	6.37**	(1)>(3)
(2) Exp. Group 2	31	3.94	0.66		(2)>(3)
(3) Control Group	30	3.36	0.59		

$^{**}p < .01$

In terms of perceived ease of use, Table 3 shows the ANOVA results of the ratings of the relevant questionnaire items. It was found that the two experimental groups revealed significantly better ratings than the control group (F = 8.32, $p < .01$), indicating that the computerized concept mapping systems were perceived by the students as being much easier to use in comparison with the paper-and-pencil approach.

Table 3. ANOVA for perceived ease of use of the three concept mapping approaches

Group	N	Mean	SD	*F*	Post hoc
(1) Exp. Group 1	31	3.41	0.60	8.32**	(1)>(3)
(2) Exp. Group 2	31	3.69	0.62		(2)>(3)
(3) Control Group	30	3.04	0.67		

$^{**}p < .01$

Discussion

Although several previous studies have reported the effectiveness of the concept mapping approach, it remains an open issue to investigate the effects of using touch technologies on students' learning attitudes and technology acceptance degrees in concept mapping activities. In this study, an experiment was conducted to compare students' learning attitudes and degrees of technology acceptance when using different types of touch technology-based concept mapping approaches. It was found that the students who learned with both the IWB and the touch screen-based concept mapping approaches revealed significantly better perceptions in terms of their learning attitudes toward the science course and the usefulness and ease of use of the concept mapping approaches. The findings of this study conform to those of some previous studies that applying novel technologies in learning activities has the potential to inspire students' extrinsic motivation and enhance their learning outcomes (Mistler-Jackson & Songer, 2000; Wang & Reeves, 2007). That is, the enjoyable experiences brought about by using touch technologies could be one of the factors that motivated the students. Moreover, the use of touch technology enabled the students to easily edit and directly operate on their learning tasks, which could be the factor affecting their perceived ease of use and usefulness owing to a reduction in the Split-Attention Effect indicated by Mayer and Moreno (1998, 2003).

Moreover, it is interesting to find that the average learning attitude rating of the students in Experimental Group Two decreased after the learning activity, although the decrease was not significant. Moreover, the average rating of the control group was significantly decreased. From the interviews, it was found that the students in Experimental Group Two and the control group showed less interest in the learning activity since they spent most of their time developing concept maps (i.e., their learning tasks), while the students in Experimental Group One enjoyed the interactions with the teacher and their peers via the IWB. This finding implies the need to design some interaction or competitive activities in the concept map development tasks.

It should also be noted that the use of touch screens by students is more learner-centered, while the interactive whiteboard approach is more teacher-centered; however, this does not imply that the findings are trivial since student-centered approaches are not always more effective than teacher-centered approaches, in particular for elementary school students who might require more instruction or guidance. In this study, although the teacher attempted to interact with students using the IWB and to guide them in discussion, the students had to mainly listen to the teacher and exchange information; thus, they had less time to organize their knowledge. However, from the learning attitude ratings of the students, it can be seen that the IWB-based approach has the potential to promote students' learning interest and hence improve their learning attitudes. Consequently, in the future, more thoughtful learning design of IWB-based instruction could take into account the time required for knowledge organization.

To investigate the factors affecting the performance of the students in Experimental Group One, an in-depth interview was arranged. Seven students from the group were randomly selected to take part in the interview.

The interview results showed that most of the students in this group liked the IWB-based learning approach. Several students indicated that, in such an interesting interaction mode, the teacher presented the notation and illustrative examples of the learning content in the form of concept maps, and interacted with the students on the IWB by asking them to answer some questions or fill in some concepts or the relationships between concepts. However, several students also pointed out the problems of such a teacher-centered instructional mode of using concept maps, including "less time to practice" and "less opportunity to reflect." For example, one of the students stated that "*Although it was fun to interact with the teacher and my classmates on the IWB, I did not have much time to organize what I learned in this subject unit*." Another student stated that "*Lack of sufficient practice was the problem of learning in this way. I liked to interact with everyone, but there were dozens of classmates in the class and each of us had only a few chances to practice on the IWB. Most of the time we just watched the teacher's presentation and the interactions between the teacher and our classmates*."

It can be seen from the interview responses that the IWB-based concept mapping approach is able to attract the attention of students; however, with such an approach, the students were less involved since the concept maps were used as an instructional tool. On the contrary, each of the students in Experimental Group Two used a computer with a touchscreen to develop concept maps based on what they had learned in the class; that is, they learned with a student-centered approach that allowed them to have sufficient time to practice and organize their knowledge. Therefore, insufficient time to practice and organize knowledge could be one main reason why the learning achievement of the students who learned with the IWB-based concept mapping approach was worse than that of the students who learned with the touchscreen-based approach.

Although the learning approach used by the control group students was student-centered, the efficiency of using paper and pencils for developing concept maps was not as good as that of the touchscreen-based approach, because it is inconvenient for the control group students to draw and modify concept maps with paper and pencil. Such a learning context could lead to a decrease in their learning efficiency, which could be a factor influencing their learning achievement. Previous studies have also found that the performance of students who learn with paper and pencil is usually inferior to that of those who learn with technologies, in terms of learning achievement and motivation (Komis, Ergazaki & Zogza, 2007; Kordaki, 2009; Liu, 2011). Therefore, the students' learning attitudes toward the natural science course appeared to be negative after the learning activity. Moreover, their feedback regarding the "perceived usefulness" and "perceived ease of us" was significantly worse than that of the other two groups. Such findings conform to what has been reported by previous studies, namely that computerized concept mapping approaches are more readily accepted by students in comparison with the traditional paper-and-pencil approach (Hwang, Shi & Chu, 2011; Trundle & Bell, 2010; Wu et al., 2012).

It should be noted that the three concept mapping approaches reflected the teaching reality of most schools in Taiwan. The experiment design aimed to investigate the effects of using touch technologies in practical applications on students' learning attitudes and perceptions in comparison with the traditional paper-and-pencil approach. Both the teaching methods applied to the touch technologies followed the real instructional designs in the selected school (and many other schools) as well as the nature of the technologies, although several factors could be involved and might not be easy to control. Consequently, in the future, it is worth investigating impacts of individual factors in depth by conducting extended experiments. Moreover, it is also worth evaluating the effectiveness of those touch technology-based concept mapping approaches from the aspects of human factors, such as genders, learning styles or cognitive styles (Hwang, Sung, Hung, & Huang, 2012).

Conclusions

Many past studies have shown that concept mapping strategies could improve students' academic achievement (Erdogan, 2009; Hwang, Shi & Chu, 2011; Lim, Lee & Grabowski, 2009). What is more, researchers have also indicated that a potential way for educators to conduct concept map-based instruction is to use computerized tools in place of traditional paper-and-pencil-based approaches (Kim & Olaciregui, 2008). This study investigates the effects of two different touch technology-based concept mapping interaction modes on students' learning attitudes and learning achievement. The research findings of the study are summarized as follows:

- *The IWB-based concept mapping approach could improve students' learning attitudes toward the natural science course, while using concept maps with paper and pencil might have a detrimental effect on students' learning attitudes.*

The experimental results show that the learning attitudes of the students in Experimental Group One (i.e., the teacher-centered IWB-based approach) significantly improved after the learning activity, indicating that the IWB-based interaction mode promoted the students' learning attitudes towards the natural science course. On the contrary, the students in the control group (i.e., the traditional paper-and-pencil-based approach) revealed significantly worse attitudes after the learning activity. Such a finding conforms to some of the previous studies that report the differences between the learning motivations and attitudes of students using computerized and paper-and-pencil concept mapping approaches (Hwang, Shi, & Chu, 2011; Wu et al., 2012).

- *Both computerized approaches, including teacher-centered (i.e., IWB-based) and student-centered (i.e., touchscreen-based), were highly accepted by the students in terms of the perceived usefulness and perceived ease of use of the concept maps for learning.*

The experimental results concerning the students' degree of acceptance of using concept maps during the learning activity are encouraging. It can be seen that both forms of touch technology-based computerized concept mapping approaches were highly recognized by the students as being useful and easy to use. That is, with the help of the touch technologies (i.e., the IWB and computers with touchscreens), the students felt that learning with concept maps was not difficult and was helpful to them in understanding the learning content. Such a finding conforms to most of the previous studies that have recognized the effectiveness of computerized concept mapping strategies (Liu, Chen & Chang, 2010; Reader & Hammond, 1994).

From the findings and the above discussion, it is concluded that touch technology-based concept mapping approaches are highly accepted by students in terms of their perceived usefulness and ease of use; moreover, the teacher-centered IWB-based approach seems to be effective in improving the students' learning attitudes, while the student-centered touchscreen-based approach seems to be effective in improving their learning achievements. Consequently, it is inferred that the IWB-based approach is a good instructional strategy for teachers to adopt when interacting with students and to gain their attention, while the touchscreen-based approach provides students with a good interface for developing their concept maps. To sum up, it is suggested that teachers and educators note the importance and strategies of employing touch technologies in conducting concept mapping-related learning activities (Smith, Higgins, Wall, & Miller, 2005).

In the future, it is worth developing a touch technology-based concept mapping system which not only allows students to develop their own concept maps, but also allows teachers to interact with students during the learning activities, that is, a computerized concept mapping approach that integrates the teacher-centered IWB and the student-centered touchscreen technologies to benefit students in terms of improving both their learning attitudes and their learning achievements. It is also worth investigating the effects of other innovative touch technologies, such as multi-touch interfaces, on students' learning performance in concept mapping-related learning activities. Moreover, as numerous previous studies have employed various computerized concept mapping approaches, it would be interesting to compare the effect of touch technology-based concept mapping with other kinds of computerized concept mapping in future studies.

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Appendix

Questionnaire of students' learning attitudes toward the natural science course
(*inverse items)

1. The learning content of the natural science course is plentiful and helpful.
2. The learning content of the natural science course can benefit me a lot.
3. I have fully concentrated on the learning activity.
4. I often do my own thing in the natural science class.*
5. I am very interested in the natural science class.
6. The learning content of the natural science course is not attractive to me.*
7. The learning content of the natural science course is useful.
8. I can gain a lot from the natural science course.
9. I don't like the natural science course.*
10. The knowledge learned from the natural science course is useless in daily life.*
11. I like to do the assignments of the natural science course.
12. It is important to actively solve problems encountered in learning natural science.
13. I expect to gain good grades in the natural science course.
14. I shall apply what I have learned in the natural science course to daily life.
15. I hate the course since it often needs me to think and make reflections.*
16. I like to propose questions and discuss with the natural science teacher.
17. I expect to learn to solve problems by myself in the natural science course.
18. It is important to spend time on previewing and reviewing the natural science course content at home.
19. The learning content of the natural science course is helpful to me in observing the natural phenomena of daily life in depth.
20. The learning content of the natural science course is important.
21. It is important to do the assignments and prepare for examinations of the course on time.
22. I like to discuss with teachers and peers when I cannot fully understand the learning content.
23. It is important to take notes on the key points of the learning unit.
24. I usually give up when encountering problems during the learning process.*
25. I like to take assessments to assure that I really understand the learning content.