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THE EFFECTS OF INCORPORATING CONCEPT MAPPING INTO COMPUTER-ASSISTED INSTRUCTION

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ABSTRACT

A study was carried out to determine the effects of incorporating concept mapping into computer-assisted instruction. There were 37 boys and 54 girls from a Special Assistance Plan school who participated in this study.

The students received computer-assisted instruction on the topic "organic chemistry" for about 7.5 hours. They were randomly assigned to three different groups. In the Partial Map group, the students were given partial concept maps in the program and they were assigned the task of constructing complete concept map after each topic. In the Complete Map group, the students were provided with complete concept maps and they performed note-taking activities during the lessons. In the Menu-selection group, the students used traditional menu-selection system and they also performed note-taking activities. The following test and instruments were then administered to the students: Chemistry Achievement Test, Attitudes towards Chemistry, Attitudes towards Computer-assisted Instruction and concept mapping exercise.

The results and their implications will be discussed in this paper.

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INTRODUCTION

Effective instruction is often designed based on learning theories. Many researchers have voiced their concern about the pedagogical effectiveness of educational software available and the importance of integrating learning theories in instructional design of computer software (Shuell & Schueckler, 1989).

Ausubel's learning theory is one important cognitivist theory which emphasises meaningful learning. Ausubel proposed that meaningful learning occurs when new knowledge is consciously linked to relevant concepts possessed by the learner. Based on this learning theory, concept mapping was devised by Novak (1979) as a cognitive tool to promote meaningful learning. Concept mapping is a process which involves the identification of key concepts in a domain of knowledge and the organisation of these concepts into a hierarchical arrangement. Novak (1977) believes that concept learning is important in science education and concept mapping is a system of learning and instruction that is both consistent with the structure of scientific knowledge and the psychology of learning.

Concept mapping has received much attention from science education researchers and it has been shown to be a useful tool to facilitate meaningful learning in science. For instance, concept mapping has been shown to improve problem-solving abilities (Pankratius, 1990), to reduce students' anxiety towards learning (Jegede, Alaiyemola and Okebukola, 1990) and to enhance achievement (Fraser and Edward, 1985). This led Heinze-Fry, Crovello and Novak (1984) to suggest that concept mapping can be incorporated into computer-assisted instruction. This study is an attempt to investigate the effects of incorporating concept mapping into computer-assisted instruction tutorial program.

OBJECTIVES OF THE STUDY

1.To investigate the effects of incorporating concept mapping into CAI on student's performance in achievement test.
2.To investigate the effects of incorporating concept mapping into CAI on student's attitudes towards chemistry and student's attitudes towards CAI.
3.To investigate whether a correlation between concept mapping ability of students and their performance in chemistry achievement test exists.

METHOD

SUBJECTS

The sample for this study comprised ninety one Secondary Four students

in a government Special Assistance Plan (SAP) school. The subjects were randomly assigned to one of the three groups, namely : the Partial Map group, the Complete Map group and the Menu-selection group.

INSTRUMENTATION

Chemistry Achievement Test

The Chemistry Achievement Test was constructed by the researcher. It consisted of ten multiple-choice items (10 marks) and five structured questions (30 marks). Each structured question was subdivided into smaller parts and it can be effectively considered as thirty short-answer items. The items were constructed to measure the student's mastery of the concepts stated in the specific instructional objectives in the program.

Instrument for measuring Attitudes towards Chemistry

The Instrument for measuring Attitudes towards Chemistry was adapted from the Attitudes to Science Instrument developed by local researchers Dr. Foong Yoke Yeen and Dr. Lam Tit Loong (1988). A four-point Likert scale (Strongly Agree, Agree, Disagree, Strongly Disagree) was used to record the respondent's reaction.

Instrument for measuring Attitudes towards CAI

The Instrument for measuring Attitudes towards CAI was modified from the Instrument developed by Brown (reported by Mathis, Smith and Hansen, 1970). Eleven items from Brown's instrument were rephrased with the addition of nineteen new items. A four-point Likert scale (Strongly Agree, Agree, Disagree, Strongly Disagree) was used to record the respondent's reaction.

Concept Mapping Exercise

Concept mapping exercise was administered to measure the student's ability in concept mapping. An example of a concept map and steps to draw a concept map were first presented to the students. The students were then asked to construct a concept map on the topic "Separation of Mixtures" and a passage was given as a reference. The concept maps were scored by the scoring key recommended by Novak (1984). The score obtained by the students in constructing the concept map was taken as a measure of their concept mapping ability.

TREATMENTS

The students used the tutorial program "Chem Tour" to study organic chemistry for a total of about 7.5 hours over four days. The program

was developed by the researcher using Toolbook ver 1.53. The program "Chem Tour" has three versions which are different only in the navigational interface. The contents of the program were kept the same.

The Partial Map group

In the Partial Map group, concept maps without logical connectives were presented to the students (Figure 1).

Figure 1 Tutorial program for the partial map group

The partial concept map serves as a mental framework for the students by providing an overview of the concepts to be learned. It also functions as a graphical navigator, allowing students to select a topic by clicking on a particular concept. When studying the topic for the first time, the students had to follow the numbered sequence. If the students were allowed to select the topics at random, different learning paths would constitute a confounding factor which might produce different learning outcome and this would complicate the study. Each student in this group was provided with a booklet for construction of complete concept map after each unit of lesson. They could either elaborate on the partial concept map presented to them or construct a new concept map on their own. The booklets were kept by the researcher after each lesson.

The Complete Map group

In the Complete Map group, the students were provided with complete concept maps (Figure 2).

The students could select a topic by clicking on a particular concept in the map. Whenever a topic was selected, the relationships between the concept selected and other related concepts would be highlighted (Figure 3).

Figure 2 Tutorial program for the complete map group

Figure 3 Highlight of relationships between concepts

The complete concept maps were constructed by the researcher. They were intended to serve not just as graphical navigator, but also as representation of the researcher's knowledge structure on the topic. It is hoped that the students will see the inter-relationship of the concepts to be learned at a global level and more effective learning will take place with a better mental framework.

Each student in this group was provided with a booklet for taking notes. The students were instructed to list down important points while learning with the program like the normal note-taking activity they performed in classroom. The booklets were kept by the researcher after each lesson. Note-taking was also used as a control activity to reduce the difference in total time spent on learning task among the three groups of students.

The Menu-selection group

The students in the Menu-selection group were provided with a menu for selection of topics in each unit (Figure 4).

Menu-selection system was used as it is a common mode of topic selection in most computer-assisted instruction programs. There was no structural cue provided as in the case of the Partial Map group and the Complete Map group.

Each student in this group was also given a booklet for note-taking activity and the booklets were kept by the researcher after each lesson.

Figure 4 Tutorial program for the menu-selection group

RESEARCH Procedure

The subjects were randomly assigned to the three groups and the lessons were conducted in the same computer laboratory for the three groups of students at different time. The lessons were conducted over four days. The survey and tests were administered on the fourth day immediately after one-hour revision session.

RESULTS

Students' performance in Chemistry Achievement test, Attitudes towards Chemistry, Attitudes towards CAI and concept mapping exercise were summarised in Table 1.

Table 1 Chemistry achievement test score

	Chem Ach Test		Att to Chem		Att to CAI		Concept Map Ex
Group	Mean	S Dev.	Mean	SDev.	Mean	S Dev.	Mean	SDev.
Partial Map	24.71	5.37	62.45	8.50	83.74	9.15	32.26	8.73
Complete Map	22.10	7.85	58.10	11.93	82.58	9.51	28.93	8.65
Menu Selectn	22.03	6.05	59.32	8.87	84.25	9.41	27.00	7.13
Hight poss sc	35		88		112		---	

ANCOVA with chemistry mid-year results as covariate was performed. The F-value (4.311) was significant at 5% level (P-value < 0.05). Thus, there was significant difference in the performance in the Chemistry Achievement Test among the three groups of students. The least squares means for the achievement test score of the three groups were computed and compared. The questions were classified into Low Order (Knowledge and Comprehension) and High Order (Application) questions and ANCOVA was again used to test for any significant differences in results among the three groups of students.

It was found that there was significant difference in the performance in Chemistry Achievement Test among the three groups of students. The Partial Map group performed significantly better than the other two groups but there was no significant difference between the Complete Map group and the Menu-selection group. The students in the Partial Map group performed significantly better than students in the other two groups in High Order questions (Application level) but not in Low Order questions (Knowledge and Comprehension level).

ANOVA was carried out to test for any significant difference in the scores in the Attitudes towards Chemistry among the three groups of students. The results (F-value 1.583) showed that there was no significant difference among the three groups students in their attitudes towards chemistry.

ANOVA was carried out to test for any significant difference in the scores in the Attitudes towards CAI among the three groups of students. The results (F-value 0.250) showed that there was no significant difference among the three groups students in their attitudes towards chemistry.

ANOVA was carried out to test for any significant difference in the scores in the concept mapping exercise among the three groups of students. The F-value (3.208) was significant at 5% level (P-value < 0.05). Scheffe's test was then carried out to compare the mean scores among the three groups. The results showed that significant difference

only existed between the Partial Map group and the Menu-selection group. The significant difference was due to the difference in labelling relationships between concepts.

The Pearson's product-moment correlation coefficient between concept mapping score and Chemistry Achievement Test score was computed for each group of student.

Table 2 Correlation between concept mapping score and chemistry achievement test score

Group	Correlation coefficient
Partial Map	0.387*
Complete Map	0.343*
Menu-selection	-0.149

Critical value of r (df=89) = 0.206 for a=0.05 (Computed from data in Ferguson & Takane, 1989, p554)

The results showed that the correlation coefficient between concept mapping score and total score of Chemistry Achievement Test was significant at 5% level for Partial Map group and Complete Map group but not for the Menu-selection group.

DISCUSSIONS

The Partial Map group performed significantly better than the other two groups in the Chemistry Achievement Test. This could be due to the beneficial effects of both the process and product of concept mapping activities.

There are three ways in which the process of concept mapping could be beneficial : (a) It results in meaningful learning, (b) it results in meta-cognition and (c) it is a problem-solving activity.

a.Meaningful learning

In the process of concept mapping, the learners actively re-sort ideas and relate new ideas to their existing knowledge. This process involves subsumption because the learners constantly use new propositions to elaborate and refine concepts they already know (Okebukola,1992). It brings about meaningful learning as a result of integrating information into a progressively more complex conceptual framework (Schmid & Telaro, 1990).

b.Meta-cognitive skill

Concept mapping can be viewed as an exteriorisation of a learner's

knowledge structure and McAleese (1985) considered the process of exteriorisation a meta-cognitive process because in so doing, the learner has to think about his underlying knowledge structures, to resolve inconsistencies, to make his understandings coherent and to explain understandings. Novak, Gowin and Johansen (1983) also believe that concept mapping results in meta-cognition as it assists learners in understanding concepts and relationships between them, and in seeing the hierarchical, conceptual, propositional nature of knowledge. In this way, a learner is aware of, and can control, the cognitive processes associated with learning.

c.Problem-solving skill

Fisher (1990) viewed the process of map construction as a problem-solving exercise. Similarly, Okebukola (1992) proposed that concept mapping training equips the learner with the skill of searching for patterns and relationships which happens to be an essential ingredient for problem-solving. Concept-mapping helps in increasing the total quantity of formal content knowledge but more importantly, it helps in organising such knowledge in a way that future application is greatly enhanced. It is possible that the students in the Partial Map group could better apply their knowledge in problem solving and therefore perform better in the achievement test.

Besides the process of mapping, the product of concept mapping (i.e. the concept maps) could also be useful to the students during their revision. Concept maps are superior to textual notes in that they are visual means of representing information. The visual nature of concept maps is more appealing than text and it activates both the spatial and verbal processing systems of a learner (Lehman, Carter and Kahle,1985). Concept maps could also assist the students in revision by reducing the burden on short-term memory. When the students refer to their concept maps for revision, information learned are not recorded in bits and pieces as in the traditional textual notes, but the relationships between concepts are explicitly linked and represented in two-dimensional graphical maps. This graphical representation could help to chunk the information, free the students of limited short-term memory and leave more capacity to apply their knowledge in answering the questions in the achievement test.

Theoretically, there are some potential benefits of providing learner with complete concept maps. The concept maps could function as advance organiser prior to learning. According to Ausubel, advance organiser is a small learning episode that is more general and more inclusive than the learning material that follows. It could facilitate the learning process by providing a conceptual framework for the learning that is to follow. In this study, however, it seems that the positive effects of concept mapping manifested only in the Partial Map group but not the Complete Map group. The Complete Map group only performed

slightly better (not significant) than the Menu-selection group.

One possible reason is that students in the Complete Map group might have perceived the concept maps only as topic-selection interface and did not actively process the information presented in the maps. There was no occurrence of "small learning episode" and the maps did not function as advance organiser. Besides, students in the Complete Map group did not perform the same level of mental processing of information compared to the Partial Map group. This finding is congruent with the results obtained by Jonassen and Wang (1993).

In this study, students generally showed favourable attitudes towards chemistry and towards CAI but no significant difference in attitudes towards chemistry and towards CAI were found among the three groups of students. It could also be due to the short treatment period since change of attitudes is unlikely to be effected over such a short period of time. However, there was some indication that concept mapping activities had an influence on the student's affective outcome. Many students in the Partial Map group requested to keep their concept maps after the treatment but no students from the other two groups had requested to keep their notes. Students in the Partial Map group claimed that they had put in a lot of effort in drawing the concept maps and they felt a strong sense of ownership of these maps. Many of them also felt that the concept maps could help them in the learning of the topic, organic chemistry, which was to be introduced in the formal curriculum some time after the study.

The result that the Partial Map group had higher concept mapping ability is as expected since the Partial Map group had more practices. Further analysis showed that the significant difference came from labelling of relationships between concepts. According to Novak (1984), a learner would have difficulty identifying the relationships between concepts and label the linkage if the concepts are not sufficiently differentiated. Thus, it could mean that students in the Partial Map group had higher ability in differentiating component concepts.

Significant correlation between concept mapping score and total score in Chemistry Achievement Test were found in the Partial Map group and the Complete Map group but not in the Menu-selection group. This results indicated that some relation could exist between concept mapping ability and achievement. This supports the claim that the significant difference in the performance in the Chemistry Achievement test was due to the concept mapping activities.

CONCLUSIONS

From the results of this study, it can be concluded that incorporating

concept mapping activity into computer-assisted instruction could have positive effect on student's performance in achievement test. However, it would be more beneficial to assign students the task of constructing concept maps after computer-assisted instruction than to provide students with complete concept maps. The beneficial effects of concept mapping activities on students could best be discerned by questions of Application Level rather than questions of Knowledge or Comprehension Levels, as classified in Bloom's taxonomy.

For a short treatment period, concept mapping activities seem to have no effect on student's attitudes towards the subject content or towards computer-assisted instruction.

It is also evident that for students with some concept mapping experience, there is a correlation between their concept mapping ability and their performance in achievement test.

Since the use of concept mapping in this study showed positive effects on some measurements and no negative effect was shown in any case, it is suggested that concept mapping is a good supplementary activity in CAI.

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