The effect of concept mapping on students' cognitive load

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ABSTRACT: The study described in this article examined whether or not concept mapping can be used to help students to reduce their learning cognitive load. The participants were 131 students from two classes enrolled in a food principles course at the School of Food and Beverage Management of a university in Taiwan. The experimental data revealed that adopting a concept mapping strategy can significantly reduce cognitive load. The results indicated that concept mapping can help the investigated students to understand and clarify concepts included in the curriculum, and also enhanced considerably their interests in studying food science.

INTRODUCTION

Food related technology has had a major impact on modern life and the work environment, including the move toward food technology-delivered instruction in universities [1]. Researchers have suggested that technical difficulties and a high cognitive load have the potential to disrupt the learning process. Researchers have also found that technological issues can have a negative effect on learning outcomes. Furthermore, technical difficulties increase students' frustration and have a negative effect on their satisfaction with the learning experience [2].

A major challenge in designing multimedia lessons, such as the electric motor lesson, is to be sensitive to the learner's cognitive load during learning. In particular, the curriculum should be designed so that the amount of cognitive processing required for learning at any one time does not exceed the learner's processing capacity [3]. Whereas the differentiation of instruction and curricula to meet the needs of diverse learners has become an expected practice at the elementary and secondary school levels, fewer such expectations exist in higher education [4].

Unfortunately, learning strategy instruction and teaching methods employed at the university level, even for students with identified disabilities, is not commonplace [5]. Researchers have posited that those college students who are at risk of learning failure might benefit from teachers' instruction, such as concept mapping.

Concept mapping is also regarded as a good technique for encouraging students' learning in a higher education setting in many countries. However, there have been relatively few research studies to evaluate the usefulness of concept mapping in university-level hospitality education courses. The goal of the current research was to address this gap by examining the effects of concept mapping as a teaching method and on students' cognitive load. In short, this study sought to:

- find out whether concept mapping reduce the cognitive load of students' learning in a food principles course within the School of Food and Beverage Management.

LITERATURE REVIEW

Constructivist Learning Theory

Based on Piaget and Vygotskian learning theories, constructivist activities mirror the way the mind gathers, assesses and retains information. Specifically, based on constructivist theory, understanding is gradually constructed through engagement with problems, issues and questions [6]. Hence, constructivism is a main educational idea and educational

innovation in every country [7]. Under the teacher's guidance, constructivism emphasises that a learner voluntarily explores and finds knowledge, as well as constructs known knowledge [8].

Concept Mapping

Concept mapping is a meta-learning strategy that can be used to develop students' capacity to learn independently. Much research on concept mapping has proved that it can improve meaningful learning and help learners to learn independently. A concept map is a graph structure containing nodes that are interlinked by labelled, directed arcs. Concept maps can be used as a knowledge representation tool to reflect relationships that exist between concepts that reside within an individual's long-term memory. When constructing a concept map, the focus is on the relationships between concepts [9].

Cognitive Load

Meaningful learning means that learners can integrate new knowledge into their existing networks of concepts and propositions in their cognitive structures. Cognitive load theory derives instructional design principles from aspects of the cognitive architecture. The theory assumes a very limited working memory, an effectively unlimited long-term memory and holding large numbers of schemas that can vary in their degree of automaticity.

This architecture interacts with instructional material in various ways [10]. Cognitive load is a multidimensional concept in which two components, mental load and mental effort, can be distinguished. *Mental load* is imposed by instructional parameters (e.g. task structure, sequence of information), and *mental effort* refers to the amount of capacity that is allocated to the instructional demands.

METHODOLOGY

This study adopted the quasi-experimental method, including both experimental and control groups. The experimental group participated in the concept mapping programme and the control group participated in regular instruction. In the experimental group, the teacher first explained why concept mapping is a useful tool for learning and how concept mapping can be used to show relationships between concepts and, then, spent an hour training students to draw concept maps in accordance with the procedures suggested by Novak and Gowin [11].

The teacher then taught from the textbook using teacher-constructed concept maps as the instructional medium. The above procedure was repeated until the end of the text content, lasting over an implementation period of 12 weeks. In the control group, the teacher gave an introductory lesson that included the objectives of the lesson and how to proceed and, then, taught from the textbook using teacher-made power-point teaching slides as the instructional medium. The implementation period was the same as for the experimental group.

Participant

The data assembled in this study came from 131 students from the School of Food and Beverage Management of a university in Taiwan. The study was carried out over one semester in food principles courses. One class of 64 students was randomly assigned as the experimental group; the other class of 67 students was used as the control group.

Instruments

A cognition load test (CLT) developed for the purpose this study was also used in the pre-tests and post-tests. This instrument was developed after considering the relevant literature [12]. It consisted of six constructs and a total of 24 items and was rated on a six-point Likert scale from *strongly low* to *strongly high*. The Cronbach Alpha coefficient of the instrument was 0.81 for the study sample. The instrument exhibited a high construct validity, with a part-whole correlation of 0.91 [13].

RESULTS AND DISCUSSION

Differences in Cognitive Load Test Scores

The results of the control and experimental group of cognitive load test scores by the students show the reduction of cognitive load. Table 1 presents *t*-value results to examine whether the concept mapping strategy contributes to the reduction of students' learning cognitive load. It shows that there was a significant difference ($t = 5.80$, $p < 0.01$) of *Mental load*; ($t = 5.79$, $p < 0.01$) of *Frustrate*; and ($t = 3.59$, $p < 0.01$) of *Total score* in the cognitive load test scores between the two classes.

In other words, the experimental class outperformed the control class. The result obtained seems to suggest that the concept mapping strategy more effectively reduces the students' cognitive load than the traditional teaching method.

Table 1: *T*-value and descriptive statistics of the cognitive load for the two classes.

Sub-structure	Class group	n	*t*-value	p
Physiological load	control	64	0.98	0.379
	experimental	67		
Mental load	control	64	5.80	0.004**
	experimental	67		
Difficulty	control	64	2.95	0.055
	experimental	67		
Frustrate	control	64	5.79	0.004**
	experimental	67		
Self-report performance	control	64	1.35	0.261
	experimental	67		
Time load	control	64	0.85	0.427
	experimental	67		
Total score of cognitive load	control	64	3.59	0.030*
	experimental	67		

*p ＜0.05; **p ＜0.01

CONCLUSIONS

The main objective of this study was to investigate whether or not the meta-learning strategy of concept mapping could be used to help students in the School of Food and Beverage Management to reduce their cognitive load in a food related technology course. Two classes in Taiwan were chosen to participate in the experiment.

The results showed that students in the concept mapping class reduced cognitive load more than did students in the traditional teaching class. These result findings are in agreement with earlier findings in other fields and disciplines, such as those included in the article by Chiou [14].

From the results of significant difference of concept map scores, one can assume that the whole experimental group was more positive about the usefulness of concept mapping in decreasing the learning load after they took the concept mapping course. This concept mapping course may help to understand the concept, structure and inter-relations of the curriculum content.

The reason why the students reduced their learning loads is because concept mapping helps in the integration of curriculum knowledge. The original intent of the concept mapping strategy was to facilitate students' independent learning and thinking. Furthermore, the results of students' reduced cognitive load, suggested that adopting the concept mapping strategy helped them reduce their frustration and mental loads during learning.

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