Effect of Novak Colorful Concept Map with Digital Teaching Materials on Student Academic Achievement

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**Abstract**

This study explores whether the Novak colorful concept map with digital teaching materials can enhance student academic achievement in learning Advanced Accounting. Four different teaching materials included conventional digital teaching materials (CDMs), Novak monotonic concept maps digital teaching materials (MCMDMs), hierarchical Novak colorful concept maps digital teaching materials (hierarchical CCMDMs) and clustered CCMDMs. Three major results were found in this study. First, the MCMDMs and CCMDMs can significantly improve student achievement than CDMs. Second, CCMDMs can significantly improve student long-term memory than MCMDMs and CDMs. Third, no significant differences exist in student achievement by using different coloring methods.

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**Keywords:** Advanced Accounting; colors; concept maps; constructivisit perspectives; higher education

**1. Introduction**

Different from the conventional rote learning, Ausubel (1963) suggested the assimilation theory of cognitive learning and proposed the human’s cerebrum and nervous system is an information-processing and information-storing system with the actively cognitive capabilities to receive and store messages. In virtue of the learning taken as a cognitive course including various processes such as advance organizer, superordinate learning, integrative reconciliation, subsumption, and progressive differentiation, Ausubel

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advocated the “meaningful learning”, i.e., the meaning of knowledge discovered by students themselves, and emphasized both the relationship between the new learning and the old experience existed in the inherent “cognitive structure” of an individual’s cerebrum and nervous system and the linking of new and old knowledge to embed new knowledge into the existing conceptual system. In consideration of an organizational structure composed of knowledge and experience inherent in the cerebrum with the concepts (or principles) categorized to abstraction, generality and inclusiveness on the top layer while specific or concrete instances on the lower layer (Lefrancois, 1988), Ausubel (1963) argued the top-down learning in which a student should first absorb the top-layered concepts with inclusiveness and generality, and then the lower-layered concepts, definitions or properties while the concrete or specific instances at the last.

Referring to the assimilation theory of cognitive learning proposed by Ausubel (1963), Novak and Gowin (1984), scholars of Cornell University, proposed the concept map as one tool for teaching, learning and evaluation in which students construct the integrated knowledge structure realized by scholars for diagnoses of misconceptions. Thus far the concept map has been extensively and well-effectively applied to teaching various academic disciplines such as Physics (Roth & Roychoudhury, 1993), Chemistry (Novak, 1984), Mathematics (Malone & Dekkers, 1984), Medicine (Laight, 2004), Language teaching (Carrell, Pharis, & Liberto, 1989) and Business education (Chiou, 2008, 2009).

As one basic unit to develop the human being’s senses and memories, colors possess superior expression and identifiability or psychological imagery effect (Davidoff, 1991). In contrast to monotonic teaching materials, colorful ones substantially attract student attention (Bacon & Egeth, 1997; Kaptein, Theeuwes, & van der Heijden, 1995; Pett & Wilson, 1996), effectively save time in searching information (Pett & Wilson, 1996; van Schaik & Ling, 2001), and promote student learning memory (Pett & Wilson, 1996; Schwier, Misanchuk, & Boling, 2000). In this regard, colorful teaching material, compared to the monotonic ones, is an instrument to improve the interaction between students and teaching materials and it can not only catch student attention but encourage student to learn more in a comfortable way (Pett & Wilson, 1996; Schwier et al., 2000; Tufte, 1990).

Despite concept maps and colorful teaching materials can significantly improve learning performance have been confirmed in the previous studies, studies about the impact on the learning performance by integrating these two teaching materials are rare. With the knowledge map and the display of colors integrated, Hall and Sidio-Hall (1994) studied college students and found that their learning memories receiving colorful teaching materials (both the knowledge map materials and conventional ones) were significantly superior to those receiving monotonic teaching materials.

Extending the theoretical basis of the Accounting Principles as well as the Intermediate Accounting, the curriculum of the Advanced Accounting contain consolidation accounting, accounting treatment for long-term equity investments based on the equity method, and the preparation of consolidated financial statements. To this end, student could complete the meaningful learning by linking the learned concepts for the Advanced Accounting to both the Accounting Principles and Intermediate Accounting previously comprehended (Ausubel, Novak, & Hanesian, 1978; Chiou, 2008). Basically, the concept map is characterized by linking two relational concepts to become one meaningful proposition (Chiou, 2008), for instance, the proposition of “consolidated Balance Sheet includes consolidated assets” connects two concepts of “consolidated Balance Sheet” and “consolidated assets” by the relation link of “includes”. In addition, the concept map is also a hierarchical structure (Novak, Gowin, & Johansen, 1983), for example, “consolidated Balance Sheet” (the most generalized concept of Advanced Accounting), “consolidated assets”, “parent company’s assets”, and “parent company’s current assets” (other lower hierarchical concepts with specific characteristics) which constitute a hierarchy. Furthermore, the cross link is one important property in the concept map learning because it displays a student breaking through his or her one-way thinking (Chiou, 2008, 2009). For example, two concepts, “parent company’s inventories” and
“subsidiary’s inventories”, connected by the cross link become the concept of “non-contra accounts combined in merger of a parent company and a subsidiary”.

Despite the concept map seldom cited in literatures of business education in contrast to other academic disciplines, it is applicable to business education but few studies verified its effectiveness instead (e.g. Chiou, 2008, 2009). Therefore, in consideration of few literatures studying student learning performance by integrating the concept map and colors with digital teaching materials, this paper intends to combine the Novak concept maps and the display of colors, and applies them into Advanced Accounting class.

In addition, the positive effects of colorful teaching materials on students’ learning performance have been demonstrated in previous studies (Bacon & Egeth, 1997; Kaptein et al., 1995; Pett & Wilson, 1996; Schwier et al., 2000) and current technology could well support display of colorful digital teaching materials (Durrett & Stimmel, 1982). However, research about the topic of effectively improving student’s learning achievement and long-term memory by the colorful digital teaching materials with the concept maps is wanting thus far.

To summarized, this study intends to investigate if student’s learning achievement and long-term memory for Advanced Accounting are improved with the digital teaching materials based on concept maps, and if there is any difference between digital teaching materials out of colorful concept maps and monotonic concept maps on student’s learning achievement and long-term memory.

2. Method

2.1. Participants and materials

Participants in this study were juniors in required Advanced Accounting classes from department of Accounting and Information in one private technical university in Taiwan. There were 120 students involved in this study of them 51 enrolled in day program and 69 in evening program. None of the students had any experience with concept map. The sample was 77% female. The teaching hours were two hours per week.

Four kinds of digital teaching materials were designed for different educational purposes and showed from Figure 1 to Figure 4. The conventional digital teaching materials (CDMs) were similar to textbook except for the digital format and illustrated in Figure 1. The monotonic concept maps digital teaching materials (MCMDMs) were designed according to concept maps theory with black and while colors in the digital format and illustrated in Figure 2.

The hierarchical Novak colorful concept maps digital teaching materials (hierarchical CCMDMs) were designed also according to concept maps theory with multiple colors in different hierarchical concept levels in the digital format and illustrated in Figure 3. The major difference between this teaching material and MCMDMs was the coloring method on hierarchical concepts and color selections were adjusted to computer screen following the suggestions of Heinich, Molenda, Russell, and Smaldino (2002). For example, light background with dark text and the combination of related colors were considered.

Figure 4 illustrates clustered Novak colorful concept maps digital teaching materials (clustered CCMDMs). It was also a digital teaching material with coloring based on individual clustered concepts and the coloring design was also following the suggestions of Heinich et al. (2002).
2.2. Experimental design

This study adopted randomized subject with unequalled pretest-posttest control group design. To minimize the differences in students’ accounting prior knowledge, we randomly assigned students into four groups in which 31 in CDMs, 29 in MCMDMs, 31 in hierarchical CCMDMs, and 29 in clustered CCMDMs.

Four treatments, CDMs, MCMDMs, hierarchical CCMDMs and clustered CCMDMs, were contained as four independent variables. Each group received identical lectures and pretest and took the same
posttest after self-learning by using different digital reviewing materials. Two dependent variables were short-term learning achievement and long-term memory.

2.3. Experimental process

Six phases were involved in this experiment. Phase one referred to official class period, the teacher taught chapter one to three using textbook lecturing method from week one to week five with two hours per week. In phase two, it took 30 minutes for students to finish Advanced Accounting pretests as a measurement of their accounting prior knowledge. In phase three, students were randomly assigned to four groups. Three groups, except for CDMs group, were explained how different concept map digital materials were used for 15 minutes. For example, MCMMDMs group was taught about the meaning of concept map, hierarchical CCMDMs group was taught both the meaning of concept map and hierarchical displayed by colors, clustered CCMDMs group was taught both the meaning of concept map and clustered displayed by colors. Students in each group should obtained fully understanding of the use and meaning in their digital teaching materials. In phase four, all students reviewed chapter from one to three by using their assigned digital reviewing materials as self-learning tools for 30 minutes. In phase five, after self learning stage, all students were administered an Advanced Accounting posttest for 30 minutes. In the last phase on week 13, seven weeks after phase five, four groups of students were again took the Advanced Accounting posttest two for 30 minutes to measure their long-term memories for the Advanced Accounting.

2.4. Instruments

An Advanced Accounting pretest was applied to evaluate the students’ initial accounting knowledge and posttest one and two were administered to measure the experimental effect on learning achievement. The original pretest contains fifty multiple choice questions, from chapter one to three, which developed from the National CPA (Certified Public Accountant) TEST sponsored by the Ministry of Examination of the Examination Yuan of ROC and the textbook exercise. Three chapters include: introduction of business combination, long-term investment and introduction of consolidation financial statements. The test was piloted by thirty-nine students of which thirty-three senior students from Department of Accounting at National Changhua University of Education and six senior students from Overseas Chinese University in Taiwan. Ten questions were eliminated after the pilot test and the final pretest was constructed with 40 multiple choice questions. The K-R 20 reliability coefficient of the instrument was 0.81 for the pilot sample used in this study. Posttest one (as the achievement test) and posttest two (as the long-term memory test) contain the same questions as the pretest of 40 final multiple choice questions. The K-R 20 reliability coefficients of the two instruments were 0.88 and 0.91 for the experiment sample used in this study.

3. Results

3.1. Effect of different digital materials on short-term learning achievement

The overall average scores in the pretest were 67.95 and the average scores for CDMs group were 69.47, the average scores for MCMMDMs group were 68.97, the average scores for hierarchical CCMDMs group were 67.74, the average scores for clustered CCMDMs group were 65.52. The overall average scores in the short-term learning achievement posttest were 77.65 and the average scores for CDMs group
were 70.00, the average scores for MCMDMs were 76.12, the average scores for hierarchical CCMDMs group were 82.82, the average scores for clustered CCMDMs group were 81.81.

This study explored the effect of different digital materials on students’ learning achievements. Students in four groups did not perform equally well in their pretest scores and this may interfere the result of this experiment. In this regard, a one-way analysis of covariance (ANCOVA) was applied. The pretest scores were the covariates and the posttest scores were the dependent variables.

A statistical significance was found in different groups in terms of various digital materials, $F(3, 115) = 12.24$, $p < .001$ (see Table 1). The result implied that different digital learning materials have significantly different effects on students’ Advanced Accounting posttest one scores.

LSD on post hoc comparisons showed that students performed significantly better in MCMDMs, hierarchical CCMDMs and clustered CCMDMs groups when comparing with CDMs group, $t(115) = 2.38$, $p < .05$; $t(115) = 5.18$, $p < .001$; $t(115) = 5.09$, $p < .001$ (see Table 1). In addition, students performed significantly better in hierarchical CCMDMs and clustered CCMDMs groups when comparing with MCMDMs group, $t(115) = 2.72$, $p < .01$; $t(115) = 2.69$, $p < .01$. However, no statistically significant difference was found between hierarchical CCMDMs group and clustered CCMDMs group, $t(115) = 0.02$, $p = .98$.

| Source of variation | SS    | Df  | MS   | $F$     |
|---------------------|-------|-----|------|---------|
| Model               | 6999.90 | 4   | 1749.98 | 16.31*** |
| Group               | 3940.65 | 3   | 1313.55 | 12.24*** |
| Pretest scores      | 3786.51 | 1   | 3786.51 | 35.28*** |
| Error               | 12341.30 | 115 | 107.32 |

### Post hoc comparisons

| Groups              | Difference in mean | $t$  |
|---------------------|--------------------|------|
| MCMDMs-CDMs         | 6.12               | 2.38* |
| hCCMDMs-CDMs        | 12.82              | 5.18*** |
| cCCMDMs-CDMs        | 11.81              | 5.09*** |
| hCCMDMs-MCMDMs      | 6.70               | 2.72** |
| cCCMDMs-MCMDMs      | 5.69               | 2.69** |
| hCCMDMs-cCCMDMs     | 1.01               | 0.02 |

Note. hCCMDMs=hierarchical CCMDMs; cCCMDMs=clustered CCMDMs. *$p < .05$. **$p < .01$. ***$p < .001$.

### 3.2. Effect of different digital materials on long-term memory

The overall average scores in the posttest two were 78.10 and the average scores for CDMs group were 71.94, the average scores for MCMDMs group were 76.09, the average scores for hierarchical CCMDMs group were 83.22, the average scores for clustered CCMDMs group were 81.21.

A one-way ANCOVA in which the pretest scores of the four groups were the covariates and their long-term memory test scores were the dependent variables was conducted. Table 2 shows that the main effect was significant, $F(3, 115) = 6.88$, $p < .001$, thus implying that with the exclusion of pretest scores, the four groups achieved significantly different scores in the long-term memory test.

Post hoc comparisons showed that no statistically significant difference was found between CDMs and MCMDMs groups, $t(115) = 1.43$, $p = .16$ (see Table 2). However, statistically significant better
performances existed in students’ long-term memories in Advanced Accounting for hierarchical CCMDMs and clustered CCMDMs groups when compared with CDMs group, $t(115) = 3.99, p < .001; t(115) = 3.52, p < .001$. In addition, students performed significantly better in long-term memories on hierarchical CCMDMs and clustered CCMDMs groups when comparing with MCMDMs group, $t(115) = 2.50, p < .05; t(115) = 2.07, p < .05$. However, no statistically significant difference was found in long-term memory between hierarchical CCMDMs and clustered CCMDMs groups, $t(115) = 0.39, p = .70$.

Table 2. Analysis of covariance in long-term memory test scores

| Source of variation | SS     | Df   | MS   | F     |
|---------------------|--------|------|------|-------|
| Model               | 4694.11| 4    | 1173.53 | 8.49*** |
| Group               | 2853.21| 3    | 951.07 | 6.88*** |
| Pretest scores      | 2304.05| 1    | 2304.05 | 16.68*** |
| Error               | 15888.53| 115  | 138.16 |

Post hoc comparisons

| Groups               | Difference in mean | t     |
|----------------------|--------------------|-------|
| MCDMs-CDMs           | 4.15               | 1.43  |
| hCCMDMs-CDMs         | 11.28              | 3.99*** |
| cCCMDMs-CDMs         | 9.27               | 3.52*** |
| hCCMDMs-MCMDMs       | 7.13               | 2.50* |
| cCCMDMs-MCMDMs       | 5.12               | 2.07* |
| hCCMDMs-cCCMDMs      | 2.01               | 0.39  |

Note. hCCMDMs=hierarchical CCMDMs; cCCMDMs=clustered CCMDMs. *p < .05. ***p < .001.

4. Discussions and conclusions

The purpose of this paper was to explore the effect digital teaching materials based on Novak colorful concept maps on improving student’s learning performance for the Advanced Accounting. For the above purpose, this study investigated if four kinds of digital teaching materials such as the CDMs, MCMDMs, hierarchical CCMDMs and clustered CCMDMs had difference in improving students’ short-term learning achievements and long-term memories.

In the case of the short-term learning performance, the Novak concept map digital material was verified to significantly improve students’ short-term learning achievements for the Advanced Accounting that was identical to the outcomes concluded in previous literatures (Chang, Sung, & Chiou, 2002; Chiou, 2008, 2009; Mass & Leauby, 2005; Simon, 2007).

Many scholars (Beasley & Waugh, 1995; Chang et al., 2002; Dias & Sousa, 1997; Huang et al., 2012; Lee & Baylor, 2006; Liu, 1994) showed that using an e-learning environment based on conventional linear digital material might create problems such as learning disorientation, cognitive overload and the inability to integrate knowledge structure, all of which can reduce students’ learning performance. Using the maps’ two-dimensional displays can reduce weaknesses in conventional linear teaching. Chang et al. (2002) found that using the maps’ two-dimensional displaying manner can reduce students’ problems of disorientation when browsing linear-structured material. Many scholars have applied maps and graphics for designing basic internet courses. Their study results indicated that internet material using graphic displays fashions can reduce problems of learning disorientation and improve learners’ learning outcomes.
Furthermore, graphic displaying can help learners to integrate knowledge structure (Chiou, Huang, & Hsieh, 2004; Cliburn, 1990; Huang et al., 2012; Novak, 1980; Novak, 1990; Ruiz-Rrimo & Shavelson, 1996). Concept maps display graphics based on educational psychology theories. Applying concept maps to structure teaching material enables knowledge to be structured and integrated in a hierarchical order. Many previous academic researches pointed out that this application can improve the design of course material and its means of presentation and thus promote students’ academic performance (Chang et al., 2002; Chiou et al., 2004; Coffey, 2007; Huang et al., 2012; Kennedy & McNaught, 1997; Komers & Lanzing, 1997). Therefore, the Novak concept map digital material can better assist students with their short-term academic achievements than can conventional linear digital material.

Many studies showed that colored visual picture is helpful for obtaining teaching goals (see Dwyer, 1978). In addition, colored teaching materials can not only improve students’ learning motivation and attention but also structure their perceptual and associative information, and thus with the recall of pictures can enhance and facilitate learning (Lamberski, 1980). Much of the literature has confirmed that colored teaching materials can effectively attract and manage student attention in contrast to monotonic teaching materials (Bacon & Egeth, 1997; Kaptein et al., 1995; Pett & Wilson, 1996; Schwier et al., 2000; Thurmon, 1974). Attention can influence the direction of eye searching and learning performance accordingly (Pett & Wilson, 1996; van Schaik & Ling, 2001). Therefore, the application of colors in teaching can assist learners in their cognitive learning, information recalls and enhance learning performance (Berry, 1977; Pett & Wilson, 1996; Schwier et al., 2000). Short-term memory is facilitated if the same color is used in related or chunking information when designing teaching materials. In this sense, through the systematic rehearsal, long-term memory could also be enhanced (Kemp & Smellie, 1989). In this study, colored teaching materials (hierarchical or clustered CCMDMs), in contrast to MCMDMs materials, were designed based on information chunk to enhance learning memory and performance.

Results of this study showed that hierarchical and clustered CCMDMs can better enhance long-term memory in contrast to MCMDMs and CDMs; however, no significant difference was found for MCMDMs and CDMs in enhancing long-term memory.

Long-term memory serves the function not only contains information but also processes and stores information by meaning of events with creative ideas and concepts. On the other hand, short-term memory processes and stores information based on the sequence of information arrived. Given that the characteristics of long-term memory, this study employs hierarchical CCMDMs by categorizing meaning of different concepts along with the depth of colors to illustrate the hierarchical relationship of concepts and the clustered relationship of concepts in clustered CCMDMs. Long-term memory can be enhanced by either of these teaching materials. Much of the literature has confirmed that colored teaching materials can effectively improve recalls (Berry, 1977; Pett & Wilson, 1996; Schwier et al., 2000). Colored teaching materials can also assist clustered concepts and hence enhance long-term memory (Kemp & Smellie, 1989). This study confirmed the aforementioned literatures that colored teaching materials could enhance learning and our results showed that both kinds of CCMDMs have better improve student long-term memory when compared with MCMDMs and CDMs.

As the first trial to investigate if a student’s short-term achievement and long-term memory for the Advanced Accounting are effectively improved with the concept maps and the display of colors integrated, this study comprises experiments for 120 college students. In contrast to pupils as subjects studied in research for colorful teaching materials (Hall & Sidio-Hall, 1994), this study contributes to both the concept maps studied and developed in a new scope and the progress of the higher education or the research in the education field.
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