Abstract. The technique of concept mapping has served numerous and diverse functions in education. Employed as a learning tool, concept mapping has been claimed to be effective both as a cognitive strategy to stimulate learners to make cognitive progress in organizing and understanding new information and as a metacognitive strategy to empower learners to monitor and control cognitive progress. The present study in this paper examined the effectiveness of concept mapping on the transferability of metacognitive skills in problem solving. Sixty-two students in an educational psychology course were randomly assigned to either a treatment group or control group. The results indicated that the use of concept mapping as a learning tool did not make any difference in the growth of the metacognitive skills between the two groups. The explanatory variables for such results are described.

Concept Mapping, a technique for externalizing concepts and propositions, was developed by Novak and his colleagues at Cornell University (Novak, 1979). The technique was at first used to study the changes in students’ understanding of science concepts. The investigator constructed the concepts and propositions described by students in a clinical interview or in a work sample (Novak, Gowing & Johasen, 1983). Later strategies were developed to help students construct their own concept maps. Since
its development, concept mapping has served numerous and diverse functions. It has evolved into a multifaceted tool in education (Novak, 1990a; Admaczyk, Wilson & Williams, 1994; Jonassen et al., 1997).

The various applications of concept mapping include its use as an instructional tool, an assessment tool and a learning tool. In order to develop a better organization and sequence in instruction, concept mapping has been used to define a content’s domain and organization in syllabus and curriculum planning (Starr & Krajcik, 1990) as well as content and task analysis (Jonassen, Tessmer & Hannum, 1989). Willerman and Mac Harg (1991) verify the effectiveness of concept mapping as an advance organizer at the start of a unit of instruction. Also, with its ability to reveal conceptual structures in learners’ mind, concept mapping has been proven to be a useful tool to assess the learner’s achievement (Wallace & Mintzes, 1990; Markham, Mintzes, & Jones, 1994) or detect learners’ misconceptions (Ross & Munby, 1991; Novak, 1990a; Novak, 1998).

Concept mapping, as a learning tool, has a sweeping applicability and has attracted considerable attention. Learners are asked to construct concept maps to represent their understanding in a domain and to continue to extend or redraw concept maps as they learn more about the domain along with the instruction. Employed as a learning activity, concept mapping has been claimed to be effective in two ways: As a cognitive strategy to stimulate learners to make cognitive progress in organizing and understanding new information (Novak, Gowin & Johnasen, 1983); and as a metacognitive strategy to empower learners to monitor and control cognitive progress (Jegede, Alaiymola & Okebukola, 1990; Trowbridge & Wandersee, 1994).
In order to support such claims, much research has investigated the effects of concept mapping. The research has focused primarily on how concept mapping affects both the learners’ acquisition of domain knowledge and their performance in problem solving. The instrumentation used in these studies has been mainly achievement tests whose items are located at the comprehension level and higher levels of Bloom’s taxonomy (1956) in the cognitive domain. However, the results of these assessments reflect either on the learner’s domain knowledge only or on both the learners’ domain knowledge and their metacognitive skills together. Thus, the effects of concept mapping on the learners’ metacognition alone has not been assessed with any certainty. This study, by attempting to assess the learner’s knowledge about one’s own cognitive resources and the learners’ self-regulation in the process of problem solving, aims to determine to what extent the use of concept mapping influences the transferability of the learners’ metacognitive skills in problem solving.

**Concept mapping and meaningful learning**

A major factor that gives rise to wide interest in concept mapping is that its theoretical power derives from Ausubel’s (1968) idea of meaningful learning. Ausubel (1968), in his assimilation theory of cognitive learning, postulated that meaningful learning is a process in which new information is related to an existing relevant aspect of an individual’s cognitive structure. As a hypothetical construct, cognitive structure is here referred to as the psychological structure of knowledge (Ausubel, Novak & Hanesian, 1978). The psychological structure of knowledge is the organization or relationships of concepts in memory. Quillian (1968) contends that human memory is organized
semantically and that the semantic networks in memory are composed of nodes and
labeled relationships, or links, connecting the nodes. The nodes are token instances of
concepts, and the links describe the prepositional relationship between the nodes.
Meaningful learning occurs when learners build a new knowledge structure by
consciously and explicitly constructing new nodes and interrelating them with existing
nodes and with each other. Moreover, Jonassen, Beissner and Yacci (1993) conceive
structural knowledge as the structure of how information within a knowledge domain is
organized, and state the importance of structure knowledge as a conceptual basis for
knowing why. The explicit awareness of those interrelationships and the ability to
explicate those relationships is essential for higher order, procedural knowledge, a type of
knowledge of knowing how.

Novak (1980) demonstrates how concept maps put into practice the theoretical
principles of Ausubel’s assimilation theory. Novak describes how, during the evolution
of a concept map, learners continually develop new propositions to elaborate and refine
concepts that the learners already know. The new and more specialized concept is
subsumed into more general concepts existing in the learner’s cognitive structure. Thus,
through such interaction with new learning, concepts are modified and integrated into a
progressively more complex conceptual framework. Okebukola and Jegede (1988) have
pointed out that Ausubel’s learning theory places central emphasis on the influence of
students’ prior knowledge on subsequent meaningful learning.

By explicitly identifying concepts and the relationships between concepts, concept
mapping facilitates the development of a learner’s representation of domain knowledge.
Also, in order to establish a nonarbitrary association between the new information and the
relevant concepts or propositions they already possess, learners are required to engage in an analytical process in which they evaluate, integrate and elaborate on their understanding in new ways during the construction of concept maps. In this reflective process, concept mapping becomes a way “to learn how to learn” (Novak & Gowin, 1984). It serves as a metacognitive tool to help learners take charge of their own meaning making.

Much research states that the determination of meaningful learning can be based on the learners’ comprehension of information and on their ability to use the new knowledge. These studies have investigated the power of concept mapping in this cognitive aspect of meaningful learning (Novak, Gowin & Johansen, 1983; Stevold & Wilson, 1990; Jegede, Alaiyemola & Okebukola, 1990). The studies have looked at the relationship between instructional use of concept mapping as a class activity and learners’ performance in achievement tests. For example, Jegede, Alaiyemola & Okebukola (1990) conduct a study on the effect of concept mapping on students’ achievement in biology. The results show that the experimental group achieved significantly better than the control group. The study suggests that the concept mapping strategy enhanced learning in biology more effectively than traditional expository teaching. Also, the concept mapping strategy led to a significantly greater reduction in anxiety level.

Horton et al. (1993) in their metaanalysis of nineteen studies has shown positive effects of concept mapping on students’ achievement, but the studies that investigated the effects of concept mapping on students’ achievement had mixed findings. To account for the differences in the findings, several studies have explored the interaction between concept mapping and student characteristics, such as cognitive preference (Okebukola &
Jegede, 1988; Jonassen & Wang, 1993), and verbal ability (Stensvold & Wilson, 1990). However, few studies have investigated the effects of concept mapping on the transferability of the learner’s metacognitive skills in problem solving.

Transfer and Metacognition

The key assumption underlying the idea of meaningful learning is that, if the new information is learned meaningfully, it can be better comprehended and better applied in a wide variety of new contexts or problems. In the terminology of Novak (1998), if learners learn meaningfully, the transferability of knowledge is high. According to Salomon and Perkins (1989), transfer occurs when previous learning affects subsequent performance on a different task. Whether what is learned can be applied across many settings or whether learning is always context-specific are issues raised about transfer. Mayer & Wittrock (1996) have reviewed different views of transfer. They put their emphasis on the approach of the specific transfer of general skills and the metacognitive transfer view.

From the point of view of the specific transfer of general skills, to promote transfer, learners should learn by understanding so they will be able to discover a principle or a relationship that can be applied to a different problem (Mayer & Wittrock, 1996). Concept mapping, as a tool to help learners organize their cognitive frameworks into more integrated patterns, has its theoretical strength in meaningful learning to empower learners with the ability to apply something learned in one situation to another. The metacognitive view holds that successful transfer occurs when the problem solver is able to recognize the requirements of the new problem, select previously learned specific and
general skills that apply to the new problem, and monitor their application in solving the new problem. Flavell (1976) defines metacognition as “one’s knowledge concerning one’s own cognitive process and products or anything related to them.” The definition classifies two aspects of metacognition: knowledge about cognition, and regulation of cognition. Knowledge about cognition concerns knowledge about one’s own cognitive resources, and regulation of cognition concerns self-regulatory mechanisms used by an active learner during ongoing attempts to solve problems. Concept mapping is claimed to engage a high degree of metacognitive involvement (Novak, 1990b; Jegede, Alaiyemola & Okebukola, 1990) because the learners are aware of and are active in their own knowledge construction.

**Problem Solving and Metacognition**

In this study, problem solving tasks related to the content learned are provided in order to establish a context for the learners to engage metacognitive processes. Problem solving, one of the unique human capabilities, is categorized as a learning outcome, in which the learners are able to selects and use rules to find a solution in a novel situation (Gagne, 1966). What learners acquires during the process of problem solving is a synthesis of other rules and concepts.

Mayer and Wittrock (1996) states that metacognitive processes in problem solving include assessing the requirements of the problem, constructing a solution plan, selecting an appropriate solution strategy, monitoring progress toward the goal, and modifying the solution plan. Thus, if concept mapping has facilitated meaningful learning for the learners to transfer their metacognitive skills from one situation to another, the
learners should be consciously aware of themselves as an active problem solver participating in these metacognitive processes in problem solving. Therefore, in order to verify such transfer, the learners are asked to introspect their own thinking after they participate in a problem solving task. The metacognitive ability is measured on the basis of their self-report. The metacognitive ability is expected to improve after the concept mapping instruction.

Methodology

Participants

Concept mapping can be used across different knowledge domains. However, much of the research has been done in science education. Therefore, this study has implemented concept mapping as a learning activity in a social studies subject to add variety to this body of research. Students enrolled in an educational psychology course at Penn State serve as subjects for the study. Initially sixty-two students in the course volunteered to participate in the research were randomly assigned into two groups: one control group and the other experimental group, though only 27 students in the experimental group and 22 students in the control group showed up in the pretest session. However, only 24 students in the experimental groups and 16 students in the control group completed the posttest session.

But, to ensure that all the participants did not have prior experience in constructing concept mapping, a question about individual experience in using concept mapping as a learning tool was posed in the pretest. It turned out that, among all 40 students, 7 students in the experimental groups and 9 students in the control group had
prior experience in constructing concept maps. In the end, only the data of 17 students in the experimental group and 7 students in the control group were usable for analysis.

**Materials**

The experimental group differs from the control group in that the former will be taught how to draw concept maps. Two time slots of training sessions on concept mapping were provided to accommodate students’ different schedules. In the training session, a handout with information about the definition and the uses of concept maps and an example of a concept map was distributed to students (see Appendix 1). The trainer then explained the basics of concept maps, such as what a concept and how the concepts are related to each other. After showing several examples of concept maps, the trainer constructed a concept map on the blackboard by inviting students to contribute their ideas. Later, students were given a topic on chocolate. Each student had to construct their individual concept map with identification of the concept words and the linking words. Two students were asked to draw their concept maps on the blackboard. Students compared the similarities and differences between two maps. After the training sessions, the experimental group participants were asked to construct their concept maps on the basis of their understanding of the information taught in the class.

For the purposes of this study, concept mapping as a learning strategy is the independent variable. The dependent variable is the learners’ metacognitive skills in problem solving. The instrument used to measure the metacognitive skills consists of 20 Likert-type statements with a five-point scale (See Appendix 2). The statements are developed based on Flavell’s (1976) definition of metacognition as knowledge about
cognition and regulation of cognition. Knowledge about cognition concerns use of strategies, and regulations of cognition includes planning, monitoring, and evaluating. The items are adapted from the writing of Schraw and Dennison (1994), and Fortunato, Hecht, Title and Alvarex (1991). Behind the administration of a pretest and a posttest on this self-regulatory inventory, there is an assumption that the metacognitive skills are developmental and the measures of such skills fall in a continuum.

**Procedures**

The data collection involves the administration of (1) a pretest that measures the independent variable: the metacognitive skills in problem solving, and (2) a posttest that measures the dependent variable again after a week. Although the pretest might produce threats to internal and external validity, it is used here to detect the initial differences between the two groups.

A pretest-posttest experiment with cluster sampling assignment of subjects to experimental and control groups were employed to examine any possible treatment effects due to exposure to concept mapping. The main analysis of data in this study concerns the group differences in performance on the metacognitive skills in problem solving related to the concept mapping activity. Analysis of Variance (ANOVA) will be employed, in which the effects of different treatments on the dependent variable will be examined by the group differences in the gains of the posttest against the pretest. The statistical significance of the contribution to metacognitive skills of learning treatments was tested.
Results and discussion

The data for the study were analyzed using the Minitab statistical software package. The means and standard deviation of the pretest and posttest scores on metacognitive skills of the experimental and control group subjects are reported in Table 1.

Table 1

Pretest, Posttest, and Gain Scores of Metacognitive Skills in the Experimental and the Control Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest Mean</th>
<th>Pretest SD</th>
<th>Posttest Mean</th>
<th>Posttest SD</th>
<th>Gain Mean</th>
<th>Gain SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept Map</td>
<td>66.41</td>
<td>10.28</td>
<td>70.94</td>
<td>10.30</td>
<td>4.53</td>
<td>10.22</td>
</tr>
<tr>
<td>(N=17)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>69.29</td>
<td>9.76</td>
<td>73.86</td>
<td>6.59</td>
<td>4.57</td>
<td>8.28</td>
</tr>
<tr>
<td>(N=7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

A preliminary one-factor ANOVA test revealed no significant difference between the mean gain scores on metacognitive skills of the experimental and control groups (F(1,22)=0.00, p>0.05). In fact, according to Table 1, the mean of the gain scores in the control group was higher by 0.04 than that in the experimental group.
In order to examine why there was no significant difference between the mean gain scores in two groups, two more analysis procedures were conducted. In the posttest, a question was asked about whether students actually used concept mapping as a learning tool during the time period between the pretest and the posttest. The results of the answers were not expected. In spite of not having training sessions, four students in the control group practiced the method of concept mapping on their own during the treatment week. The influence of practice on metacognitive skills was examined. The means of standard deviation of the gain scores on metacognitive skills with practice and no practice in the experimental and control group subjects were computed. The results are reported in Table 2.

The second analysis procedure was a 2 (practice, no practice) x 2 (experimental, control) ANOVA on the gain score. The main effects due to practice were found to be nonsignificant ($F_{(1,20)}=0.06, p>0.05$). However, among the subjects in the experimental group, the mean gain score of those who practiced is higher by 5.00 than that of those who did not practice. The interaction effects of practice and concept mapping were also found to be nonsignificant ($F_{(1,20)}=1.92, p>0.05$). By inspecting the graph of the interaction effects (Figure 1), the unparalleled lines showed the interaction was present. To the subjects of the control group, practice had negative effects. Students who practiced in the control group had the mean gain score of 1.5, which is much lower than the mean gain score of 8.67 of students who did not practice in the same group.

Table 2
Gain Scores of the Experimental and the Control Groups by Practice

<table>
<thead>
<tr>
<th>概念</th>
<th>实践</th>
<th>sd</th>
<th>n</th>
<th>控制</th>
<th>sd</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>概念映射</td>
<td>6.87</td>
<td>8.81</td>
<td>9</td>
<td>1.87</td>
<td>11.61</td>
<td>8</td>
</tr>
<tr>
<td>控制</td>
<td>1.50</td>
<td>8.39</td>
<td>4</td>
<td>8.67</td>
<td>7.51</td>
<td>3</td>
</tr>
</tbody>
</table>

进一步分析了在实践和无实践组中学生的元认知技能表现。表3报告了预测和后测元认知技能分数的平均值和标准差。单因素ANOVA测试显示，实践和无实践组的元认知技能平均得分之间没有显著差异（F(1,23)=0.14, p>0.05）。然而，根据表3，实践组的平均得分比无实践组的平均得分高1.50。
Interaction Effects of Practice and Concept Mapping

Table 3

Pretest, Posttest, and Gain Scores of Metacognitive Skills in Practice and No Practice Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest</th>
<th></th>
<th>Posttest</th>
<th></th>
<th>Gain</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Practice (N=13)</td>
<td>68.85</td>
<td>8.09</td>
<td>74.08</td>
<td>8.22</td>
<td>5.23</td>
<td>8.72</td>
</tr>
<tr>
<td>No Practice (N=11)</td>
<td>65.36</td>
<td>12.03</td>
<td>69.09</td>
<td>10.20</td>
<td>3.73</td>
<td>10.75</td>
</tr>
</tbody>
</table>

Interaction Plot - Data Means for Gain
The major purpose of this study was to investigate whether the use of concept mapping as a learning tool has effects on the transferability of metacognitive skills in problem solving. However, in this study, no significant difference was found in the metacognitive skills performance of the subjects between the experimental and the control groups. Does this mean concept mapping as a learning tool does not have effects on the transferability of learners’ metacognitive skills? If we look at the gain scores of the students who used and practiced concept mapping for their studies, the group who used the method of concept mapping still have higher gain scores than the group who did not use the method of concept mapping.

In this study, the student’s brief experience with concept mapping and the internal threat of the experimental diffusion interfered with the results of the study. The control group adopted the method of concept mapping. Also the small sample size made it hard to detect the difference if there is any. A long-term study with a larger group of subjects might result in substantial effects of concept mapping on the learners’ metacognitive skills in problem solving.
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