THE CONCEPT MAP: A POWERFUL COGNITIVE TOOL

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Abstract

This paper emphasizes the importance of active cognitive participation of the learner during learning. Learning is viewed as an active, constructive, cumulative, self-regulated and goal-oriented process in which the learner plays a critical role. The way the learner processes new information determines the quality of learning. Concept mapping is cited here as an example of a learning tool that engages the learner actively in cognitive processing of knowledge during learning. The benefits of both the process and product of concept mapping are discussed. The theoretical basis and research findings attesting to the efficacy of concept mapping as a learning tool are also presented.

Introduction

What is learning? Is learning the mere accumulation of information by the learner or should there be more to it? What cognitive operations should the learner engage in during the learning process so that there is efficient assimilation, retrieval and application of knowledge? Recent findings from research on learning and memory show that for learning to be effective, the learner must be actively involved in the learning process (Shuell, 1993; Matlin, 1994). Learning is now considered to be an active, constructive, cumulative, self-regulated and goal-oriented process in which the learner plays a critical role.

Learning is active in that the learner must carry out cognitive operations on the newly presented information. The way the learner processes the information determines the quality of learning. According to Shuell (1987, p. 243), "what and how much an individual learns depends on the activities in which he or she engages; learning involves more than passively responding to the environment". Performing cognitive operations such as semantic processing, analyzing, and organizing information enhances learning. Learning is constructive in that new information must be elaborated upon and related to other information. Learning involves the construction of knowledge as new ideas are integrated with prior knowledge. Learning is cumulative in that all new knowledge builds upon and utilizes the learner’s prior

knowledge in ways that determine what and how much is learned. Learning as a process of building upon the knowledge base was emphasized by Ausubel (1968) when he said "The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly". Learning is self-regulated in that the learner must have the capability to mobilize, direct and sustain his or her learning efforts towards achieving a goal. Finally, learning is goal-oriented in that it is most likely to be successful if the learner is aware of the goal toward which he or she is working and possesses expectations that are appropriate for attaining it. Efforts made to translate these new conceptions of learning into classroom practices include development of instructional methods that will engage the learner actively in the process of knowledge acquisition. Concept mapping is one of the tools towards this end.

Concept Mapping

What is a Concept Map?

A concept map is a schematic device used to enable the learner to explicitly represent a number of concepts and their interrelationships. A concept map in its simplest form consists of just two concepts connected by a linking word to form a proposition. For example, "sky is blue" is a proposition consisting of two concepts, "sky" and "blue", and a linking word "is" (Novak & Gowin, 1984). Propositions therefore consist of two or more concepts semantically linked together by linking words. A complex concept map consists of many concept labels embedded in a framework of propositions. The terms "chunks" or "clusters" is generally used to refer to groups of superordinate and linked subordinate (at least two) concepts. "Cross-links" refer to meaningful connections between one segment of the concept hierarchy and another segment, that is, between concepts belonging to different clusters in the map.

What is Concept Mapping?

Concept mapping is the process of organizing concepts and relationships between concepts in a hierarchical manner, from more inclusive concepts to more specific, less inclusive concepts (Novak & Gowin, 1984). Concept maps are hierarchical in that the more general, more inclusive concepts are at the top of the map, with progressively more specific, less inclusive concepts arranged below them.

The concept mapping activity usually starts off with the student either being given a list of ranked (general to specific) concept words (in the case of primary school students) or being asked to identify key concepts in a passage and rank them in the general to specific order (for the older students). This is then followed by the students getting down to creating the concept map, either working with the teacher, with friends, or individually. The most general or main concept is located at the top of the page, followed by the concepts subordinate to it, while the more specific concepts are placed at the bottom of the concept map. The concepts are placed in ovals and are connected by suitable linking words to form meaningful propositions. Students are encouraged to look for cross-links between concepts in different clusters of the map. Arrows are used to indicate cross-links. Novak and Gowin (1984) emphasized that concept maps need to be redrawn. The first concept map a person makes is bound to have flaws: some concepts which can be cross-linked may be in opposite ends of the

map and there may be mistakes in the spelling and hierarchical organization of concepts. Redrawing the concept map therefore helps to reduce clutter or crowding, resulting in better placement of concepts and ensures spelling mistakes and wrong linkages are corrected. Students should be encouraged to do at least a second revision of their concept maps.

Apart from the paper-based concept mapping described above, students can also do concept mapping on computer. A number of computer-based concept mapping programs such as Inspiration (Ceres Software) and Learning Tool (Arborworks Software) are now available to help learners organize knowledge in an electronic environment. Computer-based concept mapping makes it easier for learners to create and modify concept maps. However, this kind of concept mapping is limited by the availability of technology and its associated costs and complexities. Paper-based concept mapping may be a tedious process, but it gives the mapper freedom to work at any time and in any place.

The Theoretical Basis for Concept Mapping

Concept mapping was developed by Novak and his team of researchers at Cornell University, Ithaca, New York. The concept-mapping tool evolved over a five-year period of theory-driven research centered on developing better teaching-learning activities to help students "learn how to learn". Concept mapping was developed based on two important ideas in Ausubel's (1968) Assimilation theory of cognitive learning:

1. Most new learning occurs through derivative and correlative subsumption of new concept meanings under existing concept or propositional frameworks. Learning that is meaningful involves reorganization of existing beliefs or integration of new information with existing information.
2. Cognitive structure is organized hierarchically, with new concepts or concept meanings being subsumbed under broader, more inclusive concepts.

The meaning of any given concept is dependent not only on the number of relevant relationships we perceive but also on the hierarchy (inclusiveness) of those relationships in our conceptual framework. The hierarchical organization of concepts in a concept map is supposed to reflect the hierarchical organization of knowledge in cognitive structure while links between concepts demonstrate the manner in which new concepts are integrated with existing knowledge structure. This view of knowledge representation in long-term memory is parallel to that of Collins and Quillian's 1969 Hierarchical Network Model (cited in Matlin, 1994), which proposes that concepts are stored hierarchically with meaningful associations between superordinate and subordinate concepts.

Concept Mapping as a Learning Tool

Concept mapping has been found to be an effective learning tool through both the process of map construction (Fraser & Edwards, 1985; Jegede, Alaiyemola & Okebukola, 1990; Mason, 1992; Pankratius, 1990; Schmid & Telaro, 1990) and the product, that is, the completed map (Malone & Dekkers, 1984; Roth & Rodchoudhury, 1993; Willerman & Mac Harg, 1991). This is because:

1. The concept mapping process

- Requires deep-level, semantic processing of information. As students identify concept meanings and analyze relationships between concepts, they are engaging in a deeper level of information processing than when they are transcribing, memorizing or recalling information. According to Craik and Tulving (1975), deep-level processing promotes duration of memory, ease of retrieval from memory, and ability to apply knowledge in new situations.
- Engages the learner in cognitive construction of knowledge. During concept mapping, the learner has to make sense of concepts through relating new concepts with prior concepts and then organizing the concepts hierarchically to form an integrated, coherent framework of the material learned. This is believed to promote meaningful learning (Novak, 1990).

- Helps the learner to organize knowledge in meaningful related chunks. This ensures better knowledge organization in memory and facilitates retrieval. Organizing knowledge into meaningful chunks also increases working memory capacity, which in turn, leads to more efficient problem solving.

> *"A scientist must organize. One makes a science with facts in the same way that one makes a house with stones; but an accumulation of facts is no more a science than a pile of stones is a house."*
>
> Henri Poincare

- Engages the learner in alternate bottom-up processing of information (identifying concept meanings, forming relationships between concepts) and top-down processing of information (able to see general patterns in the completed map, resulting in generalized schemata for certain concepts). This shift back and forth between top-down processing and bottom-up processing is believed to promote meaningful learning (Fisher et al., 1990).

- Helps the learner to realize that learning is an individual responsibility one must accept and which cannot be shared. The process of concept mapping ensures that the learner expends more effort and time to think deeply and clear any fuzzy ideas on the subject matter studied.

2. The product, the completed map, can be used

- As an advance organizer to motivate students to organize knowledge systematically and as reference maps to understand the text better. Willerman and Mac Harg (1991) found that using concept maps as an advance organizer produced a significant increment in students' achievement in physical science.

- As an aid to memory. When a person has constructed the map, it can facilitate recall of information through visual imagery of the completed map. However rote-memorization of concept maps is NOT to be encouraged as to do this would be to do the very opposite of what concept mapping is intended for.

- For cognitive assessment. Concept maps are remarkably effective tools for showing misconceptions, as they are an explicit representation of a person's understanding of a particular domain or topic. Concept maps generated prior to or after a topic has been taught can give both the teacher and student an idea of how much the student knows about the topic. Malone and Dekkers (1984, p. 231) aptly described concept maps as "windows to the mind" of students, "for seeing in (by the teacher and other students), for seeing out (by the student) and for reflecting on one's own perceptions (by everybody)".

Concept mapping therefore is a tool that requires the learner to understand concept meanings, sort and group concepts, organize concepts hierarchically, and assemble overviews of the topic. As the learner does this, he is using cognitive strategies such as organizational strategies (sorting, grouping, developing hierarchies, constructing networks) and elaboration strategies (summarizing, creating analogies) (defined by Weinstein & Mayer, 1986). The use of such cognitive strategies have been found (Chi, Leeuw, Chiu & Lavancher, 1994; Lonka, Lindblom-Ylainne & Maury, 1994; McCrindle & Christensen, 1995) to produce better learning.

A review of the literature on concept mapping shows that it is indeed an effective learning tool especially for the learning of science concepts. There have been many documented studies that show a positive relationship between concept mapping and improvement in science achievement. These studies were conducted in various settings, ranging from the elementary school level to the college level. These studies examined the use of concept mapping in the learning of various content areas such as biology (Heinze-Fry & Novak, 1990; Schmid & Telaro, 1990; Wong, 1997), chemistry (Stensvold & Wilson, 1990), physics (Pankratius, 1987), and physical science (Willerman & Mac Harg, 1991). In most of these studies the concept mapping strategy has been found to have tremendous capacity for helping learners cope adequately with the demands of learning different science concepts.

Conclusion

Concept mapping is a powerful strategy that requires learners to participate actively in the process of building their knowledge base. It requires the learner to make an effort to understand concept meanings, organize concepts hierarchically and form meaningful relationships between concepts to form a coherent, integrated network of the material learned. Engaging the learner in such constructive and transformative cognitive operations during learning enhances memory and recall for the material learned. The use of concept mapping as a learning tool should therefore be more widely encouraged.

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