



# Learning, Creating, and Using Knowledge: Concept maps as facilitative tools in schools and corporations

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For more than half a century, my students and I have sought to understand why some learners acquire a deep, meaningful understanding of materials studied, whereas others have only a superficial grasp of the information presented. Often the latter kind of student had high school grades and high standardized test scores. What appeared to underlie the differences in these two groups of students was the differences in the way they approached learning of subject matter. Unfortunately, as a graduate student at the University of Minnesota in the 1950's, the only learning psychology taught was behavioral psychology, and this largely sought to remove meaning from learning experiments, either by using animals, nonsense syllables, paired-word associations, or other material that would not "contaminate" experiments due to the almost idiosyncratic nature of learner's meanings of concepts or ideas. I thought then that behavioral psychology had essentially no relevance to human learning of the kind I was interested in. Fortunately for our research group, Ausubel's assimilation theory of meaningful learning was published in 1963, and this provided a solid theoretical foundation for the work we were interested in doing.

The key idea in Ausubel's theory is the distinction between learning by rote versus learning meaningfully. When learning by rote, no effort is made to relate

new ideas with relevant existing ideas in cognitive structure. In meaningful learning, the learner chooses to integrate in some substantive way new concepts and propositions with existing relevant ideas in her/his cognitive structure. Ausubel calls the latter process subsumption, since the new knowledge is subsumed into existing concept and propositional meanings. Occasionally a learner acquires a more general, more abstract concept that subsumes more specific related concepts in a process Ausubel calls superordinate learning. The process of meaningful learning builds an integrated framework of concepts and propositions organized hierarchically for a given domain of knowledge. Building expertise requires a continuous process of meaningful learning. There is also a positive affective dividend in meaningful learning in that the learner feels in control of the knowledge acquired and capable of using this knowledge in problem solving or facilitating further meaningful learning. The latter is strong positive intrinsic motivation for the learner, in contrast to the extrinsic motivation that derives from rote learning where the primary dividend is a high test score. Moreover, knowledge acquired

meaningfully is usually retained longer, functions to facilitate future learning and can be used in novel problem solving or creative thinking.

Another important development that occurred in the 1960's was a movement from positivistic epistemologies rooted in Baconian ideas to constructivist epistemologies based on the work of Conant (1949), Kuhn (1962), and Toulmin (1972) and others. Constructivist epistemologies see knowledge creation as a human creation rooted in a social context that affect the kinds of hypotheses constructed and the research methods used. Our research group saw a close parallel between constructivist epistemological ideas and Ausubellian ideas on human learning. In time, we described an epistemology I called Human Constructivism (Novak, 1987; 1993).

Throughout my graduate work in the sciences and in education, I was struck by the sharp contrast between research in education and research in the sciences. Whereas research in the sciences was guided by solid theoretical foundations and relevant methodologies, research in education either lacked any theoretical foundation or claimed theories that were dubious at best and had little explanatory power. The research tools used in educational research likewise had dubious validity and results from studies were often contradictory. It seemed to me that educational research and practice could be improved if a stronger theoretical foundation could be developed. My first effort to present a theory for education was published in 1977 (Novak, 1977) and this was modified and expanded in 1998 (Novak, 1998). This theoretical foundation served to guide our research and instructional innovations and also led to the development of a new tool we called the concept map.

My theory of education, as presented in 1998 and further refined in 2010

(Novak, 2010) built on the ideas of Schwab's (1973) four commonplaces of education and added a fifth idea, evaluation. Because these commonplaces, cannot be reduced or subsumed by others, I chose to call them elements of education. Somewhat analogous to elements in chemistry, my five elements of education could be combined in an infinite number of ways, many of which would be ineffective and some of which could be highly effective. The five elements of education I proposed were: learner, teacher, knowledge, context, and evaluation. My theory described the learner element essentially along the lines of Ausubel's assimilation theory, with some updating based on our research and other relevant research. The knowledge element was described based on what I call human constructivism (Novak, 1993) and views knowledge as largely concept/propositional in structure with new knowledge construction occurring as a process of high levels of meaningful learning by creative people. The teacher element was presented to include any event where a learner is guided in acquiring new meanings, including vicarious teaching such as is common in e-learning. The context element was described to include not only the structure of a specific learning event but also the multiple levels of physical and social environment in which the learning event occurs. Finally, evaluation serves to inform the learner and the teacher as to how well the new meanings were acquired and/or applied.

For all of these five elements, the primary criterion of effectiveness is the extent to which the element empowers learners to be more effective in the near term and through life. Consequently, my theory of education can be summarized as:

*Meaningful learning underlies the constructive integration of thinking, feeling, and acting leading to empowerment for commitment and responsibility.*

It is not easy to determine if a learner has acquired meanings for new concepts and propositions. Piaget (1926) pioneered the use of structured interviews to ascertain children's beliefs, and we have also found structured interviews to be of value. However we also found that it was difficult to ascertain explicitly what concepts and propositions were being acquired when children studied science. The need to show explicitly how new concepts and propositions were integrated into the learner's cognitive structure led to the development of the concept map tool in the early 1970's (Novak, 1977; Novak & Musonda, 1991). Subsequently we found that concept maps could help students learn how to learn (Novak & Gowin, 1984), capture explicit and tacit knowledge held by experts, assist in the design of instruction, facilitate creative work in every discipline, and facilitate improvement of management and marketing methods. It is not often that a tool comes along that can be used from pre-school through

adult learning in any discipline. Just as new research tools have made possible new kinds of research studies in the sciences, the concept mapping tool has made possible new studies of human learning in any context. Some of these studies have been reported in three international conferences on concept mapping, and these papers can be seen at: <http://cmc.ihmc.us>

In the second edition of *Learning, Creating, and Using Knowledge*, I sought to extend examples pertinent to corporations as well as to add some new insights into how my theory of education could be applied in school and corporate settings. It was interesting to me that I found few new ideas presented in recent business and management literature, or in most educational literature. I see this as indicative of practices that largely do more of the same kind of things, and the results are largely more of the same limited value. However, there were some exceptions. For example, Otto Silesky, principal of a secondary school in Costa Rica, and his staff sought to apply ideas from our work and the concept mapping tool in all subjects in all grades. Their first year (2003) with this effort proved that changing teaching patterns and student learning patterns toward more meaningful learning was not easy, and in fact the percentage of students passing State exams that year declined. Nevertheless, teachers and students felt that good things were happening with the new emphasis on meaningful learning and they agreed to continue with the new program. Figure 1 shows that not only did the percent passing State exams improve the second year, but in following years, 100% of the students passed these exams. Moreover, students gained much more than that assessed on typical State exams; they also felt more confident in their abilities and less stressed in school learning, and more confident in their ability to pursue college studies. What Silesky and his colleagues demonstrated is exactly what my theory of education predicted.

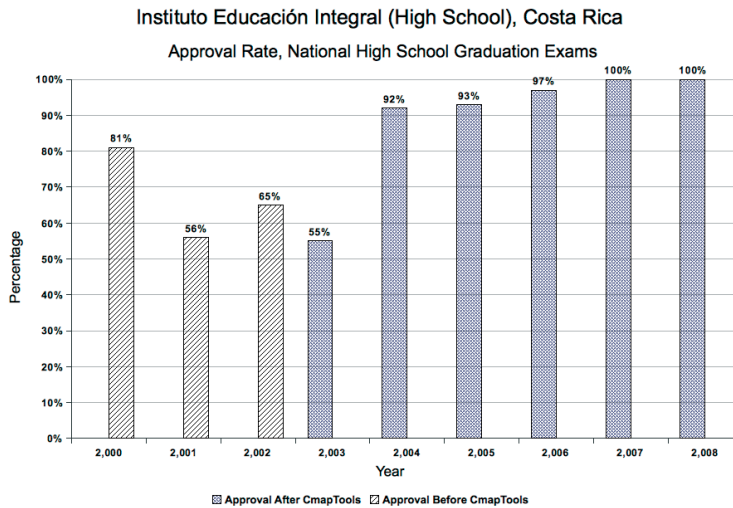


Fig. 1 - Percent of high school students passing State exams before and after introduction of concept mapping and other meaningful learning practices. (From Novak, 2010, page 10)

Over the past decade, there has been further improvement of software for producing concept maps by the Florida Institute for Human and Machine Cognition. This software, CmapTools, also allows easy search for pertinent digital resources on the WWW, and these resources can be added to a concept map by simply dragging and dropping the icon for the resource to any concept. The resource becomes part of the file for the concept map stored on a server and can be retrieved by clicking on the icon for a type of resource and selecting the desired resource. Figure 2 illustrates a concept map with resource icons attached, and insets illustrate some of these resources when opened. When setting up a folder for new concept maps. CmapTools provides the option of creating a “Knowledge Model”. When concept maps and resources are stored in a Knowledge Model folder, they transfer along with the concept maps if transferred to another folder or to another server.

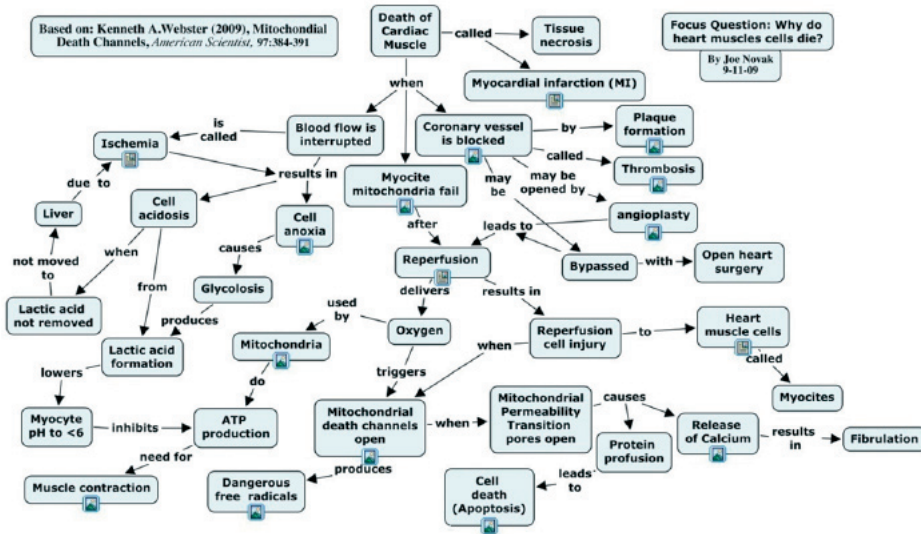


Fig. 2 - A concept map prepared to present ideas dealing with mitochondrial death channels as a factor in heart attack. Icons show related resources that illustrate and elaborate on concepts presented that can be accessed by clicking on the icons.

While there are other knowledge representation tools, such as Ven diagrams and Mind Maps (Buzan, 1974), concept maps in the form that we developed them rest on a solid theory of learning and theory of knowledge that buttresses their use and help to design new applications. CmapTools software was designed to greatly facilitate construction of our kind of concept maps with the patented feature of easy resource attachment. Moreover, the excellent CmapTools software is available at no cost to any user (<http://cmap.ihmc.us>).

### A New Model for Education

Over the past decade, there has been enormous development of the WWW, low cost, greatly increased computer capability, and increased Internet bandwidth. These capabilities provide for a new way to organize and deliver learning experiences that allow for the coordinated and integrated use of all instructional approaches into a new synthesis we call a New Model for Education. Professor Cañas, who led the team developing CmapTools, and I put forward this New Model for Education that builds on the capabilities of CmapTools to create concept maps that can serve as a “backbone” for a learner’s emerging knowledge model for any given domain of study (Novak & Cañas, 2004). All of the usual educational activities can be combined and integrated through an

evolving concept map. The result is the creation of a digital portfolio for a domain of knowledge that can be preserved and serve to scaffold future learning in the domain. This is illustrated in Figure 3.

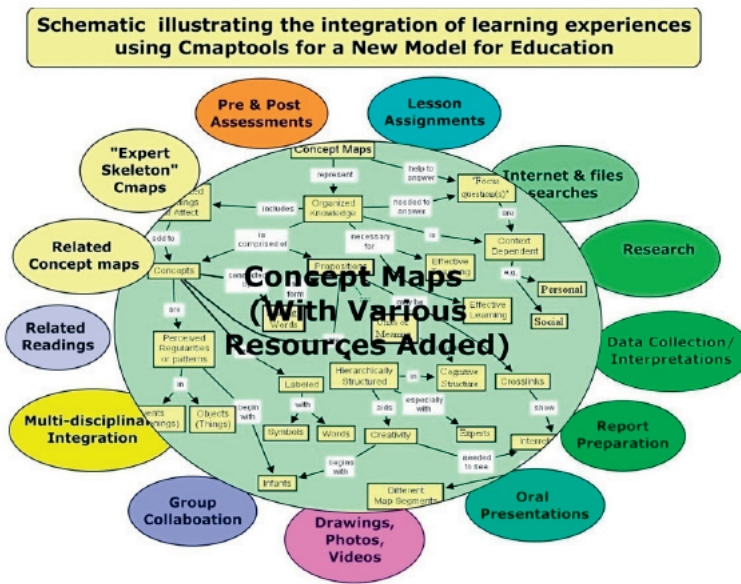


Fig. 3 - Schematic showing that a New Model for Education builds on the use of CmapTools to develop a digital knowledge portfolio incorporating all forms of instruction using a concept map as a “backbone” and integrating tool.

One of the ideas introduced in our New Model is the use of “expert skeleton” concept maps to serve as a starting point. Expert skeleton concept maps are prepared by an expert in the knowledge domain to guide and “scaffold” learning. The idea of scaffolding learning has gained increased prominence in the past decade and is one of the metacognitive tools teachers can use to facilitate meaningful learning. Expert skeleton concept maps help learners begin the process of meaningful learning in a given domain, and they can also serve as Ausubelian advance organizers to facilitate integration of new concepts and ideas with the learner’s existing relevant knowledge. Figure 4 shows an example of an expert skeleton concept map without and with a “parking lot” of suggested additional concepts that might be incorporated into the map (A and B, respectively). Starting a concept map for a new knowledge domain can be a bit frightening for a learner, and expert skeleton concept maps help to ease the learner into study of a new domain. In addition, learners often have

misconceptions or faulty ideas about many domains of knowledge and these misconceptions can interfere with new learning. Scaffolding early learning can help to overcome the deleterious effects of misconceptions and improve the chances that misconceptions will be remediated (Novak, 2002).

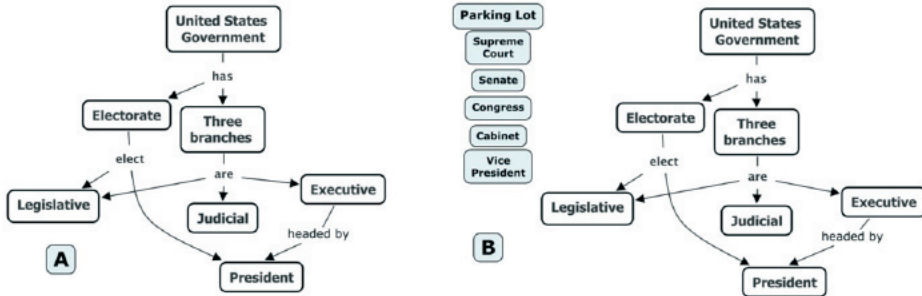


Fig. 4 - Two examples of “expert skeleton” concept maps with B showing a “parking lot” of suggested additional concepts that the learner can consider to incorporate into the skeleton concept map.

The second edition of Learning, Creating, and Using Knowledge further describes our New Model and also provides additional examples where efforts are being made to implement this model in school settings. The model is also being implemented in some organizations and in corporate settings. Bowen and Meyer (2008) have shown how the New Model has been helpful in for The New Teacher Alliance for a teacher improvement program in Washington State. Figure 5 shows a concept map developed collaboratively by the Alliance. Icons on the map open up various resources assembled by the team.



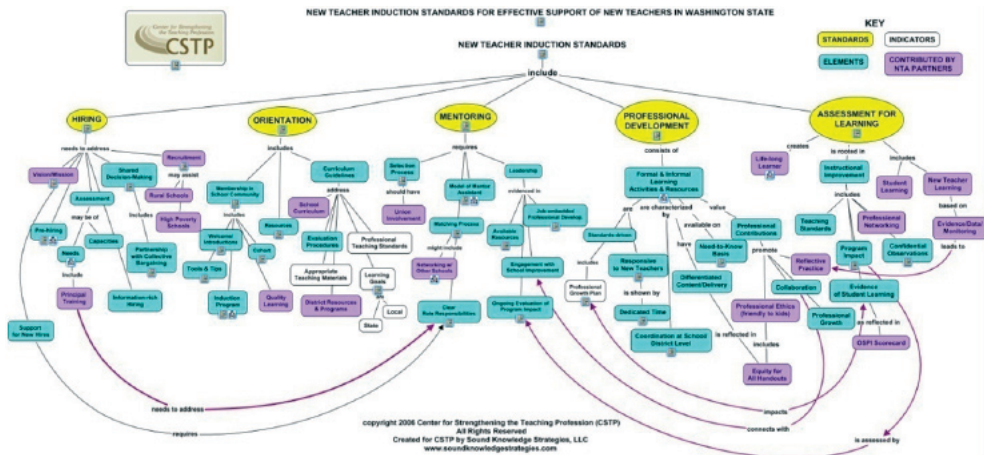


Fig. 5 - A concept map prepared as part of an ongoing in-service training program for teachers in Washington State. (Reproduced with permission from the authors).

At this time, the application of the New Model is still in its infancy, but I expect that its use will increase as more groups of various disciplines see the value of the model.

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