Building on New Constructivist Ideas and CmapTools to Create a New Model for Education[1]

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Abstract. There is today almost universal agreement that every learner must construct her/his own knowledge structure, or cognitive structure, through her/his own efforts. The commitment to building a powerful knowledge structure must be the learner's commitment. There is less universal recognition that knowledge structures are built primarily through *meaningful learning*, and by contrast, rote learning or simply memorizing information contributes little to building a person's knowledge structure. We believe that Ausubel's cognitive learning theory (Ausubel, 1963, 2000) provides a strong foundation on which to improve teaching and learning. We shall seek to illustrate this through efforts that employ constructivist epistemology and constructivist cognitive psychology, together with the use of the Internet and CmapTools, a software toolkit to aid in the construction of concept maps. CmapTools can serve as the foundation for a new kind of integration of Internet resources and all classroom, laboratory, and field experiences, and when used with "expert skeletal " concept maps to scaffold learning, they provide for a New Model for Education.

1 Introduction

Concept maps have been used in all facets of education and training. With the fundamental goal of fostering learning (Novak & Gowin, 1984), they have been shown to be an effective tool for –and we don't pretend to provide an exhaustive list– evaluation, displaying students' prior knowledge, summarizing what has been learned, note taking, aiding study, planning, scaffolding for understanding, consolidating educational experiences, improving affective conditions for learning, teaching critical thinking, supporting cooperation and collaboration, and organizing content (Coffey et al., 2003). We are aware that *new* technologies have failed to deliver on the false expectation of being the solution to education's problems, however, we propose that good theory-based use of the appropriate technology can increase the benefits of using concept maps in education and lead to dramatically improved education.

In this paper we first explore the power of CmapTools and how these can support concept mapping and integration of a whole array of learning experiences, and then discuss how these tools and new ideas can lead to a New Model for Education.

2 The Power of CmapTools

For the past dozen years, the Institute for Human and Machine Cognition (IHMC) has been developing CmapTools (Cañas *et al.*, 2004) a client-server software environment that greatly facilitates the construction and sharing of concept maps. The software is used extensively throughout the world by persons of all ages and for a large variety of applications. Describing the complete functionality of the program is beyond the scope of this paper, so we will present some key features that will provide an idea of how the software supports concept mapping.

CmapTools has been designed with the objective of supporting collaboration and sharing. The client-server architecture, together with a collection of Public Places (CmapServers) where any Internet user can create a folder and construct, copy or publish their concept maps, facilitates the sharing of concept maps and collaboration during concept map construction (Cañas *et al.*, 2003a). Additionally, a CmapServer (Place) can easily be installed in a classroom or school to facilitate collaboration locally. Collaboration is supported at several levels. If two or more users attempt to edit the same concept map at the same time, the program will –with the consent of the users– establish a *synchronous* collaboration session where the users can concurrently modify the map and communicate via a chat window. Peer review and collaboration are facilitated through Annotations (post-it notes) that can be added to map after selecting the portion of the map to be annotated, and through Discussion Threads that can be added to a node (concept or linking phrase). When a user creates a folder in a Public Place (server) he/she becomes the Administrator of that folder, and can determine which users receive "annotation" permission (can comment on a

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[1] An earlier version of this paper was presented as Novak & Cañas (2004). Based in part on earlier papers, Novak (2003), Novak (2004a), and Novak (2004b).

map but cannot modify it, appropriate for peer review), "write" permission (can modify the maps, appropriate for teamwork and collaboration) or read-only permission (appropriate for publishing). In addition, the Knowledge Soups enable collaboration at the proposition or knowledge level (Cañas *et al.*, 1995; Cañas *et al.*, 2001).

CmapTools supports the construction of "knowledge models": sets of concept maps and associated resources about a particular topic (Cañas *et al.*, 2003b). Through simple drag-and-drop operations students can link all types of media (images, videos, text, web pages, documents, presentations, etc.) and concept maps, whether theirs or constructed by others, to their maps. These resources can be located anywhere on the Internet.

Novak and Gowin (1984, Chapter 2) have depicted the act of mapping as a creative activity, in which the learner must exert effort to clarify meanings, by identifying important concepts, relationships, and structure within a specified domain of knowledge. Knowledge creation requires a high level of *meaningful learning*, and concept maps facilitate the process of knowledge creation for individuals and for scholars in a discipline (Novak, 1993). Educators have recognized that it is the *process of creating* a concept map that is important, not just the final product. However, in many cases the teacher cannot accompany the students during the process of concept mapping, whether it's because there are too many students, the student is doing the work at home, or the learning is taking place at a distance. CmapTools provides the capability of "recording" the process of constructing a concept map, allowing for a graphical "playback" at a later time, controlling the speed and moving forward or backwards as needed. Figure 1 shows at the right the pane that allows the user to control the recording. In this example, the student has taken 83 steps to reach this point in the map construction, and pressing on the playback button will start showing step by step the complete process of map construction. The recording is saved with the concept map, so if it is copied or moved the recording is not lost. The playback also identifies which user performed each step, which is essential to support collaborative work. In effect, the playback of concept maps created by an individual reveals the processes by which meaningful learning was occurring.

Despite the free-style format that concept maps can take, specific characteristics of well-constructed concept maps (structure, semantics, context, etc.) provide an abundance of information on which to develop smart tools that aid the user in the process of constructing concept maps (Cañas & Carvalho, 2004). One such tool allows the user to select a concept in a map and search the Internet and Places (CmapServers) for information (including concept maps) that are related to the concepts selected, taking into account the context of the concept map itself (Carvalho *et al.*, 2001). That is, the program tries to determine "what the concept map is about" and performs a

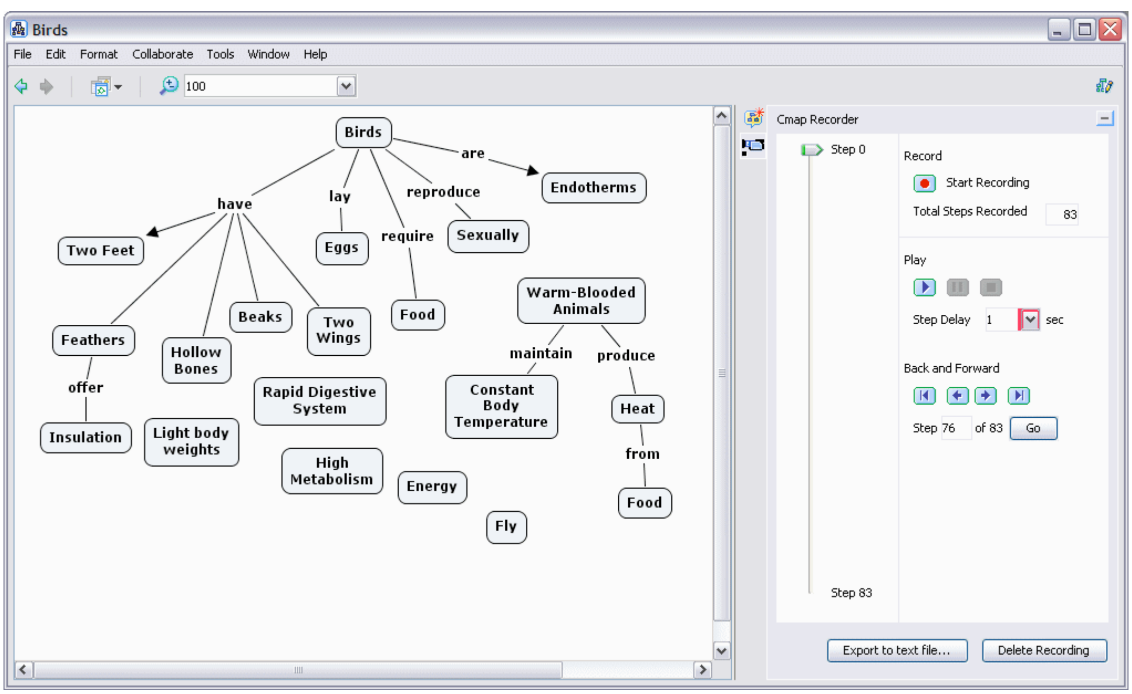

Figure 1. The Recorder feature of CmapTools allows the graphical playback of the steps in the construction of a concept map. This feature can be used by map makers to review their progress, or by teachers and researchers to study contributions by individuals over time.

query accordingly. Researching a topic can begin by constructing a small map and using the search to locate information related to the map. The information retrieved can then be used to improve the map, and the cycle continues. By linking relevant resources found onto the map itself, the concept map becomes the centerpiece of the research endeavor. Figure 2 illustrates how many of the activities in learning can be integrated through the structure of a concept map built with CmapTools.

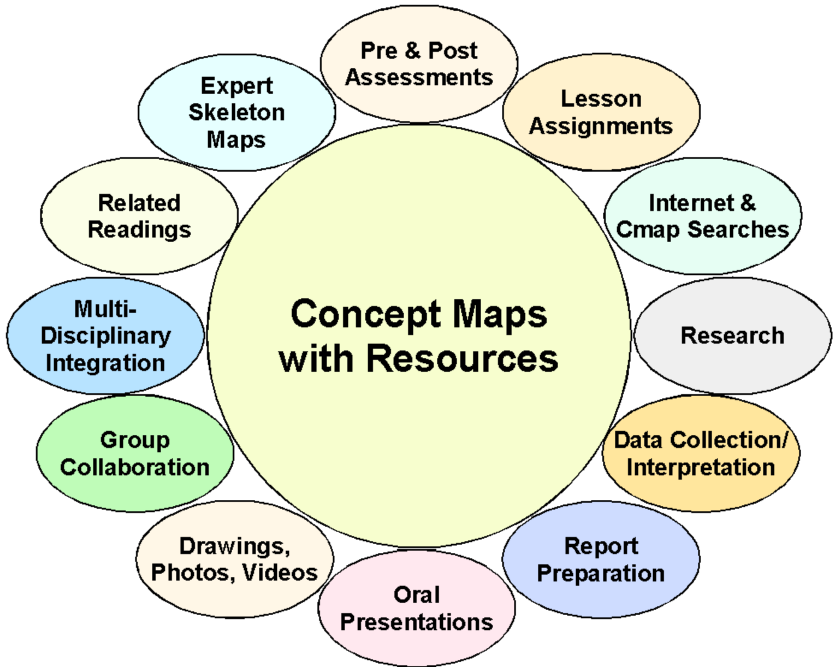

Figure 2. The whole spectrum of learning activities can be integrated using CmapTools, incorporating various learning activities recorded via the software creating a digital portfolio as a product of the learning.

The program contains other features that support the user, whether a student, teacher, or instructor, in the use of concept mapping in an educational environment, such as a map-comparison module and automatic generation of an HTML version of the concept map when stored in a Place. For the purpose supporting the ideas presented in this paper, we consider that the combination of the collaboration tools, the knowledge model construction features, and the search mechanism provide a strong foundation on which to build on the "expert" map scaffolding ideas in the New Model for Education described in the following sections. Using "Expert skeletal" Concept Maps to "Scaffold" Student and Teacher Learning. Scardamalia amd Bereitere (1993) have suggested how students or other learners might use technology to help build their knowledge, and we believe that CmapTools greatly extends this capability.

During the first author's last 20 years teaching at Cornell University he taught a course called "Learning to Learn". The book, *Learning How to Learn* (Novak & Gowin, 1984), derived in large part from experiences teaching the course. One of the techniques Novak found most helpful to students was to prepare concept maps showing key ideas and their relationships. These were not complete maps, just the key concepts. Students were asked to add concepts to the professor's maps and restructure the map in ways that would make the most sense to them. The exams in this course typically provided the students with a list of 20-25 concepts, and they were asked to build a concept map using these concepts and additional concepts they wished to add. Students were also asked to select a "learning partner", since considerable research supports the value of cooperative learning (Qin *et al.*, 1995). It was impractical in terms of student schedules to form learning groups larger than two, although sometimes the students took the initiative to meet in groups of 4-6, usually comprising 2-3 learning partner teams. Course evaluations repeatedly commented on the value of the learning partner arrangement, and in fact a few of these led to later marriage of the learning partners. Examples of the kind of concept maps that were used with students can be seen on the CmapTools Network[2].

Novak's experiences in using concept maps to help guide student learning were highly positive. They were supported by Vygotsky's (1978) ideas of the importance of social exchanges in learning. Another idea that was

[2] Place: IHMC Public Cmaps (2), Folder: JDN's LCKKnowledge.

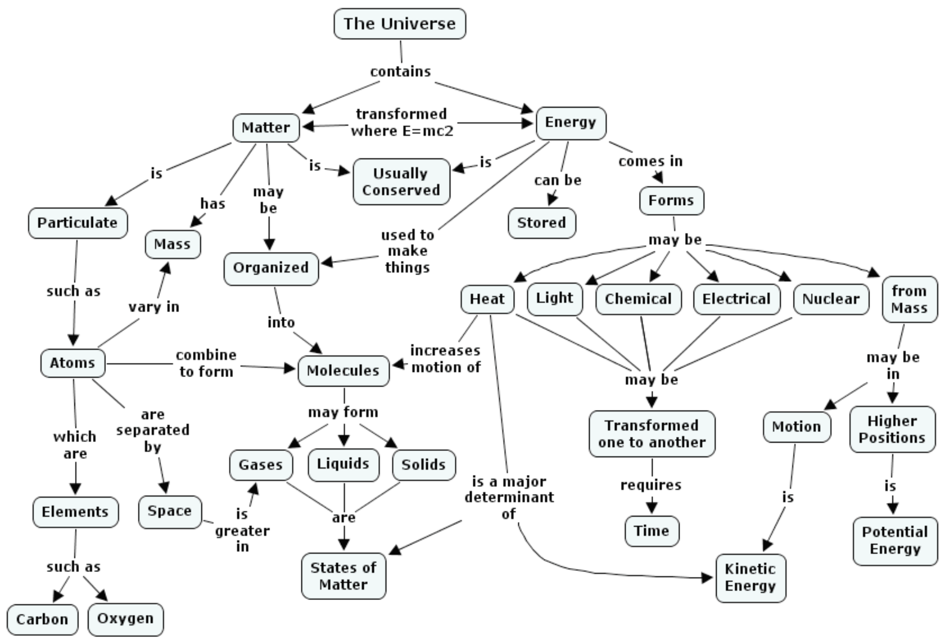

Figure 3. A "global" concept map presenting the major concepts needed to understand most areas of science.

supported is Vygotsky's concept of "Zone of Proximal Development" (ZPD). Vygotsky's studies showed that there was a level of cognitive development that allowed a learner to advance in understanding of a given domain of knowledge without coaching, and a higher level of understanding beyond which the learner cannot advance without coaching. He called this range of understanding the Zone of proximal Development. One advantage of cooperative learning approaches is that students tend to be at about the same ZPD, hence they can better communicate ideas to each other, and when assisted by "expert skeletal" concept maps, they can progress even further. In general, the literature on "coaching" students using various approaches shows significant facilitation of learning (Bransford *et al.*, 1999). Given the extraordinary range of learning activities that can now be facilitated and integrated using CmapTools, we believe that even greater advantage of Vygotsky's ideas and ideas from the literature on coaching can be incorporated into instruction.

Our plans are to begin developing "expert skeletal" concept maps in the area of science, since science is universal and it is also a subject poorly taught, especially at the elementary school level. The same could be said for mathematics, and this might be the second area to be developed. We estimate that the project would require some 300 expert concept maps to provide reasonable coverage of all areas of science for grades one through twelve, or ages 6 through 18. There are many scientists who have already prepared concept maps for specific disciplines, so this would be an easy starting point, although many of the maps might need some revisions to make a better fit with the project. Also, we would need to prepare some "global" concept maps to give broad conceptual overview of science or sub-domains of science. Figure 3 is an example of one such "global' concept map. Figure 4 shows a concept map dealing with the kind of energy transformation we call photosynthesis, and could represent a sub-map for Figure 3.

Pérez et al. (2000) report on using concept maps to scaffold university and high school student's learning of physics for more than a decade. Although their students did not use computer software, their feedback indicated better understanding of physics concepts with the use of concept maps. They are now moving towards leveraging on the use of CmapTools and technology (Pérez et al., 2004). O'Donnell, Dansereau, & Hall (2002) report on a study where a kind of concept mapping was used successfully to scaffold learning. A number of other school and university teachers have reported on using scaffolding approaches with concept maps, but little empirical data is available at this time. Therefore, we proceed with this approach with the support of underlying theoretical ideas, and indirect empirical support such as can be found in some of our research (Bascones & Novak, 1985; Novak & Musonda, 1991). The Bascones and Novak study showed approximately 100% greater improvement in problem solving scores for high school physics students using concept mapping, compared with students doing traditional

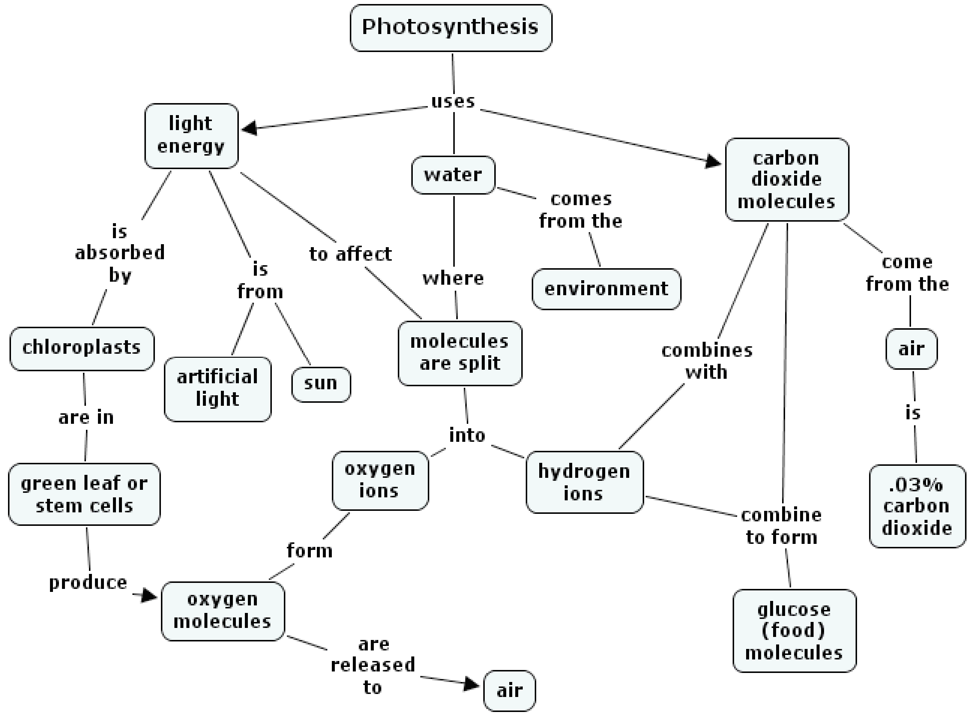

Figure 4. An example of a sub-concept map for Figure 3, dealing with one form of energy transformation done by green plants called photosynthesis. This concept map can be attached to the concept light energy in Figure 3 as an icon that opens this map when clicked.

exercises. The Novak and Musonda study showed that students taught with audio-tutorial methods in grades one and two achieved 100% or more improvement in understanding of molecular kinetic concepts when compared over twelve school years with students who did not receive this early science instruction. The latter study illustrates in part that technologically mediated instruction can be very effective. The two studies and other similar research show the huge unattained learning improvement potentials that currently exist for the improvement of teaching and learning. No study has looked at the learning improvement that could be attained by applying the best technology and the best pedagogy over the 12-year span of schooling, but the studies that exist suggest that such learning augmentation can approach an order of magnitude greater than that now commonly observed.

An important advantage of organizing instruction beginning with an expert concept map is that learners and teachers almost always have faulty knowledge or misconceptions in virtually every domain of knowledge that has been studied. Research has also shown that these misconceptions are notoriously difficult to overcome with traditional instruction (Novak, 1977, 2002). The use of concept maps has been shown to be effective for remediating misconceptions, especially when learners begin with a valid "expert" concept map and when they work collaboratively to construct a new knowledge model. We are currently working with a number of organizations that are building on what we know about learning, creating, and using knowledge (Novak, 1998), and developing sets of expert concept maps for training new workers and other purposes.

3 The World of Science Project

During the early 1960's, Novak worked on a series of elementary science books that had first been published by Bobbs-Merrill as The Wonderworld of Science, which was a fairly traditional elementary science book series. Most elementary school science textbooks cover many, many topics of science very superficially. None of these books present basic concepts of atoms and molecules and the nature and transformation of energy in early grades. Without introducing these concepts, it is essentially impossible to provide *explanations* of why things in the universe behave as they do. Wonderworld was an apt name for the early Bobbs-Merrill books as well as all other 28 elementary science series that were on the market in the 1960's, since they did little to explain why things in the universe work the way they do. Indeed, this remains the case today for most elementary school science programs! The problem of superficial coverage of science topics was also recognized by the Curriculum Committee of the National Science

Teachers Association and their plan to build science instruction on “basic conceptual schemes” (Novak, 1964). Ausubel’s (1963, 1968) cognitive learning theory was published in 1963, and this became a foundation for final writing in the books for The World of Science. Novak sought to take many of the good illustrations, activities and ideas in the Wonderworld of Science books and to rewrite the books to include information and activities that would illustrate the particulate nature of matter, energy and energy transformations, and the interplay of energy and matter in living and non-living systems. After 4 years of writing and editing, the *World of Science* was published in 1966 (Novak *et al.*, 1966). Unfortunately, Bobbs-Merrill was sold to another company in 1968 and this company decided to not market the World of Science books. Nevertheless, the books began to enjoy some success in elementary school classrooms in the USA, and later served as the primary foundation for audio-tutorial lessons designed for our 12-year longitudinal study (Novak, 2004a; Novak & Musonda, 1991). All of these books have now been scanned and we hope to make them publicly available soon at the IHMC web site (www.ihmc.us).

Our plan is to use The World of Science books as a starting point for a demonstration project for A New Model for Education. To begin, concept maps have been prepared for all sections of the grade two book of the World of Science entitled The Exciting World of Science. All concept maps are publicly available on the CmapTools Network[3]. The concept maps would serve as a starting point for students and teachers for each section illustrated in the book, and then students would use these Cmaps together with CmapTools to search the Internet for pertinent resources and ideas. Figure 5 illustrates one of the “expert skeleton” concept maps that could be used as the starting point for building a knowledge model, preferably students working in teams and sharing ideas.

The science books provide relevant readings and suggested activities. It would be important for the teacher to help students perform these activities, and similar related activities, some of which might by suggested in Internet resources. Learners would also add their own concepts to the “skeleton expert” concept map, as well as resources identified in readings and from the Internet. Figure 6 illustrates a stage in this process.

Obviously, it would be a very deficient science program that did nothing more that to have students copy and do some building on the “expert skeleton” concept maps provided for grade two, or for any other grade. Students need concrete, hands on experiences with real things and to observe real phenomena to put meaning into the concept labels provided in the concept maps and other resources Figure 7 shows concept map illustrating some of the key features of Novak’s New Model for Education. When online, clicking on the icons on concepts provides additional information. Other concept maps for the New Model for Education can be found at the CmapTools Network[4].

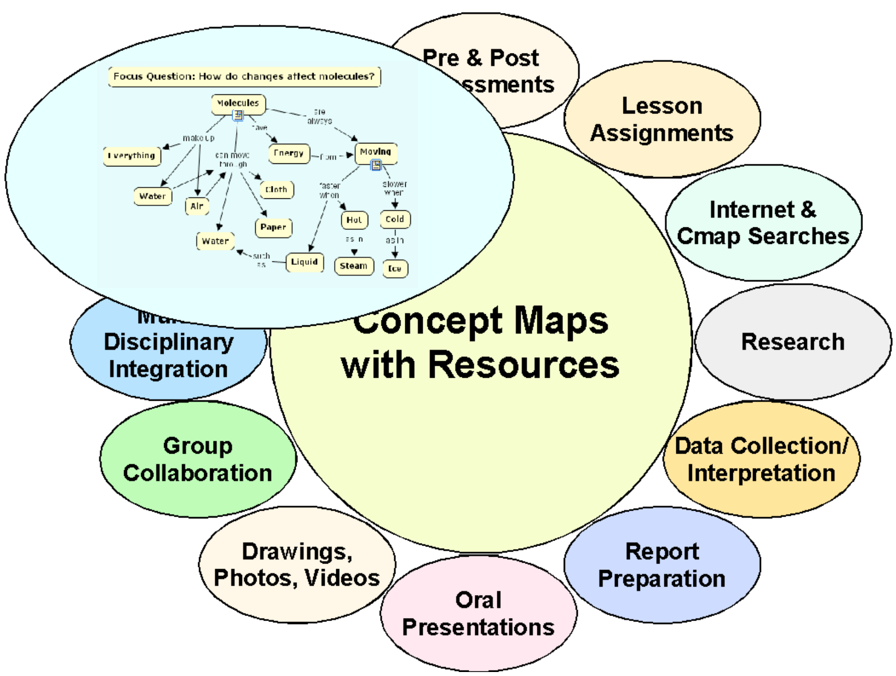

Figure 5. Schema showing the New Model for Education with a “skeleton expert” concept map.

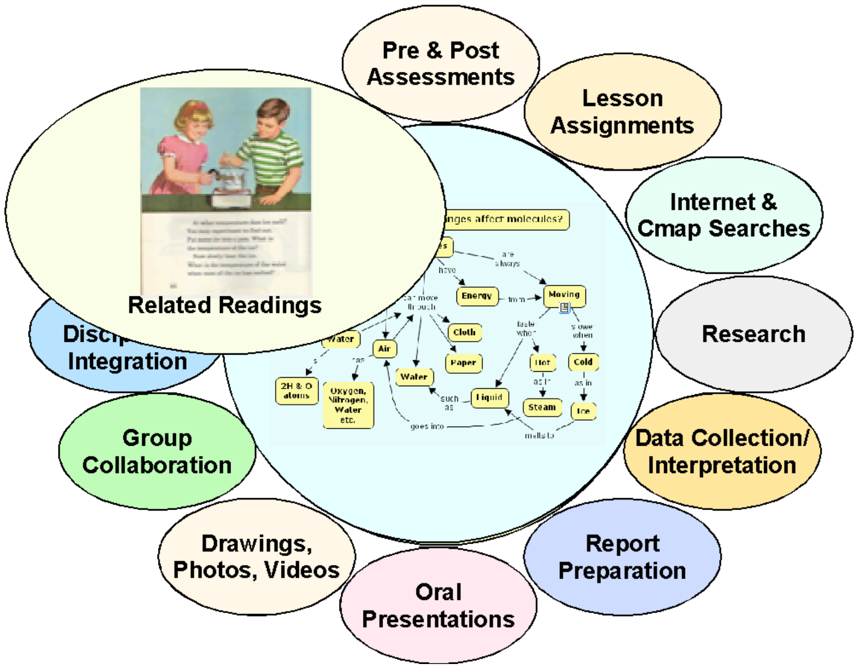

Figure 6. Schema showing the New Model for Education with concepts and resources added to the "expert skeleton" concept map, plus a page from a World of Science book providing relevant reading and activities.

A pilot program effort is already in progress in Italy, where Giuseppe Valittuti (2004) is now working to translate The World of Science books into Italian. Valittuti and his colleagues have obtained funding from the Italian Ministry of Education for teacher training and expect a number of elementary school teams to begin working with the World of Science concept maps and other resources during the year. The plan is to have four sets of schools focus on different aspects of The World Of Science series and produce photos and videos of students doing projects that illustrate and utilize the various science concepts. There will be much feedback from classrooms helping the teams to refine their work, sharing "electronic portfolios" using CmapTools. This feedback should help us to rapidly refine concept maps, techniques and approaches for improving practice of the New Model for Education. The CmapTools Network may serve as a clearinghouse for some of these efforts through its Public servers in Italy and other countries. We anticipate that an abundance of both anecdotal and empirical data will flow from these efforts in a few years. Based on the solid theoretical and related research findings now available, there is every reason to be optimistic that these innovative efforts will be successful.

4 Problems of Implementation

The greatest challenge we may expect is to change the school situational factors in the direction of teacher as coach and learner from the prevailing model of teachers as disseminator of information. We know that we need to engage teachers and administrators in training programs that can model the new educational approaches, and we also need to seek their counsel on ways to improve on the New Model for Education. There is also the challenge of changing assessment practices that now rely primarily on multiple-choice tests that measure mainly rote recall of information, to performance-based tests that require students to demonstrate that they understand basic concepts and can use these concepts in novel problems solving, and that they can use Internet resources to grow and modify their concepts and learn new concepts. There remains in the New Model plenty of room for acquisition of specific facts and procedures, but now these should be in learned within the context of powerful conceptual frameworks. Research (Bransford et al., 1999) has shown that factual information acquired in a context of meaningful learning is not only retained longer, but this information can be used much more successfully to solve new problems.

[3] Place: IHMC Public Cmaps (2), Folder: The World of Science.
[4] Place: IHMC Public Cmaps (2), Folder: Novak's New Model of Education.

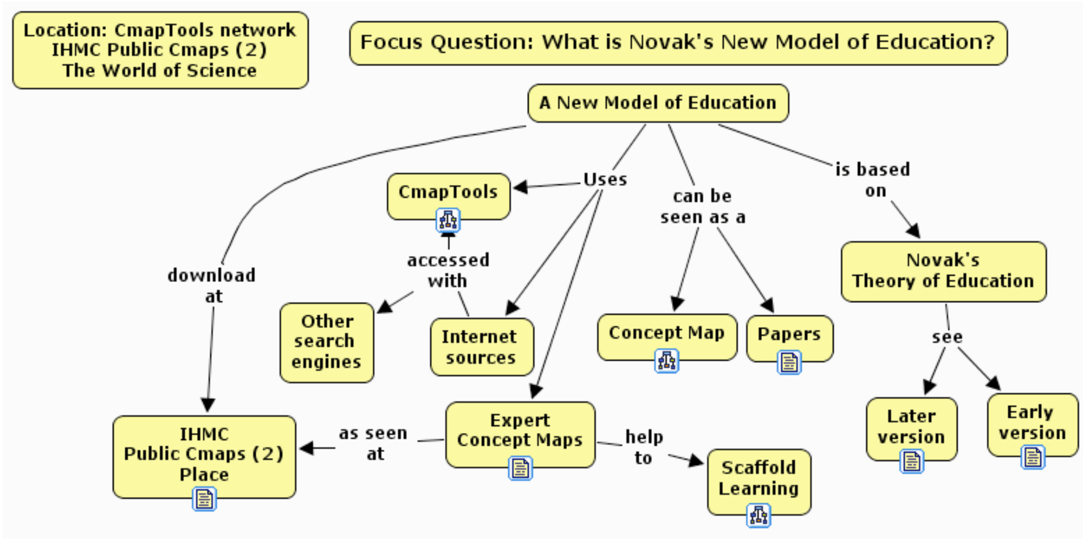

Figure 7. A concept map showing some of the key features of Novak's New Model for Education. When online, the icons below concepts lead to additional information.

Even with the current state of technology and pedagogical understandings, it is possible for schools, states or countries to mount a New Model for Education. In some poor countries, new technology is providing new communication capabilities. Rather than installing expensive phone lines and cables, use of cell phones is simply stepping over one hundred years of communication technology used in more affluent countries. Cell phones and cheap hard drive capacity is making possible transmission of large quantities of information including information from the Internet (see for example: http://www.wired.com/news/print/0,1294,63131,00.html) Even in these poor countries, a New Model for Education can be introduced, and the enormous problems they have with poor school facilities, lack of books and highly trained teachers and other things the affluent countries have thought as essential can be largely obviated by emerging technologies. In fact, it may the poorer countries that may be the first to embrace a New Model for Education. As technology continues to advance, we should expect that what is relatively expensive and difficult today will become an order of magnitude less costly, and more effective in a relatively few years. Furthermore, research on teaching and learning is improving, and this too will contribute to greater effectiveness. The rate and kind of new technological advances is difficult to predict, but the history of the past few decades can serve as a model of where we might expect to be in 10 or 20 years, if we begin to exploit more fully the technologies and ideas available today. The possibilities are enormous; what we need is good leadership.

References

Ausubel, D. P. (1963). *The psychology of meaningful verbal learning*. New York: Grune and Stratton.

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York: Holt, Rinehart and Winston.

Ausubel, D. P. (2000). *The acquisition and retention of knowledge: A cognitive view*. Dordrect; Boston: Kluwer Academic Publishers.

Bascones, J., & Novak, J. D. (1985). Alternative instructional systems and the development of problem solving skills in physics. *European Journal of Science Education, 7*(3), 253-261.

Bransford, J., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school*. Washington, D.C.: National Academy Press.

Carvalho, M. R., Hewett, R., & Cañas, A. J. (2001). *Enhancing web searches from concept map-based knowledge models.* Paper presented at the SCI 2001: Fifth Multi-Conference on Systems, Cybernetics and Informatics, Orlando.

Cañas, A. J., & Carvalho, M. (2004). Concept maps and AI: An unlikely marriage? In *Proceedings of sbie 2004: Simpósio brasileiro de informática educativa*. Manaus, Brasil.

Cañas, A. J., Ford, K. M., Brennan, J., Reichherzer, T., & Hayes, P. (1995). *Knowledge construction and sharing in quorum.* Paper presented at the Seventh World Conference on Artificial Intelligence in Education, Washington DC.

Cañas, A. J., Ford, K. M., Novak, J. D., Hayes, P., Reichherzer, T., & Niranjan, S. (2001). Online concept maps: Enhancing collaborative learning by using technology with concept maps. *The Science Teacher, 68*(4), 49-51.

Cañas, A. J., Hill, G., Carff, R., Suri, N., Lott, J., Eskridge, T., et al. (2004). CmapTools: A knowledge modeling and sharing environment. In A. J. Cañas, J. D. Novak & F. M. González (Eds.), *Concept maps: Theory, methodology, technology, proceedings of the 1st international conference on concept mapping*. Pamplona, Spain: Universidad Pública de Navarra.

Cañas, A. J., Hill, G., Granados, A., Pérez, C., & Pérez, J. D. (2003a). *The network architecture of CmapTools* (Technical Report No. IHMC CmapTools 2003-01). Pensacola, FL: Institute for Human and Machine Cognition.

Cañas, A. J., Hill, G., & Lott, J. (2003b). *Support for constructing knowledge models in CmapTools* (Technical Report No. IHMC CmapTools 2003-02). Pensacola, FL: Institute for Human and Machine Cognition.

Coffey, J. W., Carnot, M. J., Feltovich, P. J., Feltovich, J., Hoffman, R. R., Cañas, A. J., et al. (2003). *A summary of literature pertaining to the use of concept mapping techniques and technologies for education and performance support* (No. Technical Report submitted to the US Navy Chief of Naval Education and Training). Pensacola, FL: Institute for Human and Machine Cognition.

Novak, J. D. (1964). The importance of conceptual schemes for teaching science. *The Science Teacher, 31*(6), 10-13.

Novak, J. D. (1977). *A theory of education*. Ithaca, NY: Cornell University Press.

Novak, J. D. (1993). Human constructivism: A unification of psychological and epistemological phenomena in meaning making. *International Journal of Personal Construct Psychology, 6*, 167-193.

Novak, J. D. (1998). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations*. Mahwah, NJ: Lawrence Erlbaum Associates.

Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or appropriate propositional hierarchies (liphs) leading to empowerment of learners. *Science Education, 86*(4), 548-571.

Novak, J. D. (2003). The promise of new ideas and new technology for improving teaching and learning. *Journal of Cell Biology Education, 2*(Summer), 122-132.

Novak, J. D. (2004a). Reflections on a half-century of thinking in science education and research implications from a twelve-year longitudinal study of children's learning. *Canadian Journal of Science, Mathematics, and Technology Education, 4*(1), 23-41.

Novak, J. D. (2004b). A science education research program that led to the development of the concept mapping tool and a new model for education. In A. J. Cañas, J. D. Novak & F. M. González (Eds.), *Concept maps: Theory, methodology, technology, proceedings of the 1st international conference on concept mapping*. Pamplona, Spain: Universidad Pública de Navarra.

Novak, J. D., & Cañas, A. J. (2004). Building on constructivist ideas and CmapTools to create a new model for education. In A. J. Cañas, J. D. Novak & F. M. González (Eds.), *Concept maps: Theory, methodology, technology, proceedings of the 1st international conference on concept mapping*. Pamplona, Spain: Universidad Pública de Navarra.

Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*. New York: Cambridge University Press.

Novak, J. D., Meister, M., Knox, W. W., & Sullivan, D. W. (1966). *The world of science series. Books one through six*. Indianapolis, IN: Bobbs-Merrill.

Novak, J. D., & Musonda, D. (1991). A twelve-year longitudinal study of science concept learning. *American Educational Research Journal, 28*(1), 117-153.

O'Donnell, A., Dansereau, D., & Hall, R. H. (2002). Knowledge maps as scaffolds for cognitive processing. *Educational Psychology Review, 14*, 71-86.

Pérez, A. L., Suero, M. I., Montanero, M., & Fernández, M. M. (2000). *Mapas de experto tridimensionales*. Extremadura, España: Consejería de Educación, Ciencia y Cultura de la Junta de Extremadura.

Pérez, Á. L., Suero, M. I., Montanero, M., & Pardo, P. J. (2004). Aplicaciones de la teoría de la elaboración de reigeluth y stein a la enseñanza de la física. Una propuesta basada en la utilización del programa informático CmapTools. In A. J. Cañas, J. D. Novak & F. M. González (Eds.), *Concept maps: Theory, methodology, technology. Proceedings of the first international conference on concept mapping* (Vol. I). Pamplona: Universidad Pública de Navarra.

Qin, Z., Johnson, D. W., & Johnson, R. T. (1995). Cooperative versus competitive efforts and problem solving. *Review of Educational Research, 65*(Summer), 129-143.

Scardamalia, M., & Bereiter, C. (1993). Technologies for knowledge-building discourse. *Communications of the ACM, 36*(5), 37-41.

Valittuti, G. (2004). Personal communication.

Vygotsky, L., & Cole, M. (1978). *Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Press.