A THEORY OF EDUCATION: *MEANINGFUL LEARNING* UNDERLIES THE CONSTRUCTIVE INTEGRATION OF THINKING, FEELING, AND ACTING LEADING TO EMPOWERMENT FOR COMMITMENT AND RESPONSIBILITY
(Uma teoria de educação: aprendizagem significativa subjacente à integração construtiva de pensamentos, sentimentos e ações levando ao empoderamento para compromisso e responsabilidade)

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Abstract

This paper traces the history of research and practice that led to the development of my Theory of Education. Based on Ausubel's assimilation theory of meaningful learning and constructivist epistemology, the theory includes five *elements*: teacher, learner, subject matter, context, and evaluation, each of which must be integrated constructively to effect high levels of meaningful learning. The development and use of concept mapping to facilitate meaningful learning is discussed and a New Model for Education is presented that builds upon the theory and associated practices.
Keywords: meaningful learning; thinking; feeling; acting.

Resumo

Este artigo descreve a pesquisa e a prática que levaram ao desenvolvimento de minha Teoria de Educação. Baseada na teoria da aprendizagem significativa de Ausubel e na epistemologia construtivista, a teoria inclui cinco *elementos*: professor, aprendiz, matéria de ensino, contexto e avaliação, cada um dos quais deve ser integrado construtivamente para levar a altos níveis de aprendizagem significativa. O desenvolvimento e uso do mapeamento conceitual são discutidos e um Novo Modelo de Educação é apresentado a partir da teoria e práticas associadas.
Palavras-chave: aprendizagem significativa; pensamentos; sentimentos; ações.

Introduction

From the time I was in elementary school in the 1930's, I often wondered why some fellow students had so much trouble understanding what I thought were relatively simple ideas. These same students might have been good at spelling and some other things, but they didn't appear to understand why 2+2= 4 was the same as 2X2= 4 or why 8 pints or 4 quarts both equal one gallon. Surely some of the reason was due to heredity, but this did not appear to be an adequate explanation.

It seemed to me that some students were just learning differently, but I did not know what the differences were. I did not understand clear reasons for these differences until the 1960's when I became familiar with David Ausubel's Assimilation Theory of meaningful learning (Ausubel, 1963; 1968; 1978). Ausubel made the sharp distinction between learning by rote, where the learner makes little or no effort to integrate new concepts and propositions with relevant concepts and propositions already known, and *meaningful learning* where the learner seeks to integrate new knowledge with relevant existing knowledge. While teachers can arrange instruction and assessment to encourage either

learning by rote of learning meaningfully, the primary responsibility for learning is the learner's, and this responsibility cannot be shared.

Human beings think, feel, and act. Every learning event involves to a greater or lesser degree all three of these actions. In rote learning, there is often little emotional commitment other than to recall the information, and the extrinsic motivation that comes with getting the right answer. In meaningful learning the recognition of how the new information integrates with prior knowledge and "makes sense" provides much more rewarding intrinsic motivation. Moreover, when the learning is integral to some activity and helps to guide and clarify the activity, there is usually a higher level of positive affect resulting. Ausubel noted that meaningful learning has three requirements and the contrast with rote learning is shown in Figure 1.

In 1973, Joseph Schwab proposed that any educative event involves four commonplaces: the learner, teacher, subject matter, and context or social milieu. Schwab maintained that each of these was distinctly important and none could be reduce into any other. Partly for this reason, I have chosen to call these four distinct entities of *education elements*, analogous to elements in chemistry that are distinct structural units of matter. Moreover, I have chosen to add a fifth element in my 1977 *Theory of Education*, **evaluation**, since so much that affects learners, teachers, subject matter selected, and the social milieu of education depends on how we evaluate teaching and learning (Novak, 1998; 2010). Educating is further complicated by the fact that each of these elements is somewhat distinct for every student, and they may be substantially different for the teacher. Thus there is a need for *negotiation of meanings* between students and between students and teachers. Thus we see that education is in some ways relatively simple – involving just five elements – and concomitantly enormously difficult, since so many idiosyncratic teacher, subject matter, evaluation, and student *elements* must be orchestrated to operate supportively, perhaps in a variety of milieus. There are so man ways to go wrong. The natural world is also enormously complex, but we have made great progress in understanding and manipulating the natural events with the advance of theory-based science. For the past 50 years, I have argued that education will not be substantially improved until it is guided by better theory-based research and practices. This has been the path my students and I have pursued.
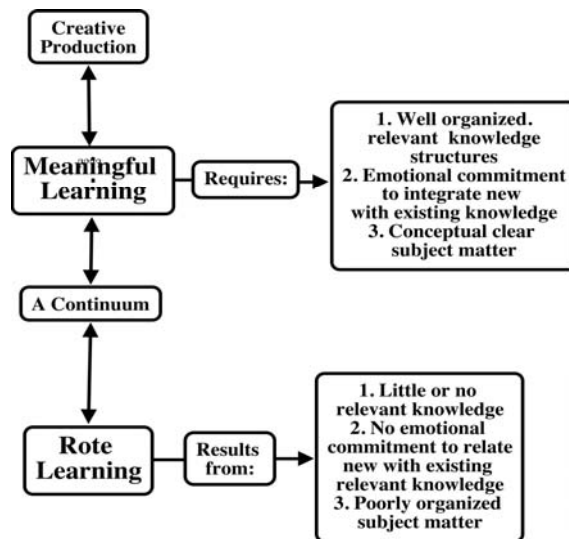

Figure 1. The rote-Meaningful learning continuum showing the requirements for meaningful learning. Creativity is seen as essentially very high levels of meaningful learning. This diagram should be part of metacognitive instruction.

A Focus on Learning

Over the past 30 years there has been major advances in our understanding of human learning. Behavioral psychology that dominated education for more than half a century began its demise in the late 1970's and pretty much collapsed in the 1980's. Almost all competent educational psychologists have moved toward cognitive rather than behavioral models of human learning; Ausubel was simply much ahead of his time with this. Moreover, advances in neurobiology are also revolutionizing our thinking about human leaning capabilities and better understanding of how our brains work (see for example Medina's *Brain Rules*). Inappropriate use of Piaget's work led to untenable prescriptions for delayed introduction of instruction in abstract concepts and a mythology now thoroughly debunked by recent cognitive research with infants and young children (Cary, 1985; Gelman, 1999; Keil, 2011). Recent studies of human brain functions show the complexity of brain mechanism and the complex interrelationships in the functioning of various parts of the brain. Simplistic ideas of right-brain and left-brain thinking have been discarded as we learn more about the plasticity of the brain and immense interactions between various parts of the brain, including those regions that generate and store feelings of affective memories. Recent brain studies also lend support to the fundamental idea in Ausubel's theory that knowledge stored during meaningful learning is fundamentally organized differently than knowledge learned by rote, and affective associations are also different. The simple distinctions shown in figure 1 underlie the profound differences in the outcomes from meaningful as contrasted to rote learning (Valadares & Moriera, 2009). It also explains why creativity is all to rare: too few people have been educated to reach high levels of meaningful learning in a given discipline, to say nothing about such achievement in related disciplines.

We are also learning more about the important role that social exchange plays in learning. Vygotsky's (1926; 1962) ideas on the importance of language and dialogue between learners, largely ignored in western psychology and education until recently, are now seen as valuable for planning the context for educating. Vygotsky's idea of the *zone of proximal development* (ZOD) that recognizes children's learning is limited primarily by the ideas they have mastered at a given point in time, and development beyond this zone requires careful coaching and scaffolding of learning.
There have also been important advances in research showing the "learning about learning" or *metacognitive* learning needs to be part of educational programs (Novak and Gowin, 1984. Novak, 1985; Bransford, et al, 1999)

In the epigraph to his 1968 book Ausubel stated:

> *If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly.*

This idea is now widely accepted in education. Unfortunately, it is not easy to ascertain precisely what a learner already knows, especially using conventional tests or even more probing interviews. This was a challenge our research group at Cornell University faced when we sought to follow children's understanding of basic science concepts such as the nature of matter and energy. We found that the usual kinds of tests were simply not adequate for showing specific changes in 6 to 7 year-old's conceptual understanding. My graduate students and I came up with the idea of translating interviews with children into what we call *concept maps*. Figure 2 shows an example of one of the concept maps made by one of my graduate students. It chows clearly and explicitly the concepts and propositions held by this student relevant to the topics studied. We have found subsequently that

concept maps can be used to represent knowledge held by anyone from young children to research professors in any subject matter domain. Moreover, using concept maps help learners learn how to learn meaningfully, and help researchers design and interpret research more effectively (Novak & Gowin, 1984; Novak, 1998, 2010). Concept maps drawn by learners prior to instruction are very effective in revealing what learners already know, including their misconceptions, and then we can "teach them accordingly". The development of excellent software for creating concept maps by the Florida Institute for Human and Machine Cognition in the 1990's that permits addition of any kind of digital resource to any concept has added new dimensions to the value of this tool permitting the construction of what we call *Knowledge Models*. These are essentially digital portfolios constructed by individuals or collaborative groups. Further discussion of knowledge models is included below under *A New Model for Education*. The software is being used worldwide and is available at no cost at: http://cmap.ihmc.us
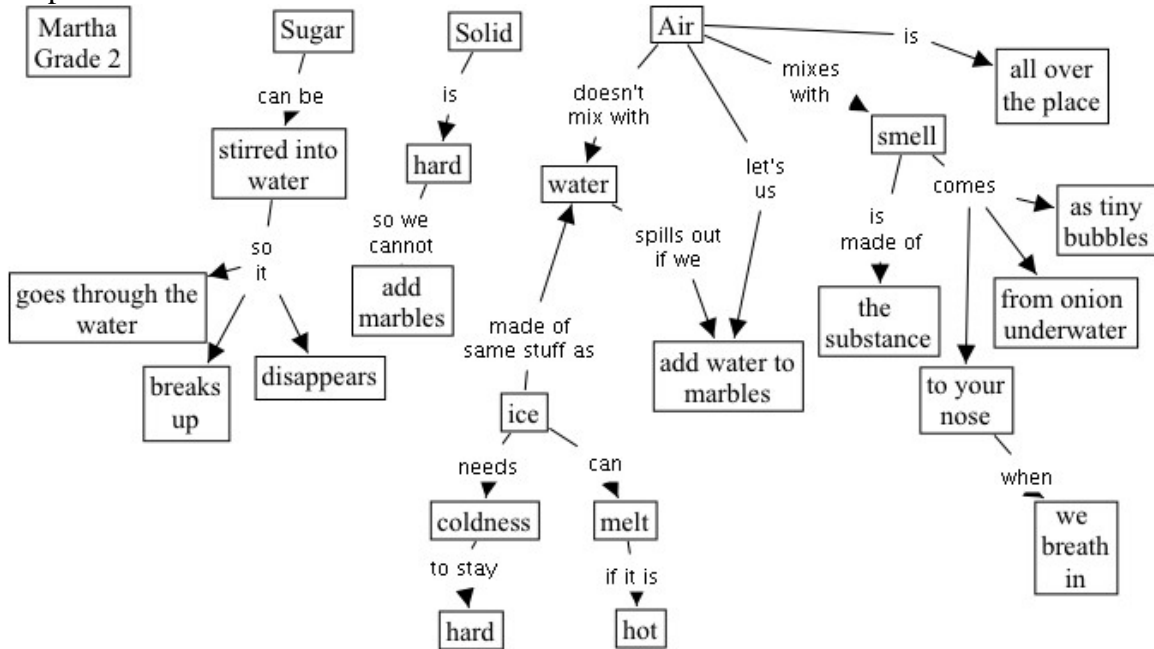

Figurer 2. A concept map drawn from an interview with a six-year old child who had audio-tutorial instruction in grades one and two, including lessons on the nature of matter. Students receiving audio-tutorial instruction in grades one and two had very significantly more valid and few invalid concepts regarding the nature of mater and energy than students who did not receive this instruction, and the difference increased from grades 2-12 (Novak and Musonda, 1991).

There is much more that can be said about ways to improve learning, but for this paper, suffice it to say that focusing on ways to encourage and enhance meaningful learning is the principal and most critical factor.

What is knowledge?

My own thinking about nature of knowledge and knowledge creation (also referred to as epistemology) was initially stimulated by Conant's (1947) book, *On Understanding Science*. A later book by one of Conant's assistants was Kuhn's, *The Structure of Scientific Revolutions* (1962). That book and Toulmin's (1972), *Human Understanding: The collective use and evolution of concepts,* helped to shape my thinking. The latter book was especially helpful not only in explaining the origins of concepts but also how they are used and how they evolve over time both for an individual and within

a discipline. Toulmin's ideas nicely complemented Ausubel's assimilation theory of learning and I later fused these ideas into an epistemology I called *human constructivism* (Novak, 1987, 1998). From these works and other readings and seminars with Gowin, a colleague at Cornell University, a definition of *concepts,* the primary building blocks of knowledge, emerged as: *perceived regularities or patterns in events or objects, or records of events of objects designated by a label, usually a word*. Most of the words in any language are concept labels, and sometime the foreign word has a slightly different meaning, since it evolved in a different milieu. Two or more concepts are combined with "linking words" to form *propositions,* and these are descriptive statements about some event of object. As we learn new concepts and propositions, we are really learning the meanings of the concepts and the relationships between them. Through the process of meaningful learning, concepts and propositions are organized into the cognitive structure of our brains. Since this learning process is to some extent idiosyncratic for every, individual, concepts and propositions have slightly different meanings for each person. This is one reason why good educational practices offer much opportunity for interpersonal interactions during learning.

As noted earlier, meaningful learning is also accompanied by some degree of affective experience and this affective connotation colors to some extent the meaning of or concepts. This is why I see knowledge creation as a human construction, and is not the same as what might be compiled by a computer. The ideas associated with Human Constructivism are on the surface simple enough, but understanding the interrelationships can be challenging. Figure 3. Shows the web of relationships that need to be considered.
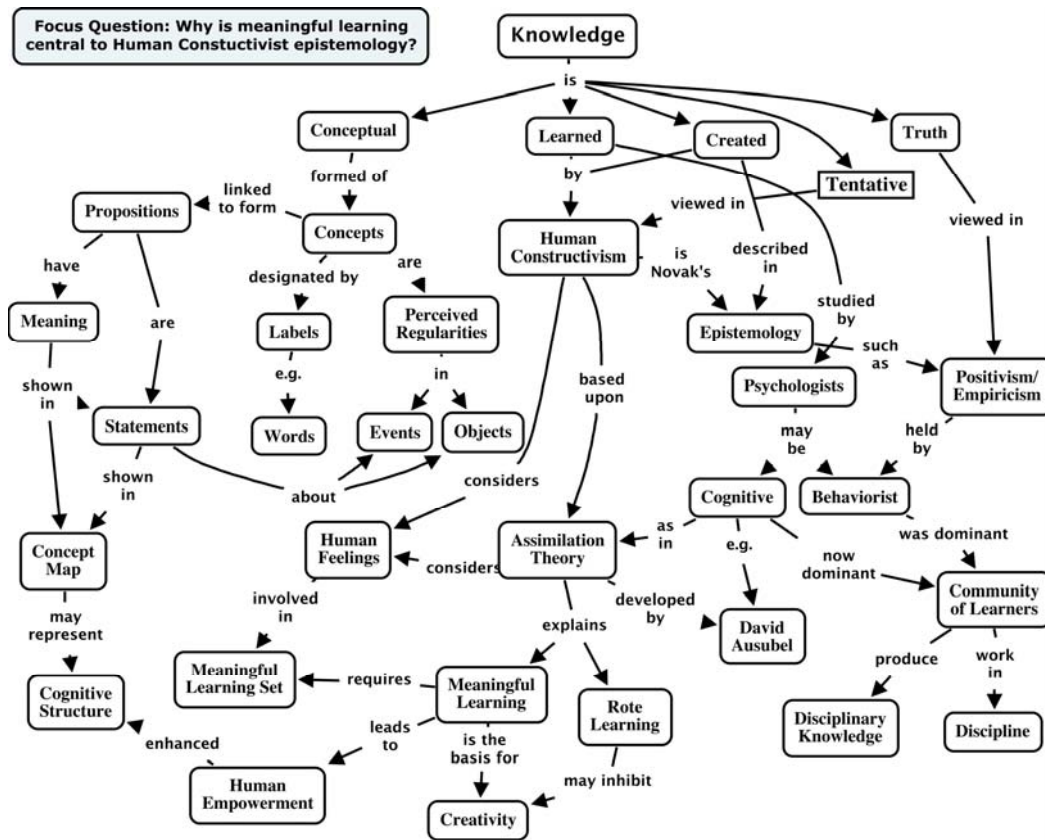

Figure 3. A concept map showing the key foundations and relationship of ideas involved in Human Constructivism (Novak, 1993).

Subject Matter

So much of school learning entails with memorization of a sea of information with little differentiation of the "big ideas" that can be so powerful in helping students build powerful knowledge structures. I recall my fascination with history after reading Muller's (1958) *The Loom of History* where he presents a series of big ideas that help to make sense out of all the details commonly taught in history classes. Similarly, Bonner's (1962) *The Ideas of Biology* showed haw several major ideas help to understand all of biology. These and similar works helped me to see that any discipline is not just an ocean of facts and figures but rather a framework of big ideas, what Ausubel called superordinate concepts, and when these were understood, all the subordinate concepts made much more sense. In other words, subject matter in all disciplines needs to be organized to first present the major ideas of a discipline and then these will help to learn and understand the usual kinds of detailed information thrown at students who may otherwise have little recourse other than to memorize the information. Of course, coming to understand a big idea such as evolution, the Renaissance, or derivative in mathematics also requires learning subordinate concepts and thus sequencing instruction around big ideas is not an easy task. This is where curriculum workers expert in the field could help, but they seldom do. We attempted to do this in 1963 for K-12 science, but the idea was far ahead of its time and never took hold (Novak, 1964; Hurd, 1964). Perhaps if we had had the concept map tool we could have better illustrated what we were proposing and made it easier for teachers and students to implement this kind of curriculum plan. Science curriculum planners would do well to revisit the plan we proposed in 1964. The curriculum proposals by AAAS (1993) and NRC (1996) failed to do this, as is also the case with the most recent NAS proposal (2010). Building concept maps as study in any field progresses can be enormously helpful to the learners and to the teachers. Thousands of examples of concept maps can be found on the web site for CmapTools (http://cmap.ihmc.us) and hundreds of research studies showing the value of concept maps can be found at: http://cmc.ihmc.us

In any discipline we mist consider more that just information in that discipline; we must also consider how new knowledge is created in the discipline, the social context in which the discipline operates and advances, and the kind of attitudes we hope to foster. We attempted to include some of this in our 1964 report and presented 5 "Processes of Science" along with a description of the 7 "Conceptual Schemes" of science. Instruction should include laboratory, library and field studies, with work guided by the conceptual schemes being illustrated. So much of the "science inquiry" activity currently so popular in the science education literature proceeds largely with students who lack the conceptual ideas needed to understand what they are doing so they can do it creatively. Without this conceptual clarity, science inquiry activities may be little better that rote learning the subject matter. More will be said about appropriate instruction as we illustrate our New Model for Education (Novak and Cañas, 2004; Novak, 2010).

The Teacher

Typically the teacher's role has been to stand before her class and dispense information to her students for them to memorize. Evaluation typically consists of multiple-choice tests that require little more than recall of information, and no evidence that the meaning of this information is understood. This model has survived for years, even though it should have collapsed after the invention of the printing press in 1440 and certainly after the development of cheap computers and the Internet in the 1990's. For most school and university classes, the traditional model of teaching remains dominant today, albeit there are some noteworthy exceptions.

It is important to recognize that ideally, teachers are also learners and they "negotiate meanings" with their students. This is a complex interaction where all five elements of education should be involved. This is illustrated in Figure 4. Concept maps when used with CmapTools facilitate a much richer exchange between teachers and learners, as well as a wide range of other educational resources. With this model, the teacher is more of a learning coach than a diseminater of information. This will be discussed later as part of our New Model for Education
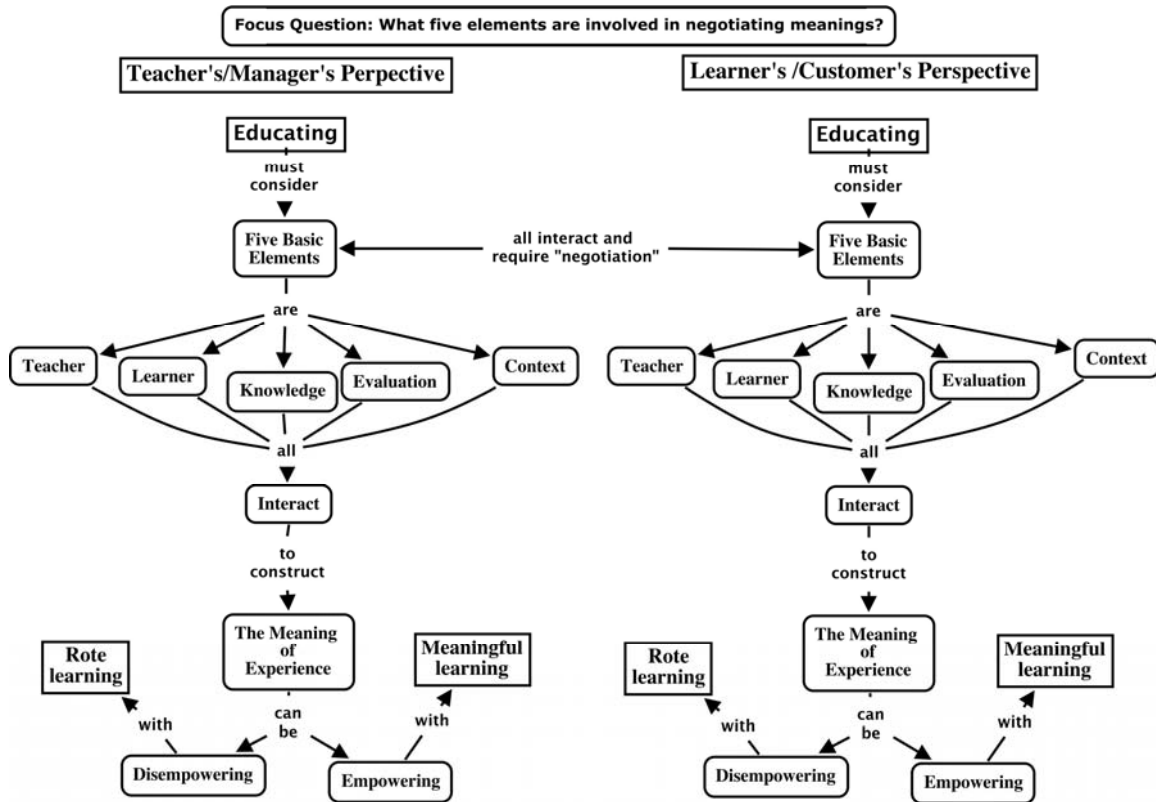
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Figure 4. Highly successful teaching requires that all five elements of education operate in learning negotiations between teachers and learners. A similar relationship should operate in business settings (Novak, 2010).

The Context for Educating

In the past two decades, we have witnessed and explosive growth in globalization. China and India have grown exponentially in economic development and their economies will surpass the US in as little as two decades. These economic realities combined with enormous growth in the number and quality of their universities mean that American workers and corporations will face even more global competition than they do today. Add to this the rapid growth of the Brazilian and Australian economies, plus a number of other countries, and we shall see a much fiercer world economic competition. This changing global context will necessitate creating much more effective educational programs for any country that seeks to maintain or raise it's living standards. For the last century, education has been the principal driver for upward mobility of individuals and countries and this is even more likely to be the case in the future. This reality is both a challenge and an opportunity. For the USA, we must seek to raise graduation rates for minorities and other groups who now suffer lost opportunities. The saying, "necessity is the mother of invention" may come to apply to education, and

the kind of education that could be achieved by the kind of science of education I am advocating here may begin to flourish in the years ahead. Progress has been slow, as is often the case when new ideas are introduced, but it is also true that subsequent changes can occur at an accelerating rate. The "egg crate" school model with rooms for a teacher and her 20 to 40 students needs to be replaced by different kinds of schools. The growth of home schooling and on-line learning already point to some of the kind of changes that need to occur Education in the future will make far greater use of technology than we see typically in today's schools.

I believe the theory of education I am sketching in this paper can help to propel the kind of changes that are needed in education. Schooling has to become more efficient. We currently spend about $10,000 per pupil per year on education in the USA, and most of the world cannot afford even a fraction of these costs. But leveraging new ideas and vastly improved use of technology, even relatively poor countries can catapult into good 21st Century education. We saw in Panama how teachers in grades 5-6 from 1000 schools could be trained to use CmapTools and the Internet in a two-week training program. Students in these schools were eager to embrace the new educational tools as shown in Figure 5. While we were a long way from implementing what we call a New Model for education, these schools were making a good beginning in moving in this direction.
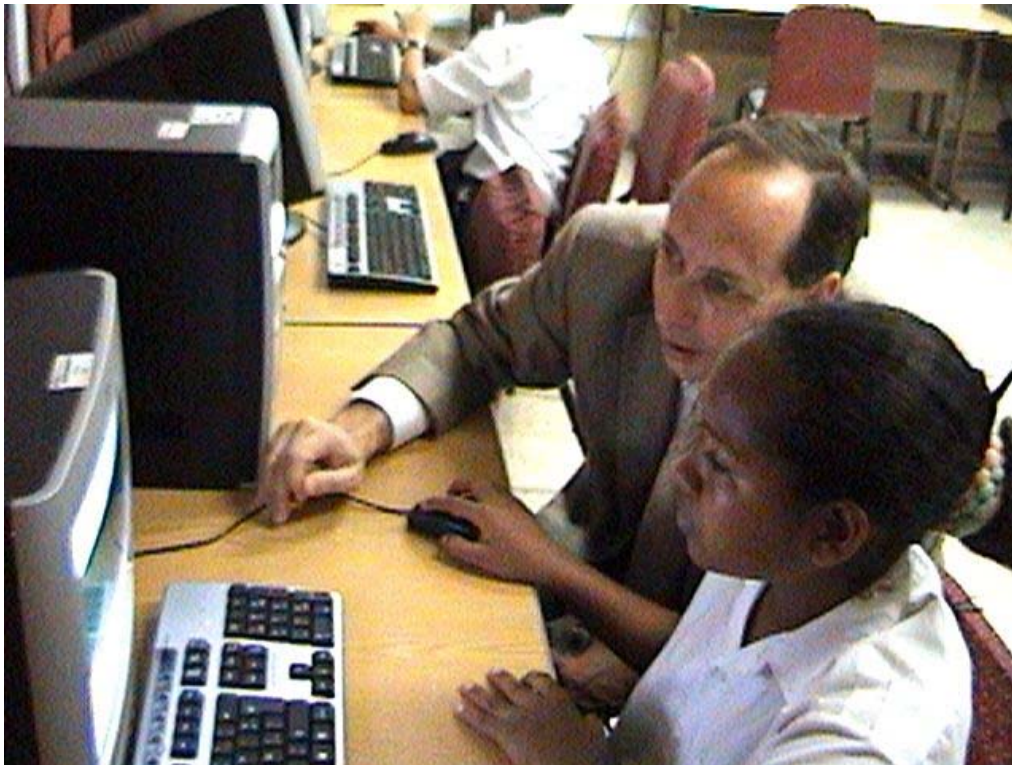

Figure 5. A 6th grade Panamanian student showing his concept map to Alberto Cañas who led the team that created CmapTools.

There have been efforts in the past to change the context for school learning such as "open classroom" configuration in the 1960's where large carpeted spaces were designed for 100 or so students to work in these common areas, but instructional materials and practices remained essentially traditional and soon these schools were demolished or walled up with book cases and cabinets or new walls. Another foolish effort was to place TV sets in every room and/or a large central facility with 50 or more TV carrel units all controlled from a central TV center. Few or no special materials were made available and by 1970, most of these efforts were abandoned.

Changing the physical context without changing all the other elements required for good education leads to costly failures. All of these elements are interdependent.

Evaluation

The fifth element in my theory of education is *evaluation*, and in some ways this is the most crucial element. For example, in the USA the No Child Left Behind program enacted in 2001 requires all schools to show higher passing scores on tests of information studied in math and English. The effect has been that most teachers and schools focus almost exclusively on raising test scores primarily by drilling on information I, and when it comes to understanding and being enthusiastic about learning, most students have been left behind. Here we see the tail "wagging the dog", where testing is driving how teaching and learning occur, but with negative consequences.

Unfortunately, it is much easier to test for rote learning using "objective" tests than to test for understanding to evaluate the gains in student understanding of subject matter, and accompanying positive attitudinal changes in their appreciation of the discipline and understanding of the ways knowledge is created in the discipline.

These issues are discussed at length elsewhere (Novak, 2010).

When instruction focuses on meaningful learning, using the kinds of tools and ideas suggested above, we not only see high achievement on standardized achievement tests but other positive outcomes. For example, Principal Otto Silesky and his teachers elected to use concept maps in every course and to stress meaningful learning and collaborative instruction. Figure 6 shows that after a year of struggle to adapt to the new strategies in 2002, achievement scores on state exams advanced to 100% passing. Perhaps even better, acceptance into tertiary education programs rose from zero percent to 20% by 2009. Both teachers and students report much more positive attitudes toward learning and toward the new educational practices.

It is not easy to change the school milieu from teacher dominated information presentation and testing for rote recall to a school where collaborative learning aimed at learning for understanding is dominant. Moreover, this kind of quality education does not cost more, it simply requires the right kind of leadership to effect the changes needed.
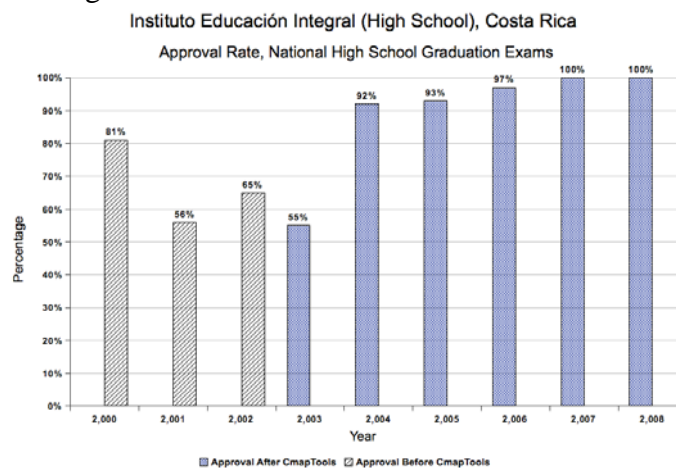

Figure 6. Approval percentages for high school graduates from Otto Silesky's school in Costa Rica before (hashed bars) and after the use of concept mapping and emphasis on meaningful learning.

A New Model for Education

With further refinement of learning theory and instructional practices that facilitate meaningful learning, the further development of CmapTools to facilitate use of Internet and other resources, and the explosive development of the WWW, it is now possible to effect what we call a New Model for Education. This New Model has three principal components:

1. The use of expert "skeleton concept" maps to scaffold learning. "Expert skeleton" concept maps are small (10-15) concepts arranged hierarchically by and expert in the knowledge domain for learners to use as a starting point to "scaffold" their learning. Possible additional concepts may be suggested in a "Parking Lot" to be integrated into the skeleton cmap.
2. Use of all features of CmapTools, including collaboration tools, to build over a span of days or weeks a personal "knowledge model" for the domain studied. This may be preserved on DVD's or hard drives and used in future years to accelerate further learning in this domain.
3. Explicit instruction in metacognitive learning and the use of metacognitive tools.

The New Model makes use of the whole palette of instructional strategies including selected readings, small group research projects, report preparation and presentation, and others as shown in Figure 7. Of course, not all of the 15 activities would be used in every study unit, but all should be used over a school year. During the course of a week to three weeks of work, 2-4 student teams work collaboratively to build a knowledge model, prepare written and or oral reports, and reflect on the work of classmates. Reports or school fairs with parents and or community groups should also follow at least once per year to engage the whole community in the learning efforts.
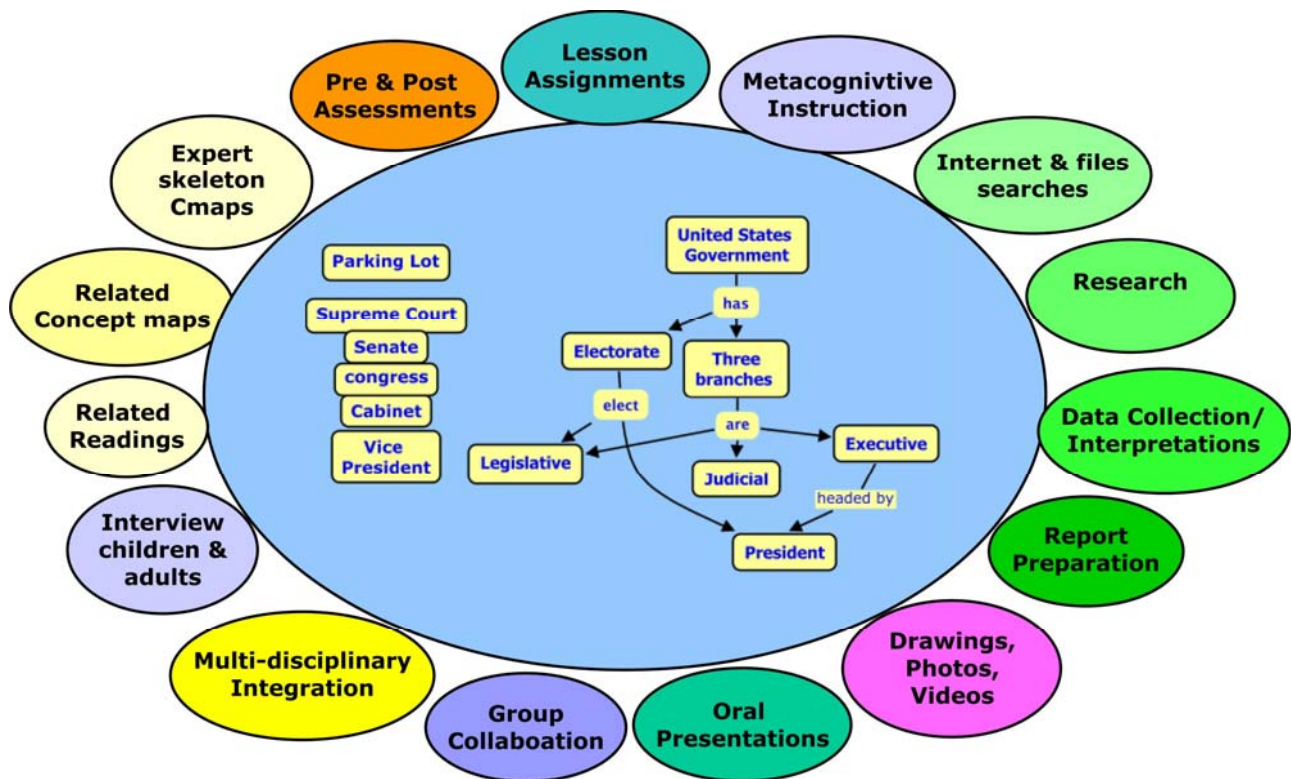

Figure 7. A schematic showing the features of a New Model for Education

While I know of no school that has fully implemented this New Model, there are all over the world many efforts at innovation that are moving in this direction. As computer prices continue to fall and capabilities of computers and Internet access continue to increase, it will be increasingly practicable to fully implement the New Model. For example, in Panama, a relatively poor country, we have worked with grade 4 to 6 teachers and principals in 1000 schools to help them begin to use the New Model. Figure 8 shows a knowledge model dealing with the Kuna Indians of Panama developed by a team of students. Figure 9 shows the chicken cages, built with help from the community, where students raised chickens to learn about animal nutrition needs, chickens that they later ate. In Italy, Professor Valitutti and his colleagues are moving towed full implementation of the New Model. Such project activities necessarily combine learning in reading, writing, oral presentation, mathematics tools and their application and the best kind of interdisciplinary study – all committed to the best form of meaningful learning. All of these projects approach the best possible implementation of all five elements of education needed for excellent meaningful learning experiences. Such implementation is not only possible in affluent countries but in all countries with stable democracies. Our only obstacle to widespread implementation of the New Model is the eternal resistance to change so common in most societies.
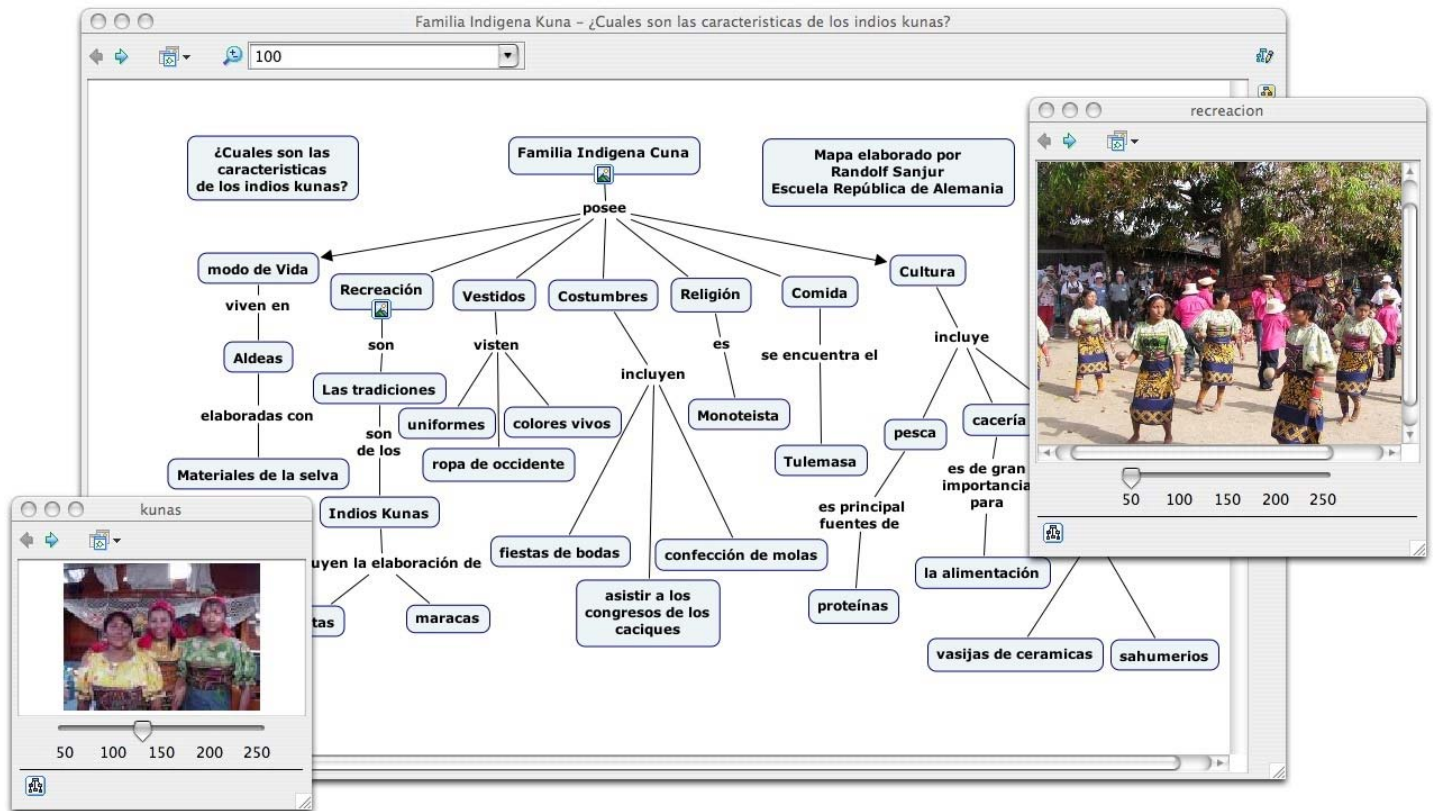

Figure 8. A digital knowledge model produced by 6th grade students in Panama, Shown are some of the resources that can be accessed by clicking on icons on concepts when connected to the server where the files are stored.

Figure 9. Chick enclosure in schoolyard where children of this rural school in Panama raise chicks. Parents helped to build the enclosures and eagerly followed the children's work.

Figure 10. 2nd grade children in Urbino, Italy study types and functions of plant leaves. Later they made concept maps to organize their knowledge.

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