MEANINGFUL LEARNING IS THE FOUNDATION FOR CREATIVITY*

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Abstract

In this paper, the author initially presents Ausubel's and his own conceptions of meaningful learning as well as the requirements for this kind of learning. In addition, creativity is seen as a consequence of high levels of meaningful learning. Creative thinking is seen as an extension of meaningful learning. Then, the focus is on the author's theory of education and on the use of concept maps as a tool to facilitate meaningful learning, to help in the work of research teams and in essential activities for professional development of teachers, to capture and record expert knowledge, using the software CmapTools, and to solve complex problems faced by private and governmental organizations. Concept mapping and this software are proposed as remarkably facilitative in creative problem solving.

Key-words: education, meaningful learning, creativity, Concept mapping.

Resumen

En este trabajo el autor inicialmente presenta las concepciones de Ausubel y sus propias concepciones de aprendizaje significativo, así como los requisitos para este tipo de aprendizaje. Asimismo, la creatividad es vista como una consecuencia de elevados grados de aprendizaje significativo. El pensamiento creativo se contempla como una extensión del aprendizaje significativo. A continuación, el foco queda en la teoría de educación del autor y en el uso de mapas conceptuales como una herramienta para facilitar el aprendizaje significativo, para ayudar en el trabajo de grupos de investigación y en actividades esenciales para el desarrollo profesional de profesores, para captar y almacenar el conocimiento de expertos, utilizando el aplicativo *CmapTools* y para resolver problemas complejos enfrentados por instituciones privadas y gubernamentales. El mapeamiento conceptual y este aplicativo son propuestos como notablemente facilitadores en la solución creativa de problemas.

Palabras clave: educación, aprendizaje significativo, creatividad, mapas conceptuales.

INTRODUCTION

Intelligence testing had its origins in the work of Binet in the early 1900s and he sought to identify those students who could profit from education in the emerging public schools in France. As the work progressed, it was recognized that intelligence is a more complex characteristic of human beings than early work might have suggested. Over time, intelligence testing evolved, especially with the advent of use of intelligence tests by the military to select soldiers for special training. By the 1950s it was recognized that intelligence tests did not measure all of the aptitudes of human beings and that another kind of assessment was needed. Guilford (1950) pioneered the development of creativity tests and this effort spread with the work of other psychologists interested in assessing a broader spectrum of human aptitudes. Torrence (1962) became well know for his tests of "creativity". Nevertheless most of the testing remained confined to some form of paper and pencil tests often times using tasks such as identifying different uses for objects such as a brick or a bottle. It was also demonstrated that IQ tests and creativity tests correlated rather poorly (Getzels and Jackson, 1962), and this might be regarded as an artifact of the unreliability of creativity tests. Today there are dozens of tests on the market that purport to assess creativity, but the theoretical foundations for these tests is at best problematic and at worst nonexistent. Numerous people have written books on creativity and two of the more widely accepted are those of Sternberg (1988) and Gardner (1994). Neither of these books explicitly links creativity with meaningful learning, albeit. Some of the recommendations for creative production could be seen as supportive of the need for meaningful learning, as I shall claim as the principal factor involved in creative production.

Building on the psychology of meaningful learning developed by David Ausubel also put forward in the 1960s, our work has taken a different direction. We see creativity as a consequence of very high levels of *meaningful learning*. Ausubel distinguished between learning by rote, or memorizing, and learning were the learner seeks actively to integrate new concepts and propositions with existing, relevant concepts and propositions the learner already knows. This is what Ausubel calls meaningful learning and he saw this form of learning as distinct from learning by rote. In our work at Purdue University and then at Cornell University, we adapted Ausubel's ideas and we found these to be powerful explanatory ideas for learning events we were observing in classroom and in laboratory settings. Initially, Ausubel did not view rote learning as on a continuum with meaningful learning, as presented in his earlier work (1963, 1968). Our work recognized that both the quality of relevant s possessed by the learner and also the degree of effort made to seek integrations of new ideas with existing ideas strongly pointed toward a continuum

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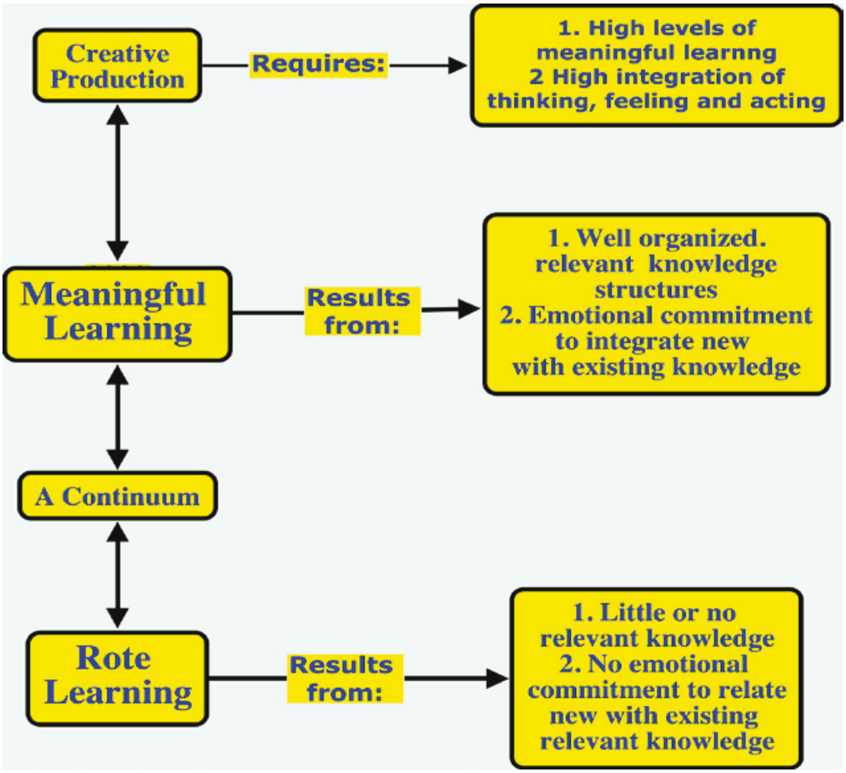

Figure 1. The rote-meaningful learning continuum illustrating also the basis for creative production resulting from very high levels of meaningful learning.

in quality of meaningful learning, and Ausubel later accepted our view (Ausubel, et al, 1978; 2000). This view is illustrated in figure 1. What we have added from our work is the idea that the creation of new knowledge is also a meaningful learning process. We see creative thinking as essentially very high level of meaningful learning, a level not reached by most individuals in the course of ordinary school learning or indeed in routine research and practice. The reason we have extended the learning continuum to include creative production derives in part from the epistemological ideas we have developed where we see the creation of new knowledge as fundamentally an extension of meaningful learning at a very high level (Novak, 1987; 1993).

In this paper I will develop further the argument that creative thinking can be seen most parsimoniously and most productively as an extension of meaningful learning. I will also discuss the implication of these ideas for the improvement of school learning and creative production including work in studio or laboratory settings. This model of creativity is equally applicable to all fields of human endeavor, although there are some obvious distinctions from discipline to discipline especially as regards the tools used for knowledge creation and the kind of skills that are needed in dealing with the content of that discipline. Obviously creating a new musical score involves a substantially different set of skills from the creation of knowledge in the science laboratory. Kuhn (1962) saw this complex of concepts and methodology as *research paradigms*, and the most creative researchers create new paradigms. Nevertheless, I see creative production in all settings as fundamentally high levels of meaningful learning.

THE REQUIREMENTS FOR ACHIEVING HIGH LEVELS OF MEANINGFUL LEARNING

There are three fundamental requirements for meaningful learning:

1. The material to be learned must be inherently potentially meaningful.
2. The learner must possess relevant concepts and propositions in her cognitive structure.
3. The *learner* must choose to relate and integrate the new ideas with existing relevant ideas in her cognitive structure.

The first requirement is that the words, images and things we use must have meaning to the learner. Most words are concept labels. We define concept *as a perceived regularity or pattern in events or objects, or records of events or objects, designated by a label,* which usually is a word. If a child has no idea what pattern or regularity is represented by a word, that word has no *meaning* to the child. By school age, normal children have acquired meanings for several thousand words, so we have a good beginning knowledge framework to initiate meaningful learning on most topics we choose to teach. Things and images can vary widely in their familiarity to any given group of children, so we must take care to check on the target group's meanings for things or images we wish to use. We also need to check on the meanings children hold for words we use, since most words have more than one meaning.

The second requirement is in part dependent on the design of the curriculum. One of my arguments with the AAAS (2011) *Benchmarks* and NRC 1996) *Standards* for science curriculum plans is that they fail to introduce children to ideas of the particulate nature of matter and the nature of energy and energy transformations until grades 7 or 8. This means that almost all ideas of science from boiling and evaporation to breathing and digestion mechanisms cannot be understood and reduce learners to the necessity of rote learning most science topics. This problem derives from years of misunderstanding of the learning capabilities of young children, a problem partly deriving from Piaget's (1926) ideas of stages of cognitive development that grossly underestimate children's learning capabilities (Donaldson, 1978; Gelman, 1999; Keil, 2011). Of course, early introduction of matter and energy concepts in our audio-tutorial program (see figure 2) required very careful selection of hand-on experiences and these were some of the challenges we faced in the

Figure 2. A 6-year old child working with a board that allows changing electric energy from a battery into light energy (bulb), kinetic (motion) energy (of a motor), and heat energy (small heating coil). Audio-guided hands on activities help young children acquire early understanding of basic science concepts.

design of these audio-tutorial lessons for 6-8 year old children (Novak & Musonda, 1991). We had to be sure each activity was based on prior common experiences 4-5 year old children had previously had, or on those that had been provided in earlier audio-tutorial lesson. Many of the lessons required the design of special equipment to illustrate the concepts we sought to teach. When early instruction in key science concepts is delayed until upper grades, children often form their own faulty ideas or misconceptions, and these can be inordinately difficult to overcome in later instruction as Schneps (1989) and his colleagues have so nicely demonstrated in the Private Universe Project. Schneps video tapes demonstrate the stubborn persistence of basic science misconceptions even with college graduates, a problem derived in part from the lack of meaningful learning in school and college (Novak, 2002).

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Third, the *learner must choose* to learn meaningfully. This is a requirement that is primarily determined by the learner, although we can influence the learner's approach by the kind of instruction we design and by the assessment or evaluation we use to judge learning. It is important also to help learners understand the difference between rote and meaningful learning and why the latter is superior. The latter is part of the metacognitive instruction that can be very helpful to learners (Bransford, et al, 1999; Kuhn, 2000). Exploration of how things work, especially with appropriate language guidance, can be very effective in encouraging meaningful leaning (Bransford, et al, 1999; Kuhn, 2000).

THE ROLE OF A THEORY OF EDUCATION

For the past half-century I have pursued the idea that education can be improved if we can make the enterprise more like science, guided by theory and sound principles that were developed and verified through systematic research. My first effort to present such a theory was published in 1977, *A Theory of Education.* That book built on Ausubel's learning theory and more recent advances in epistemology that had been developing in the previous decade. The theory helped to guide our research team and led to not only improved research studies but also significantly improved instructional programs. As our research and instructional innovation continued, it became evident that there was a need for further clarification of key aspects of the theory of education. My first effort to refine the theory was published in 1998 with the title, *Learning, Creating, and Using Knowledge: Concept maps as facilitative tools in schools and corporations.* In this book I presented 5 fundamental *elements of education* each of which must be considered in any successful educational event. The 5 elements presented were: 1. the learner, 2. the teacher, 3. the curriculum, 4. the context, and number 5. evaluation. To optimize an educational event, one must attempt to optimize each of these 5 elements as they operate in that educational event. The book presented ways to optimize each of these elements for effective education. These ideas were seen as equally applicable to the corporate world and other organizations, where managers are seen as teachers and employees as learners, albeit, in optimal educational events, teachers or managers are also learners, and employees and customers can be seen also as teachers. I summarized the theory of education presented with *this* statement:

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

In my 1998 book, I illustrated how meaningful learning plays a role in optimizing the educative value of each of the five elements. I tried to further illustrate and clarify the role that meaningful learning plays to optimize education in the second edition of this book published in 2010. Knowledge creation became recognized as the principal challenge facing corporations in the last two decades (Nonaka and Takeuchi, 1995); Ichijo & Nonaka, 2007). During the interval between 1998 and

2010, most of my efforts involved applying my theory of education in corporations and other organizations such as NASA, Department of Navy. National Security Administration, members of the Electric Power Research Institute and other organizations. Some of the latter groups also provided funding to the Florida Institute for Human and Machine Cognition to dramatically improve the concept mapping software called CmapTools. This excellent concept mapping software is available to anyone at no cost at: http://cmap.ihmc.us.

APPLICATIONS OF THE THEORY

When concept maps are used as a tool to facilitate meaningful learning, and also as an assessment tool, learners of all ability levels can improve the quality of their learning (Novak & Gowin, 1984; Novak, 1990; Cañas & Novak, 2008). Hundreds of examples of research studies demonstrating the value of concept maps in many different fields can be seen at the web site for International Conferences on Concept Mapping: http://cmc.ihmc.us

To be sure, there is a wide range of aptitudes in any population of learners, so we should expect to find variation in the skill with which individuals will master meaningful leaning in any field. However, using concept maps and applying ideas to facilitate meaningful learning can benefit all learners, including those suffering from dyslexia (Acedo. 2008) and autism (Roberts & Joiner, 2007).

We have found that the use of concept maps can facilitate the work of research teams. Typically, a research team will review and discuss relevant research papers. However, the *conceptual frameworks* that are an essential part of these papers are often poorly presented, and it is common for a research team to disagree on the value and meaning of specific papers. We have found that when the papers are concept mapped and these maps are shared with the team, the team rather quickly moves to a consensus on the value of the paper and the implications for the team's research efforts. We found this to be especially true with R&D teams in the corporate world. Unfortunately, most of the best examples of successes deriving from team concept mapping in corporate R&D settings cannot be shared for confidentiality reasons, partly due the precision with which they show strategic thinking leading to corporate problem solving. However, I can present one example from one of my graduate students who worked in the area of plant pathology at Cornell University.

Christi was interested in the problem of grey mold that attacks a number of crop and ornamental plants. She studied the literature available and found that when she concept mapped the ideas in these papers, there were six areas of the map where the literature did not provide information on key relationships. This provided six questions that needed research, and these were addressed in her thesis work. Figure 3 show the concept map Christi Palmer (1996) prepared and the six research questions she identified. The experiments that needed to be conducted to answer these questions are relatively common in plant pathology, so Christi proceeded expeditiously with her work, and also with her thesis writing that proceeded to answer the six

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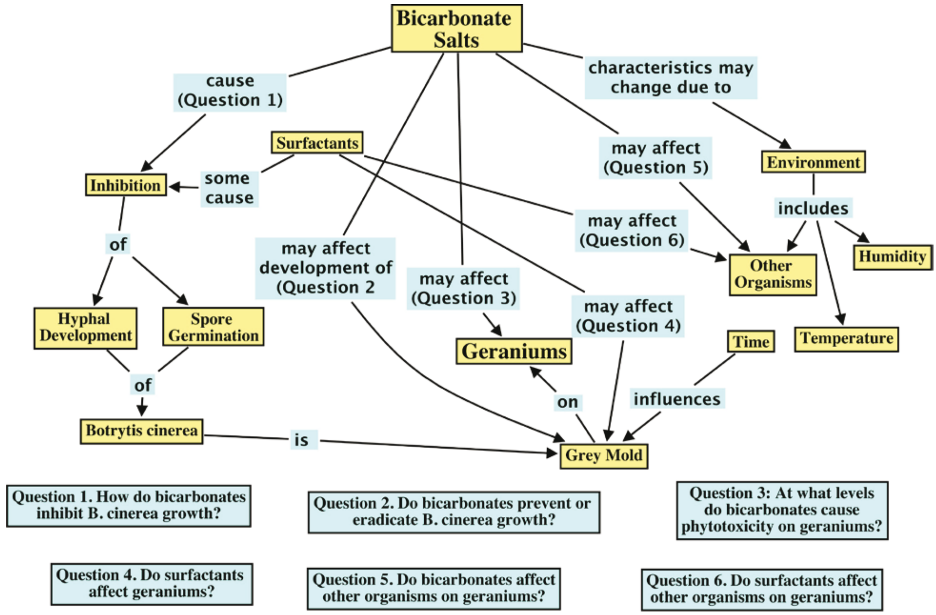

Figure 3. A concept map showing the knowledge found in the literature on the affect of bicarbonate salts on grey plant mold disease, showing 6 gaps in the knowledge pertinent to this topic. Below are 6 questions to be addressed by experiments to answer these questions.

questions identified. Her doctoral committee was pleased with her work, and she proceeded easily with preparation of papers for publication of her work.

According to our theory of learning, significant new insights may occur when concepts and propositions in one domain of knowledge can be related in some important way to concepts and propositions in another domain of knowledge. Such relationships may achieve what Ausubel called *integrative reconciliation*. In this process, new relationships of subordinate concepts may be recognized and assimilated. Concept maps can facilitate this process in that they allow relatively easy ways to search for and locate important new relationships. This is also the essence of the creative process. We have found in working with research and development teams in many settings that when they prepared good comprehensive concept maps for the knowledge pertinent to their problem, looking for cross-links in these maps often led to creative insights. Similarly, comprehensive concept maps dealing with management problems often point managers and associates to see new solutions to these problems.

A good example of the latter was work done by Bowen and Meyer (2008) in a professional development program for teachers in Washington State. A comprehensive concept map on ideas and activities essential for professional development of teachers was prepared and this was presented to 21 new mentors in the program.

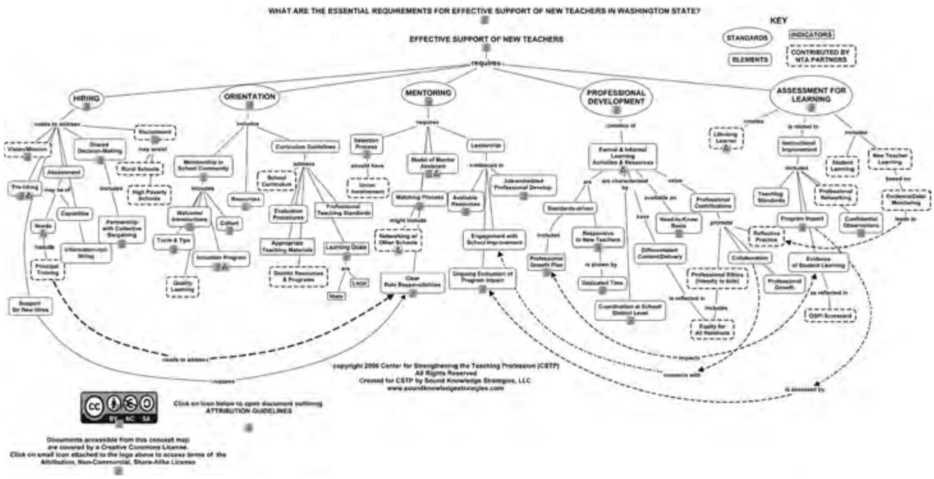

Figure 4. A comprehensive concept map prepared to guide a teacher mentor training program in Washington State led to additional creative insights (showed with dotted lines) and additional resources accessed by icons on the map. Reproduced with permission from Barbara Bowen and Jeanne Harmon (2004).

The teacher mentors discussed the map presented and suggested additional relationships and resources that could be added. The discussion led to new insights for the improvement of the mentoring program. The enhanced concept map that emerged is shown in figure 4. Dotted lines show some of the new insights that were suggested by the teacher -mentors. Icons on concepts open resources that further enhanced the mentor training program. Mentor participants and program sponsors were very impressed with the quality and creativity the training achieved with these methods.

The best example of creative insight being derived from a concept map in my own work was my effort to see how ideas from learning theory could be integrated with ideas from epistemology, leading to a more comprehensive view of human knowledge creation I call *Human Constructivism*. Figure 5 shows the figure that helped me to see how humans construct new knowledge, integrating ideas from Ausubel's learning theory and from epistemology. This figure has also proved useful in explaining my theory to students and colleagues.

Over the past 30 years, I have worked with thousands of students and colleagues using concept maps to elucidate and represent complex knowledge domains. This process has been much facilitated by the development of CmapTools, a software suit developed in the 1990's by the Florida Institute for Human and Machine Cognition and is available at no cost, as noted above. Much of the funding for the development and use of this software came from NASA, Department of Navy, National Security Administration, and other federal and private organizations. The principal uses in the training programs we offered dealt with the use

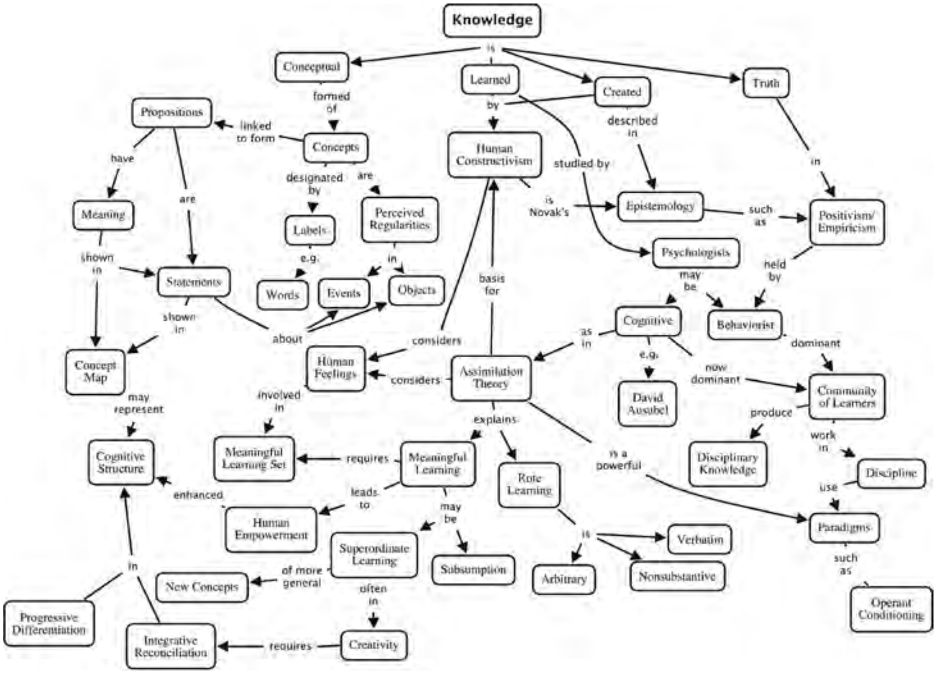

Figure 5. A map showing the key concepts and relationships in my *Human Constructivist* epistemology. Building various iterations of this concept map helped me to shape this epistemological view.

of this software to capture and archive expert knowledge, and to use the concept maps to solve complex problems faced by these organizations. We refer to these comprehensive knowledge archives as *Knowledge Models*, since they serve to guide inquiry and also new learning. Frequently it was observed that concept maps could facilitate team problem solving and the finding of creative solutions. One of the recent comprehensive knowledge models created for NASA deals with frontiers in space exploration. The concept maps and other resources assembled for this project can be seen at: http://spaceexp.ihmc.us.

At first blush one might say that the model of creativity I have presented is simplistic and not sufficiently comprehensive. I and my colleagues have not found this to be the case. What the model achieves is this: "simplicity that captures complexity is elegance". In a wide variety of subject matter domains and with various types of problems, we have found the use of CmapTools to be remarkably facilitative in creative problem solving. Albert Einstein said that everything must be made as simple as possible. Underline Communications (2010) argues: "Elegance" is simplicity in action, producing a result that is satisfyingly—and often surprisingly—powerful." As a biologist, I recognize the elegance of the Watson and Crick solution where they showed the structure and function of all things alive, or that have ever lived, could be coded by sequences of just four kinds of molecules, adenine, quanine, thymine, and cytosine—that is elegance! For skeptics, I invite you to try using concept maps whenever you seek a solution to a complex problem. This may aid you to achieve the high level of meaningful learning required for a creative solution.

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