NEXT STEP: CONSOLIDATING THE CMAPPERS COMMUNITY

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Abstract For more than three decades, the refinement and use of the concept map tool has been evolving, with new applications to improve school teaching and learning, new ways to capture and use of expert and tacit knowledge, better ways for searching and organizing information from the Web, and better tools for collaboration locally as well as internationally. While we anticipate this utilization "growth phase" will continue, we seek in this paper to present some ways to move toward building collaborative communities of users who will work to provide guidance to new users and mechanisms for evolving better organized sets of concept maps. We also seek to develop new Web sites to facilitate the latter developments.

1 The Origins

Concept maps, as we define them, were first developed in 1972 as a tool to study changes in children's conceptual understanding of basic science concepts (Novak & Musonda, 1991). We faced the challenge in our research program of trying to find a way to illustrate clearly what cognitive changes were taking place in the 6-7 year old children we were working with, providing instruction in the particulate nature of matter, energy and energy transformations. While we found modified Piagetian interviews appeared to probe children's knowledge, it was difficult to see clearly what changes were occurring in their cognitive structure that was leading to their manifest better understanding of basic science concepts. Novak's research group at Cornell University revisited key ideas in Ausubel's (1963, 1968) cognitive learning theory on which their research and instruction was based, and decided to try to represent the concepts and propositions put forward by their students in the simplest possible form, namely concept labels in boxes linked with a line and "linking words' to form a proposition. In keeping with Ausubel's ideas of hierarchical structure of cognitive structure, concept maps were drawn with the most general, most inclusive concepts at the top and most specific, least inclusive at the bottom. Working from interview transcripts, concept maps were drawn, using pen or pencil and paper, representing the concepts and propositions the child held for a given domain of science. The team found it relatively easy and reliable to represent children's knowledge in this way. Figure 1 shows and example of one of these early concept maps.

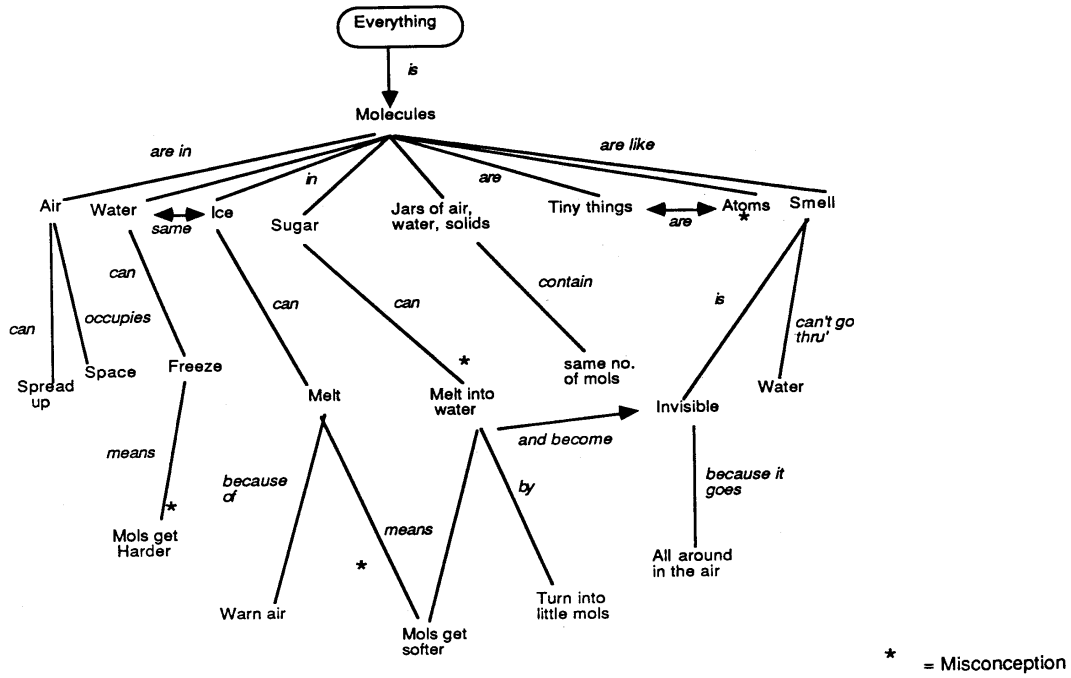

Figure 1. An example of a typical concept map drawn from an interviews with a children at the end of second grade (age 8), from Musonda (1986, p. 118).

We soon found that concept maps were also effective in helping students to organize and better learn subject matter. Six-year-old children could begin with a short list of related concepts and organize these into very meaningful concept maps. Figure 2 shows an example from our early work.

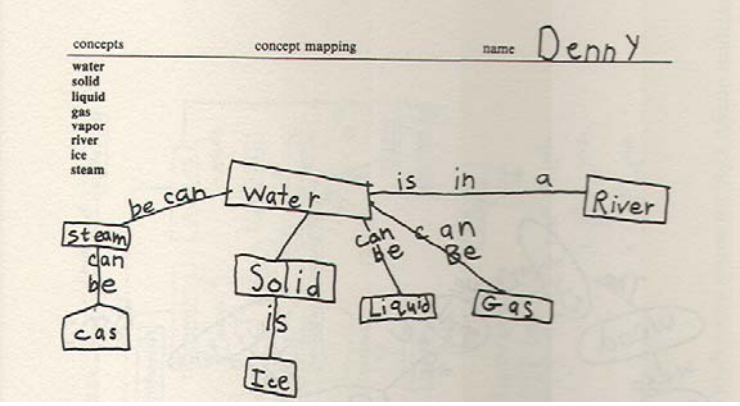

Figure 2. A concept map drawn by 6-year old children using the concepts provided on the left side. These were the first concept maps made by this child after a class demonstration drawing a sample map about plants. (From Novak & Gowin (1984, p. 177)).

By the mid 1970's, Novak and his colleagues were using concept maps as a tool to facilitate meaningful learning in every subject matter area, and at all age levels. Moreover, they found that students working with concept maps were also *learning how to learn* (Novak & Gowin, 1984).

2 In Memory of David Ausubel, 1918-2008

For most of the 20th Century, North American psychology was dominated by behavioral psychologist who held that only manifest behavior can be observed scientifically, and it was unscientific to speculate on the inner workings of the brain in describing learning processes. The behaviorists so dominated North American psychology, and psychology in many other countries, that other viewpoints had difficulty getting published or presented in classrooms. Piaget's monumental works on children's mental development, while popular in Europe were rarely presented in American classrooms until the 1960's when his work was "rediscovered" (Ripple & Rockcastle, 1964). It was the pioneering efforts of Ausubel and his students that helped to turn the tide to what is now the widely popular cognitive psychology. Ausubel's *The Psychology of Meaningful Verbal Learning* (Ausubel, 1963) and his *Educational Psychology, A Cognitive View* (Ausubel, 1968) led the way to what became the "cognitive revolution" in the 1980's.

Perhaps Ausubel is best known for his idea of *advance organizers*, i.e., a small segment of instruction that is more general and more abstract than related instruction that followed. Research studies by Ausubel and others showed that advance organizers when well planned can significantly enhance subsequent related learning. Advance organizers were an instructional tool, but they also related to a fundamental principle in Ausubel's assimilation theory of learning, namely that new learning proceeds best when it deliberately builds on the learner's prior relevant knowledge. In fact, 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.*

Figure 3. David and Gloria Ausubel touring wineries in Upstate New York, 1989.

It was the challenge of ascertaining what relevant concepts and propositions the learner already knew that was the driving problem that led Novak and his students to develop the concept map tool. This also became an important tool for helping students and teachers build on what the learner already knows. While we hear and read today a good deal about the importance of *constructivist* teaching and learning approaches, many of these fail to recognize the critical and explicit role that the learner's relevant concepts and propositions play in new learning. To fully understand how and why to use concept maps to facilitate learning, it is useful to read some of Ausubel's writings on the nature and role of meaningful learning to build powerful knowledge structures and powerful learners. Figure 3 shows David and his wife Gloria on a happy tour of wineries in Upstate New York in 1989.

3 Concept Mapping reaches Maturity

Concept mapping proliferated throughout the educational community during the 1980s, as reflected in the translation of *Learning How To Learn* (Novak & Gowin, 1984) to 9 languages. It was, however, during the 1990s that concept mapping's popularity as a knowledge representation tool began spreading into domains beyond education and started making its appearance in organizations and corporations (Novak, 1998). The development of concept mapping software further facilitated the construction of concept maps, but it was the integration of concept mapping with the Internet and the Web that took concept mapping to new levels of applications. The spreading of concept mapping to all domains and throughout the world is demonstrated in the variety and breadth of papers presented at the First (Cañas, Novak, & González, 2004) and Second (Cañas & Novak, 2006) International Conferences on Concept Mapping as reported by Daley *et al.* (2008), and at this Third International Conference on Concept Mapping (Cañas, Reiska, Åhlberg, & Novak, 2008). In this section we discuss some aspects of how this maturity was reached.

3.1 Making Tacit Knowledge Explicit, or Making Private Knowledge Public

When Michael Polyani (1958) first introduced the idea of *personal* knowledge in 1958 he was speaking primarily to how scientists reason, not only using the hard data from their research but also subtle and unarticulated ideas based on their years of experience. In 1966 he expanded on his ideas and labeled this personal knowledge *tacit* knowledge (Polyani, 1966). The importance of tacit knowledge is now recognized as very important not only in sciences but in every field. Nonaka and Takeuchi (1995) argued that tacit knowledge was essential to recognize and capture, if possible, for the successes of any business. Today most corporate executives recognize the importance of tacit knowledge, albeit many lack the tools and ideas to help make workers' tacit knowledge explicit.

When Novak and his colleagues observed young children working with science materials in guided instruction, it was evident that they appeared to have more knowledge than they were able to express. This private or tacit knowledge, if it could be captured, would help to explain why some learners appeared to grasp quickly specific scientific ideas, whereas others did not. It was this challenge that was part of the motivation to create a new tool to represent the children's concept and propositional knowledge. We soon found that the concept map tool not only could capture the explicit statements made by students to explain how some event or object behaved; it also could reveal more subtle knowledge that was not evident in simply listening to a child talk or interviews with the child. However, it took some years before we came to fully appreciate this power of the concept mapping tool.

In 1986-87, Novak spent a sabbatical year at the University of West Florida and began collaborating with Cañas and colleagues who formed what is now the Institute for Human and Machine Cognition (IHMC) in Pensacola, Florida. In the early 1990s, this collaboration lead to the development of ICONKAT (Ford et al., 1991), a software tool to aid in the elicitation and representation of experts' knowledge. ICONKAT was used with Dr. Andrews, a local Pensacola cardiologist interested in better ways to train cardiologists to use a technology that permitted a non-invasive way to assess cardiac functions and abnormalities. Concept maps were used to represent Andrews' knowledge and an expert system was developed (NUCES) that aided in the diagnosis of coronary problems and trained new users in interpreting the images used in the technique (Ford, Coffey, Cañas, Andrews, & Turner, 1996). NUCES used concept maps as an explanation/help component (Ford, Cañas, & Coffey, 1993), as shown in Figure 4. It was in NUCES that we first used icons under concepts to link other resources that contained information related to the concept, as shown in the Figure.

The success of NUCES led to new projects, including, El-Tech, a collaboration with the Department of Navy to capture the expertise needed to repair electronic equipment on ships (Coffey et al., 2003), and other

similar systems (e.g., Hoffman, Coffey, Ford, & Carnot, 2001). This attracted funding not only from the Navy but also NASA, Department of Defense, and other agencies for the development of the CmapTools software (Cañas, Hill et al., 2004), described in next section. Geoff Briggs at NASA Ames lead the development Mars 2001 (Briggs et al., 2004), which showed how concept maps could be used to organize large amounts of resources and conform an easy to navigate Website. These efforts together with work by other colleagues at other places helped demonstrate the value of using concept mapping in organizations and corporations, at a time when "knowledge management" was in its infancy.

Friedman in his book, *The World is Flat* (Friedman, 2005), presents a compelling case that we have moved from the Information Age to a new world where virtually anything can be made anywhere and shipped anywhere primarily because there are virtually no boundaries on knowledge and knowledge utilization. His case is illustrated in recent work by Procter and Gamble reported by the Vice President for Knowledge and Innovation, Larry Huston together with N. Sakkab (2006). When it was suggested that printing popular pictures on Pringles™ might increase sales, they searched the literature and found a researcher/baker in Italy had developed a method for printing pictures on bread. Working with this baker, it was relatively easy to adapt the technology for use with Pringles, and this led to double-digit growth in sales of Pringles. Procter and Gamble now routinely searches the literature for research relevant to their interests, saving millions of dollars in R&D development costs. Currently Huston is working with researchers in India and other countries to prepare comprehensive concept maps dealing with diabetes, eye care and other areas of health care. We similarly find innovative ways in which concept mappig is being used in organizations and corporations worldwide.

3.2 Concept Mapping Meets the Internet & the Web

Early concept mapping software facilitated the construction of concept maps but did not provide any additional features. When a new generation of concept mapping software appeared that took advantage of the facilities offered by Internet and the Web, (e.g., Alpert & Gruenberg; Cañas, Hill et al.; Gouli, Gogoulou, Papanikolaou, & Grigoriadou, 2003; Simón, Estrada, Rosete, & Lara, 2006), concept mapping was shown to be useful for applications that we didn't even dream of when concept mapping was developed decades earlier. Concept mapping software like CmapTools greatly expand the power of the concept mapping tool, enabling easy collaboration between individuals either locally or remotely via the Internet, and either synchronously or asynchronously. In addition, the software allows the user to easily create knowledge models –collections of concept maps and attached resources about a domain of knowledge– and publish them on the Web. These and other capabilities provided by this new generation of concept mapping software tools confer a whole range of new opportunities for facilitation of learning, creating, archiving, and using knowledge.

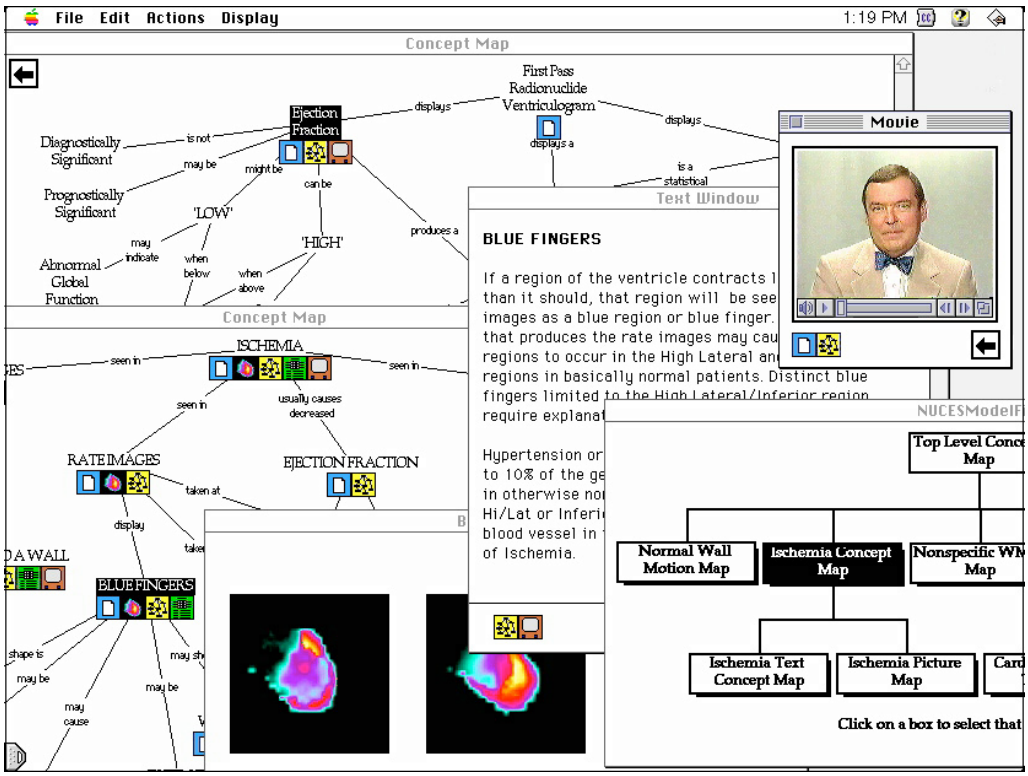

Figure 4. The development of ICONKAT and NUCES demonstrated the use of concept maps beyond education.

3.3 From Learning by Individuals to Collaborative Learning

As the Pringles example illustrates, knowledge creation and knowledge utilization is increasingly becoming a collaborative effort. The powerful collaboration tools included in CmapTools can greatly enhance collaborative knowledge building and knowledge sharing. We have proposed a New Model of education based on a concept map-centered learning environment (Cañas & Novak, 2005; Novak & Cañas, 2004) where the concept map is used throughout the development of units or projects to show the increase in understanding as students progress, creating a knowledge models that are incorporated into the students' portfolios, and where collaboration at the classroom, school, national and international level is encouraged (see, for example, Figure 5). As an exemplar of this idea, in Panama we are engaged in the *Conéctate al Conocimiento* project (Tarté, 2006), a nationwide effort lead by the President through the Secretary for Governmental Innovation that aims at incorporating meaningful learning through concept mapping into the elementary public schools in the country. Over 6,000 classroom teachers from over 700 schools have been trained and are using concept mapping, CmapTools, and collaborative projects to transform the way learning takes place in the classroom. Elsa Sanchez et al.'s (2008) "Who Am I?" project demonstrates the sense of community and the power of collaboration, publishing and sharing in *Conéctate*.

The methodology proposed and being implemented in Panama is particularly effective when used in environments with high density of laptops per child, whether its 1:1 ratio (one laptop per student) or through sharing of laptops. Otto Silesky's keynote presentation at this conference is a clear, documented, example of the results that can be obtained.

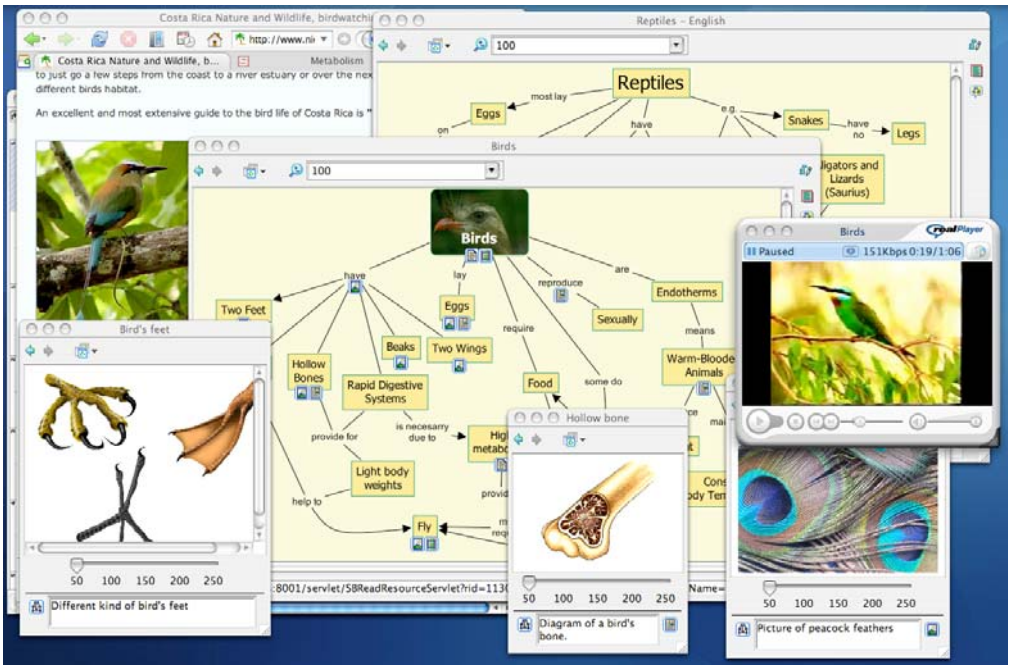

Figure 5. A Knowledge Model on birds shows the concept maps and linked resources.

4 Consolidating the Cmappers Community

After years of spreading throughout all types of organizations and domains of knowledge, we feel confident in stating that concept mapping is used all over the world. The realization of a Third International Conference on Concept Mapping, with many of the participants repeating from the previous two conferences, is proof of the existence of a strong concept mapping community. Papers from all continents and in a large variety of domains further demonstrate the worldwide breadth of the community. From our standpoint, the extended use of CmapTools throughout the world is one more evidence of the far-reaching use of concept mapping. Figure 6 shows the CmapTools clients and CmapServers that connected to IHMC's Directory of Places (DOP) during

2007.[1] Clearly, concept mapping users cover the whole world. Additionally, the *Conéctate al Conocimiento* project is a clear example that concept mapping is growing not only in extension but also in "intensity": in many organizations and countries it's not only a few isolated users that use concept mapping, it's a constantly growing number of users.

We feel that the Cmappers community has grown and matured to the point where we need to further organize and help and collaborate with each other to continue growing. We are involved in three efforts that we open to the community as a means to share and collaborate in a continuing effort to support concept mapping.

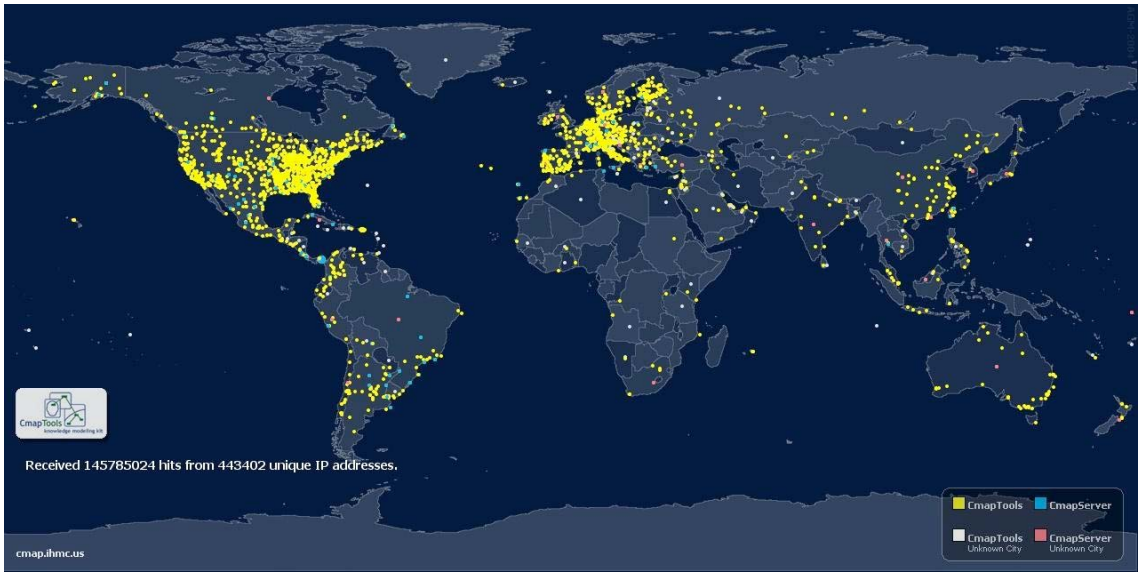

Figure 6. Locations of CmapTools clients and CmapServers that connected to IHMC' Directory of Places (DOP) during 2007.

4.1 A Concept Mapping Training Website

In a collaborative effort, IHMC and Microsoft Corporation are developing a Website aimed at facilitating learning about concept mapping and its applications. The Website will consist of a repository of resources (documents, videos, papers, Webpages, concept maps) about all topics related to concept maps (theory, applications to education at all ages, business, science, engineering, etc.) organized in numerous ways as non-linear *itineraries* by means of concept maps, in such a way that users with different expectations and interests can find an *itinerary* that will fit their needs. This Website will be open to anybody anywhere. We want to invite the concept mapping community to add resources and create *itineraries*. For example, a faculty member in nursing could create an *itinerary* that consists of the resources and activities that he/she considers his/her students should follow. This *nursing itinerary* could then be made public and could be used by people interested in concept mapping in nursing from other parts of the world. Users will rank *itineraries*, and thus those that are well received by students will be ranked high and will show as such on the site. Since learning to construct good concept maps generally requires the learner to receive feedback on the quality of the map, we propose that through forums users will be able to request from the community a volunteer that will help him/her improve his/her concept mapping skills. Through a joint effort, we could together take concept mapping to anybody who is interested with quality training.

4.2 A Student Collaboration Website

Concept maps have been shown to be an effective collaboration tool. While jointly constructing concept maps, students need to negotiate meaning and reach an agreement on the propositions that are included in the map and their organization. Additionally, the concept map is an "artifact" over which the students collaborate, and is itself the result of the collaboration. Teachers and students all over the world use concept maps in the classroom,

[1] The map actually shows the location of the Internet Provider, not the CmapTools client or CmapServer, and therefore does not really correspond to all locations where the software is run. CmapTools clients and CmapServers not connected to the Internet, behind restricted firewalls or configured not to connect to the Directory of Places are not shown.

and many are particularly interested in establishing collaboration with other classrooms. Efforts like Tifi and Lomardi's WWmaps (2006) further demonstrate that through some structure and coordination, collaborative concept mapping projects can be established between schools in different countries, even when there is no common language between the students. In a collaborative endeavor between IHMC, Microsoft Corporation, and UNESP university in Brazil, a Collaborative Projects Website for teachers and students is being developed, that will be open to teachers and students from schools all over the world. By proposing new projects or registering for pre-established projects, teachers will be able to link to other teachers and get their students involved in collaborative projects. We invite teachers from around the world to get involved, with their students, in collaborative concept mapping with students and teachers from other parts of the world through this site. We see teachers first participating in the Training Website and moving on to participate in collaborative projects.

4.3 Publishing and Searching for Concept Maps

Concept maps are an effective way of sharing knowledge among humans. As such, having a good concept map about a subject is an effective way to learn about the domain. A search mechanism that will retrieve "good" concept maps would therefore be a useful tool. There are hundreds of thousands of concept maps constructed using CmapTools and stored in CmapServers that are indexed and therefore searchable (Cañas, Hill, Granados, Pérez, & Pérez, 2003). Concept maps on all subjects are available, but there is no easy way to automatically rank these concept maps to make the searching useful. At IHMC we have created a Website (http://www.cmappers.net) that allows users to "rank" concept maps, in the same way as users rank videos in YouTube or photos in photo sharing websites. We open this Website to the community to collaborate in the sharing and ranking of maps. Through a joint effort, we can provide the community with high quality concept maps on any topic and search mechanism by which to find them. Through publishing and ranking, this collection of high quality maps could grow to cover all domains of knowledge.

5 Summary

Since the early development of the concept mapping tool in the 1970's to represent children's understanding of science concepts, the concept mapping tool has evolved with new computer software permitting easy map construction, incorporation of Internet resources, collaboration in developing and using knowledge resources, and a growing community of users with multiple interests. We see the need now for building new Web sites to facilitate the training of new users, collaboration by students and in refinement of existing maps to improve their quality, and to provide forums for all users to "publish" their maps and receive critical feedback from colleagues, much as exists in the field of literature. The goal is both to expand further the worldwide use of the tool, and to develop mechanisms for improving users skills and the quality of concept map archives.

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