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CMAP AS A COMMUNICATION TOOL TO PROMOTE MEANINGFUL LEARNING

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Abstract. The paper discusses collaboration and communication support provided by CmapTools. The discussion considers cognition theories and real experiences with undergraduate and graduate students.

1 Introduction

We are living now in a digital era of learning. Transformation in learning is taking place from "broadcast" learning to "interactive" learning. No longer are today's generation of learners satisfied in being the passive recipients of the traditional teaching process, rather, they want to discover it for themselves by becoming more interactive in the learning environment. Though, how successful technology-mediated learning activities will be at facilitating higher order thinking skills will be dependent upon the approach taken to the design, delivery, selection, and utilization of appropriate and effective technologies with a support structure to maintain and sustain the learning transactions.

Perhaps most importantly in today's information age, thinking skills are viewed as crucial for educated persons to cope with a rapidly changing world. Higher-order thinking includes the cognitive processes of analysis, comparison, inference and interpretation, evaluation, and synthesis applied to a range of academic domains and problem-solving contexts. Another way to describes high order thinking skill is using Blooms's taxonomy, the well known instructional model developed by Benjamin Bloom. It categorizes thinking skills from the concrete to the abstract—knowledge, comprehension, application, analysis, synthesis, evaluation as presented in Table 1.

Evaluation	appraise, choose, compare, conclude, decide, defend, evaluate, give your opinion, judge, justify, prioritize, rank, rate, select, support, value
Synthesis	change, combine, compose, construct, create, design, find an unusual way, formulate, generate, invent, originate, plan, predict, pretend, produce, rearrange, reconstruct, reorganize, revise, suggest, suppose, visualize, write
Analysis	analyze, categorize, classify, compare, contrast, debate, deduct, determine the factors, diagnose, diagram, differentiate, dissect, distinguish, examine, infer, specify
Application	apply, compute, conclude, construct, demonstrate determine, draw, find out, give an example, illustrate, make, operate, show, solve, state a rule or principle, use
Comprehension	convert, describe, explain, interpret, paraphrase, put in order, restate, retell in your own words, rewrite, summarize, trace, translate
Knowledge	define, fill in the blank, identify, label, list, locate, match, memorize, name, recall, spell, state, tell, underline

Table 1: Blooms's taxonomy

The ones considered higher-order skills are analysis, synthesis, evaluation.

There is evidence that cooperative teams achieve at higher levels of thought and retain information longer than students who work quietly as individuals so collaborative learning must be supported. Proponents of collaborative learning claim that the active exchange of ideas within small groups not only increases interest among the participants but also promotes critical thinking. The shared learning gives students an opportunity to engage in discussion, take responsibility for their own learning, and thus become critical thinkers and it is widely value of critical thinking at all levels of meaningful learning. The process of promoting critical thinking in online classes involves comprehension that students must be meaningfully motivated and encouraged to change their thinking skills. Therefore critical thinking and meaningful learning are interrelated.

According to Jonassen et al. (1999), meaningful learning is:

- Active - students interact with the environment, manipulate objects within it and observe the effects of manipulation
- Constructive - Activity is essential but insufficient for meaningful learning. Students must reflect on the activity and their observations, and interpret them in order to have a meaningful learning experience.
- Intentional - When students actively try to achieve a learning goal they articulate, think and learn more.
- Authentic- Presenting facts that are stripped from their contextual clues divorces knowledge from reality. Learning is meaningful, better understood and more likely to transfer to new situations when it occurs engaged with real-life, complex problems
- Cooperative - Each person lives, works and learn in communities, naturally seeking ideas and assistance from each other, and negotiating about problems and how to solve them. Meaningful learning, therefore, requires conversations and group experiences.

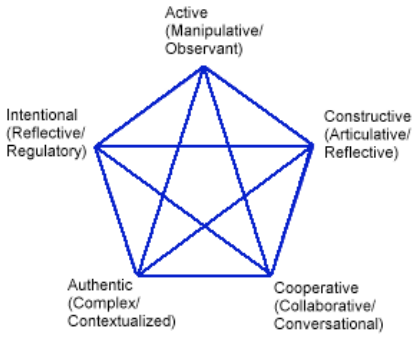

Figure 1: Attributed of Meaningful Learning

Meaningful learning, therefore, requires conversations and group experiences and aiming to create a learning environment able to stimulate critical thinking a combination of technology elements was used to foster engaging students in meaningful learning through an environment that enables cooperation in a virtual reality environment (Medina 2004). Aiming design, build and test such kind of environment it was chose to use a combination of tools derived from the following areas:

- Virtual Reality to build a virtual laboratory where learners may conduct experiments handling virtual devices able to show up significant proprieties of equipment and/or processes being targeted by the learning process, including augmented reality (Figure 2)
- Collaboration to promote conditions for supporting Vygotsky's theory of social cognitive development stating that "social interaction plays a fundamental role in the development of cognition". CmapTools (Cañas 2003, 2004) was used to support communication between students.

2 Vygotsky's Theory of Social Cognitive

To support the collective model of distance education, the purpose of this work has as theoretical foundation, the theory of Vygotsky (1998). One of the important concepts of Vygotsky's theory is that mental activities are based on social relationships between the individual and the environment in a historical process and that this relationship is mediated by symbolic systems, through instruments and signs. For Vygotsky (1998) the signs are artificial incentives with the purpose of mnemonic aid; they work as middle ground for adaptation, driven by the individual's own control. The sign is guided internally. The function of an instrument is to serve as a driver of the human influence on the object of the activity; these are guided externally. Both have in common the mediation function. Vygotsky's Theory of Social Cognitive Development reasons that social interaction plays a fundamental role in the development of cognition. Instruction can be made more efficient when learners engage in activities within a supportive environment and receive guidance mediated by appropriate tools. Another notable aspect of Vygotsky's theory is that it claims "that instruction is most efficient when students engage in activities within a supportive learning environment and when they receive appropriate guidance that is mediated by tools".

Another fundamental concept in the Vygotsky´s theory is the proximal development zone (PDZ). In mentioning the PDZ, it is necessary to define which the levels of the student's development are: the Real Development Level (RDL) refers to the functions that the student already possesses. The Potential Development Level (PDL) determines the functions a pupil can develop, through an adult's aid or from the collaboration of more experienced friends. PDZ is the distance between the real development level and the potential one. Besides these concepts, Vygotsky defends that cognitive functions happen first at social level for later to happen at an individual level: firstly among people (inter-psychological) and, later, within the person (intra-psychological).

Figure 2: Virtual lab for computer network course

Computer supported systems are cognitive tools that can team individuals with the technology to form a joint intelligence which shares the labor during the group process. These systems can support communicating ideas and information, accessing information and documents, and providing feedback on problem-solving activities.

3 New tools for quality group learning

Learning theories also state that group learning has significant relevance and must be supported also in distance education. Participation, cooperation, and collaboration in group activities must be supported and graded. But there is a lack of good tools to help and evaluate the participation of students in group activities.

Computer-mediated distance learning (CMDL) is an uncommonly bright star on the horizon of innovations in higher education. Most of pedagogical methodologies and, above all, methods involving new technologies prefer situations or contexts of individual learning. In counterpoint to this trend, the number of research involving promotion of learning using advantages of social relations, and collaborative learning has been growing over the last years, in special with the upcoming of new services available for distribution used through Internet.

Although Internet use in distance education grows exponential nowadays, services used in the beginning were only those having strong relation with ancient forms of distance education. But the use of the Internet for distance education resulted in many advantages:

- Distribution of knowledge on large scale;
- Reduction of distribution costs;
- Correction and updating are simpler, since they are conveyed in only one site, being immediately spread to all students;
- Several techniques for assessment are possible through the tracking of the interaction between students and all the other entities
- Support for collaborative writing;
- It is easier for the student to give feedback, which allows formative evaluation.

To support more kinds of interactions derived from group work related to learning activities, new applications are needed to handle participants' contributions. Despite all the bells and whistles of groupware, e-mail continues to be the most widely used groupware component. Hence one can count on all the automated work provided by email or news service servers to receive, store and/or properly forward messages. But no matter if only email or news service are used for group communication, as well as other forms of interaction, like chat combined with videoconference or with other multimedia environment the results from group activity are huge amounts of text derived from participants' contribution.

New collaboration strategies and application are required to improve the quality of the work derived. When it comes to the consolidation phase of the work, it is usually necessary to have a lot of non-automated tasks to select the main ideas from the many ones that are presented, almost randomly, during the discussion. In many courses

using Cmap as communication tool it was perceived that it works as a set of strategies and tools able to promote a more structured and organized way to integrate contributions as well as for student assessment.

Cooperation is a process of shared creation: two or more individuals with complementary abilities interact in order to create a shared knowledge that none of them had before nor could get at their own effort. Cooperation also creates a shared meaning about a process, a product, and an idea. The argumentation should be based on their existing knowledge as they try to accommodate new knowledge that is internally inconsistent. Based on the premise that knowledge construction is a socio-linguistic process dependent upon the content and culture where it occurs, this view argues that we use conversational language to negotiate meanings that results in shared knowledge and understandings. By continually negotiating the meaning of observations, data, hypotheses and so forth, groups of individuals construct systems that are largely consistent with one another.

Ausubel (1960) believed that meaningful learning involves personal recognition of the links between concepts. The most important element of meaningful learning is not so much how is presented but how new information is integrated into an existing knowledge base. A major instructional mechanism proposed by Ausubel is the use of advance organizers. The advanced organizer approach to teaching became a cognitive instructional strategy used to promote the learning and retention of new information. This approach encourages students to build upon prior knowledge and mentally organize their thoughts before being introduced to the details of new concepts.

Ausubel emphasizes that advance organizers are different from overviews and summaries, which simply emphasize key ideas and are presented at the same level of abstraction and generality as the rest of the material. Organizers act as a subsuming bridge between new learning material and existing related ideas. The most general ideas of a subject should be presented first and then progressively differentiated in terms of detail and specificity.

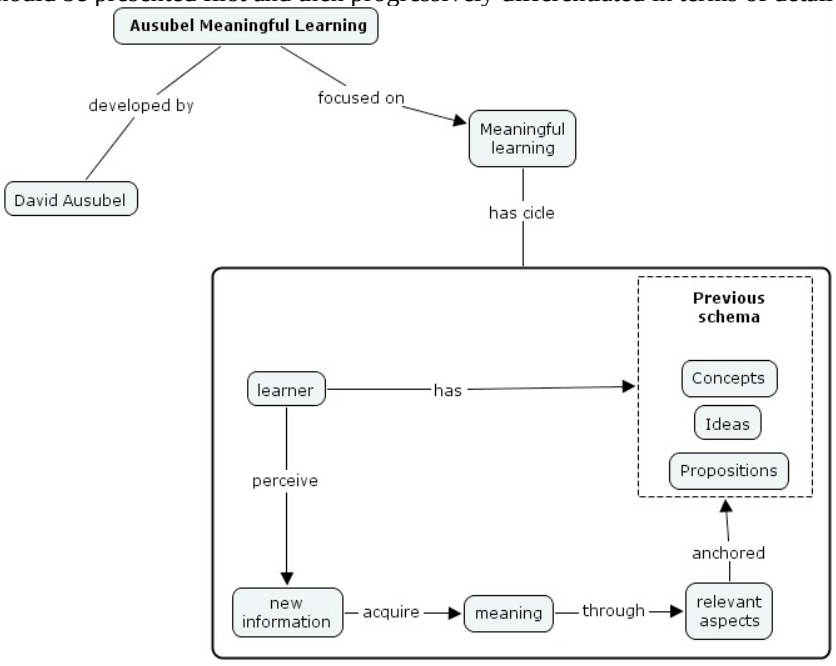

Figure 3 shows Ausubel theory as summarized by students.

4 Using Cmap as communication tool

Concepts and theories presented in previous sessions were used to plan learning activities for undergraduate course (on Computer Networks) and later with graduate students on a Computer Mediated Communication course.

The learning plan for the undergraduate students involved a project focused on a network they have to plan working in small groups. Undergraduate students were requested to build conceptual maps showing their initial knowledge on the area. They worked in face-to-face activities but the work also continued asynchronously during all the semester. This group of students also used a virtual lab that provided support for chat. Email and forum tools

were also available in the Learning Management System and allowed some degree of coordination between group members.

Once the learning activities started to evolving, with experiments being developed in the virtual lab, progressive differentiation has occurred and conceptual maps have evolved as result of group cognitive growing. Maps became more detailed and specific. Students worked actualizing conceptual maps during all the time and the tool helped them to keep track of partial results derived from lab tests and other investigations. Cmap was used as a higher thinking level communication tool.

At the end of the semester each student was asked to draw his/her own conceptual map. This activity was planned to happen 3 weeks after the ending and presentation of the project to assess retention and consolidation of concepts. The level of conceptual integration perceived in the maps was very good. The amount and quality of cross-links were evaluated and maps showed up coherent, expressive and logic. The meaningful learning became evident not only by projects presented by students as well as clear distinguished differentiation between key concepts done by students and that was essential to problem solving.

The design task proposed to students required them to consider technical issues as well as other some times conflicting issues as optimization for the solution had to consider high availability, performance, security and low cost. To choose one direction instead of the others they had to go into a decision process that involved the group as a whole. Just the technical knowledge was not enough and careful analysis of the conflicting requests as well as risk assessment was needed to weight all the factors.

Comparing initial and final conceptual maps it became evident that relations between concepts grew in number and quality. More concepts were included and relations evolved from words like "is" to expressions as "support", "enhance", "make possible", "reach" and "connect to".

We could resume main forms of utilization of the tool through the conceptual maps from Figure 2.

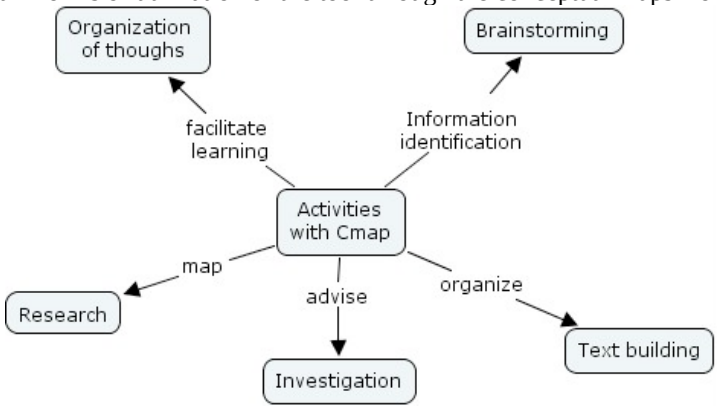

Figure 2: Activities with Cmap as higher level thinking communication tool

With the group of graduate students a more intense use of CmapTools was aimed. In that situation only Cmap was proposed as communication and coordination tool. Real time chat was used to ask permission to edit maps and during periods in which two or more students were editing the same set of conceptual maps. Discussion threads were used in support to asynchronous activity that continued at a distance after initial face-to-face work.

5 Conclusions

Both groups of students considered Cmaps a rich resource in terms of supporting a more organized communication between group participants. It was possible to note that a higher thinking level was reached because of the structured nature of the communication tool.

Once proposition registration being discussed had to be registered as a concept map, group participants should necessarily structure their thoughts about the focus of their collaborative work. Not allowing them to simple shoot

ideas without consideration targets (previous propositions and actual focus) worked as a very effective group dynamics strategy that was able to cope with usual differences in the cognitive processing styles that people may adopt in problem solving and other similar decision-making activities.

There are many different definitions of cognitive style. Some selected by Geller (2002) for a study aiming to identify the preferred communication tool by students with different cognitive style were the following:

Field dependence-independence	Field independent people tend to be more autonomous in relation to development of cognitive restructuring skills and less autonomous in relation to development of interpersonal skills. Field dependent people tend to be more autonomous in relation to development of high interpersonal skills and less autonomous in relation to development of cognitive restructuring skills.
Holist vs. serialist	The holists tend to view a situation as a whole. Serialist tend to view a situation as a collection of parts and often stress only one or two aspects at a time

But according Geller (2002), majority of students prefer the use of imagery as learning aid. The kind of support provided by Cmap to organize concepts as a semantic net and attach images and other multimedia information to concepts was indicated by all as a positive and valuable support for learning.

Geller also found that cognitive style may change during the learning process. So a student may initiate as field dependent using more discussion threads for discussion of topics before being confident enough to contribute in the concept map. He/she may become more field independent after interacting with peers, progressing to conditions such as new material may be related to relevant ideas in the existing cognitive structure on a substantive basis. Group interactions provided by Cmap helped student to reach what is possible according proximal development zone (Vygotsky 1998).

The serialist to holist transition is also a possibility once meaningful learning is a continuous process wherein new concepts gain greater meaning as new relationships (propositional links) are acquired by progressive differentiation according (Novak & Gowin, 1984). The more structured support to organize concept in semantic nets provided by Cmap proved to act as a mindtool supporting communication that engaged students in meaningful learning.

Theory and practice jointly gave us very good confidence that Cmap is a communication tool that promote meaningful learning.

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