Chapter IV

The Collective Building of Knowledge in Collaborative Learning Environments

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Abstract

The intention of this chapter is to investigate how collaborative learning environments (CLEs) can be used to elicit the collective building of knowledge. This work discusses CLEs as lively cognitive systems and looks at some strategies that might contribute to the improvement of significant pedagogical practices. The study is supported by rhizome principles, whose characteristics allow us to understand the process of selecting and connecting what is relevant and meaningful for the collective building of knowledge. A brief theoretical and conceptual approach is presented and major contributions and difficulties about collaborative learning environments are discussed. New questions and future trends about the collective building of knowledge are suggested.

Introduction

A few years ago, in the beginning of a discipline at a large university in Sao Paulo, a professor asked if his students would like to use a virtual learning environment. His intention was to promote discussion, group learning, and more interaction towards collaborative learning. Then, one of them said, "*I prefer just face-to-face classes. Interacting in virtual environment means spending more time.*" Although one of the great advantages in virtual learning environments is communication anytime from anywhere, some participants revealed that such flexibility provokes intensive interactions, information overflow, difficulty in organizing what is relevant, and consequently, time becomes a great problem.

Due to the rapid growth of online learning and the incredible increase of information on the Web, developing methodologies to build knowledge collectively, articulating what is meaningful, has been quite essential to eliciting better collaborative strategies in online courses. For that, I have been investigating how to manage information overflow and to incentivize collective building of knowledge through virtual learning environments using the software Nestor Web Cartographer (www.projeto.org.br/nestor/) and other freeware resources available on the Internet (Okada, 2001, 2002).

The purpose of this study is to develop strategies for designing and mediating collaborative learning environments from a net of knowledge perspective. This network perspective is supported by some characteristics of cyberspace, which not only highlight the intersection of oral and written language with memory, but also facilitate the process of weaving the meanings offered by subjects into a collective building of knowledge.

As a theoretical basis for the comprehension of collective building of knowledge, some authors have been selected, such as: Humberto Maturana and Francisco Varela, who consider knowledge a biological phenomenon of which knowing, being, and living are inseparable dimensions; Paulo Freire, who defines knowledge as conscious reading and rewriting of the world by the subjects themselves; and Pierre Lévy, for whom knowledge is a complex net where technical, biological, and human actors interact all the time.

In the light of the above theories, we have tried to unveil the practice behind virtual environments created during a workshop about the software Nestor Web Cartographer, a subject of the Education post-graduation course at Pontifical University of São Paulo. The participants of the workshop were two professors, doctors in Education, and twelve post-graduate research students from Education and other areas such as Administration, Computer Science, Communication, and Semiotics. One of the students was invited by the professors to organize the workshop. The data collected on the six environments were mapped and analyzed (14 descriptions about the participants, 130 forum messages, 173 emails, 15 webmaps, 10 websites, 19 papers, and all feedback comments relating to the group tasks and learning environments).

The methodology used to develop this investigation was based mainly on qualitative research. It involves description and interpretation of data obtained during the workshop from interactions and reflections of all researchers (teachers and students). Not only were the results analyzed, but the processes were also investigated to reveal how virtual learning environments can elicit the collective building of knowledge. Thus, interrela-

tions between subjects or between subjects and objects in their multiple interfaces could be better understood.

At the end of our study, some important findings that emerged from the Virtual Learning Environment (VLE) Workshop are presented that make collaborative learning environments contribute to the collective building of knowledge: a clear and common purpose, self-organization, collective building, contextualization, argumentative consensual dialogue, pleasure, and well-being.

Overview of the Course

The Nestor Web Cartographer Workshop was a course offered as part of the subject Epistemology and Computer Uses in Education of the post-graduation program, Education - Syllabus at PUC University of São Paulo.

Nestor Web Cartographer, developed in France by Romain Zeiliger, is a graphic web browser-an editor of HTML pages and a cartographer with synchronous and asynchronous resources that supports collaborative learning. This software was developed to promote the construction of a personalized web space. For that purpose, it dynamically builds a flexible and navigable overview map of the hyperspace when users interact with it. In turn, users can rearrange the map creating new objects: documents, links, annotations, sub-maps, tours, search keywords, and conceptual areas. Consequently, it allows users to solve their own navigation problems: identifying documents, delineating pertinent materials, organizing links into categories, and selecting information through contextual navigational (Okada & Zeiliger, 2003).

Figure 1: Nestor Web Cartographer. Free download: http://www.gate.cnrs.fr/~zeiliger/nestor.htm.

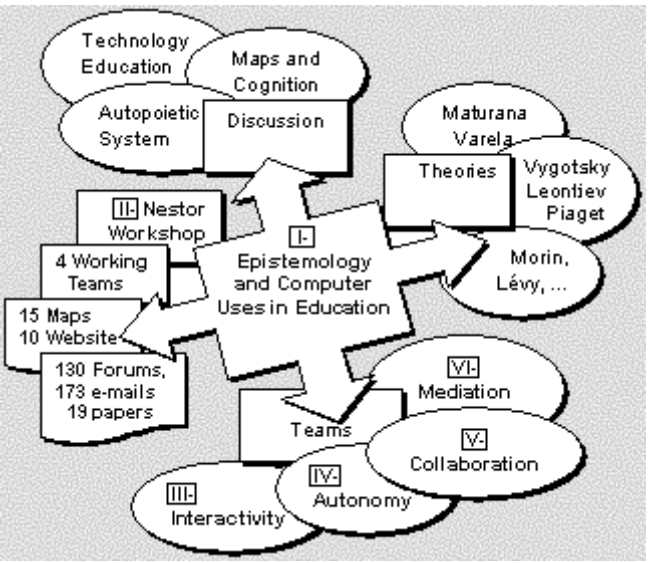
This software encourages users to reflect on their interactions with an information space, to discuss those interactions with annotations, to collaborate with others through the sharing of tours and annotated maps, and to apply their own methodologies to build knowledge-based structures. Zeiliger, Belisle, and Cerrato (1999) emphasize six important issues about this software:

1. Representing Self-Navigational Experience: Every visited document is represented as a symbol (icon). Users can rearrange the layout deleting the non-significant web pages, changing the icons, grouping them in conceptual areas, and creating arrows to connect information.
2. Constructing a Personal Web Space: Users can create web pages using Nestor Editor, insert the converted maps, and weave them with the public network. They can build thematic maps and develop personal hypertexts about what is relevant and meaningful.
3. Note-taking: Users can attach annotations to every visited public or personal document. When an annotated document is visited, the corresponding annotation is displayed in a separate window—"the bag"; a visible clipboard can be used also to select and gather important information during the navigation process.
4. Creating Keywords Objects: Users can also insert keywords, areas, and sub-guides in maps. The created keywords are automatically searched in the visited document's text and highlighted when found (both on the map and in the document). This is especially useful when users want to seek relevant information.
5. Creating and Saving Navigational Objects: All objects created by users (maps, keywords, conceptual areas, annotations, and routes) can be saved to an HTML file, retrieved, and published. Those objects are considered as "navigational objects" because they can serve to initiate new navigational operations.
6. Sharing Maps: NESTOR allows users to build maps collectively using synchronous and asynchronous resources and also to share objects published in the cyberspace. Nestor users can construct meaningful information through computer-mediated communications and collaborative navigation.

The aim of the workshop was not only to demonstrate the software Nestor Web Cartographer in order to develop maps of investigation, but also to go deeper into some theories following participants' expectations through our own collaborative environment that we created by using just freeware resources available on the Internet.

All students and teachers were encouraged to install this free software and to participate in the workshop outside of class time. The student responsible for the workshop developed the environment about Nestor Web Cartographer using the same software. The professors created the subject's environment to discuss theory and practices and the twelve researchers, organized in four groups according to their interests, developed four environments about autonomy, collaboration, pedagogical mediation, and interactivity. The six environments were connected with each other and could be accessed by everybody.

Figure 2: Epistemology and computer uses in Education Subject organized by professors Maria Elizabeth B. Almeida and Maria Cândida Moraes PUC-SP 2001.



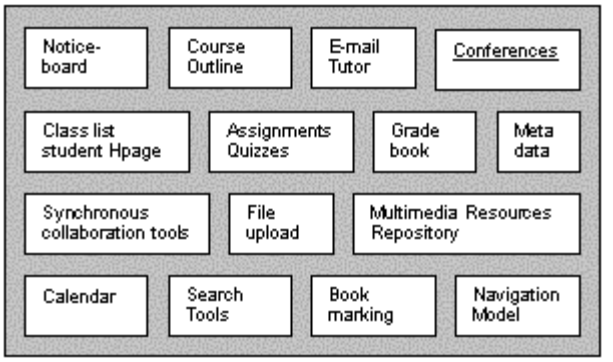
Background for Collaborative Learning Environments

What is a Virtual Learning Environment? What attributes constitute a "VLE"? Many authors, for example, Colin (1999), and Britain and Liber (1999), define virtual learning environments as software packages installed in a server to administer the learning process (interactions, information access, discussion, support. etc.) into an integrated environment. The purpose is not to reproduce the same environment of the classroom, but to offer technological resources to facilitate the apprenticeship.

Maturana and Varela (1980), both biology researchers in the autopoietic theory, consider environment as a life organization. Organisms are adapted to their environments, and their organization represents the environment in which they live. To those authors, living systems are units of interactions that exist in an ambience and are essential for its maintenance as a unit. And considering the biological point of view, it is impossible to understand those units independently or outside the ambience with which they interact.

Dodge and Kitchen (2001, 2002), both cybergeographers, define environment as a space of interactions, places of production and consumption that are recognized by their own relations inside and outside. They emphasize that our lives are rooted and given context by places we live in, the communities we inhabit, the sites of our homes, work, and leisure, and are shaped by complex socio-space processes that operate across many scales, from local to global. In turn, spaces are produced and given meaning through social practices creating places.

Figure 3: A schematic of a Prototypical VLE by Britain and Liber (1999).



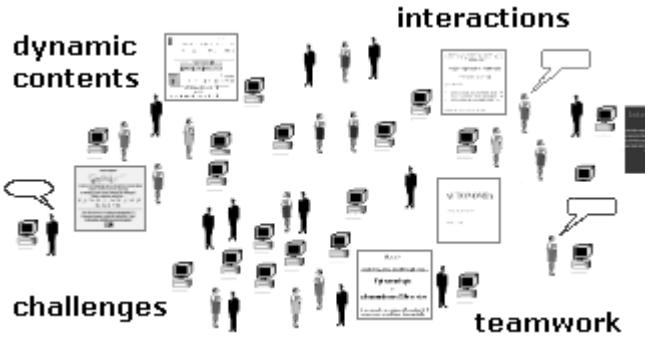
Using the conceptual approach by those authors, we can define virtual learning environments as a network of technological, human, and biological components and their interactions. Thus, it is important to consider virtual learning environments not only as technological resources (computers, modem, connectors, web servers, software, web services, synchronous and asynchronous interfaces), but also all participants (teachers, students, guests, technicians, specialists, and apprentices, including their interactions), the traffic of text, documents, images, sounds, the sharing of messages, the forum of discussion, the registering of databank and forms, the access of websites, and all information.

This information flow describes an interactive learning process and could not have been completed in isolation. Virtual learning environments begin to reveal the development of a new paradigm of education: the transformative nature of the learning process where students and teacher can learn and contribute to each other. Consequently, a network of interactions and collaborative attitudes between all participants can be formed, through which the process of knowledge building is collaboratively created.

Maturana and Varela (1980) consider living systems as emergent from or constituted by the interactivity of beings, not as a priori abstract units. The authors define social systems as a bundle of specific interactions among its participants realized primarily in linguistic consensual domains. Those interactions (e.g., regarding frequency, connectivity, membership) define the character of a social system. To Maturana and Varela, the social system exerts influence upon individual participants through affordances for and regularities in their interactivity, and this influence is recursively exercised upon the emergent social system through the participants' ongoing interactions.

About social systems, Dodge and Kitchen (2001) emphasize that information and communication technologies (ICTs) allow the reconfiguration of space-time relations and radically restructure the materiality and spatiality of space and the relationship between people and place. It is possible to interact anywhere, any time, changing any kind of information quickly and cheaply, and everybody can be emissor and receptor at the same time. It means a new way to build knowledge, interlacing thought in diverse facets, collectively and with autonomy.

Figure 4: A schematic of a Prototypical VLE as a living system.



Considering VLE as a social system whose characters are defined from its interactions, and based on the studies of Mason (1998), we can realize three models of environments:

- Instructional. The level of online interaction is low, concentrated between the student and the material, or the student and the teacher. The core of the environment is the contents, which are already produced. The methodology is based on tutorials; this model reflects the traditional teaching environment. The knowledge is built through readings and memorizing by individuals.
- Interactive. The level of online interaction is high among all participants. The environment contents are produced during the process that involves activities and online discussions. The groups build knowledge through consensual dialogue.
- Collaborative. The level of online interaction is very high and centered around collective activities and common purpose. The environment contents are dynamic and are determined largely by individual and group needs. The knowledge is the result of collaborative activities, discussions, consensual dialogue, joint assignments, and common challenges by teamwork.

Based on the Maturana and Varela's (1980) theory about cognition as a biological phenomenon, it is possible to associate collaborative learning environments as a cognitive system whose organization realizes and produces the network of interactions in which it can act with relevance in order to keep its existence. "Living systems are cognitive systems and living as a process is a process of cognition" (Maturana & Varela).

According to autopoiesis theory, a cognitive system needs to manage its complex context to maintain its existence. The world that any organization inhabits is much more complex than the organization itself, and the variety of organization is much larger than variety of organism. Therefore, in order to keep itself lively, a cognitive system can amplify or attenuate its variety, enlarge or reduce its domain of interactions, by making its internal states modifiable in a relevant manner.

Figure 5: Collaborative Leaning Environments as a living system.

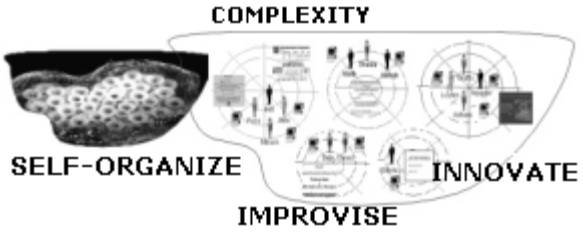
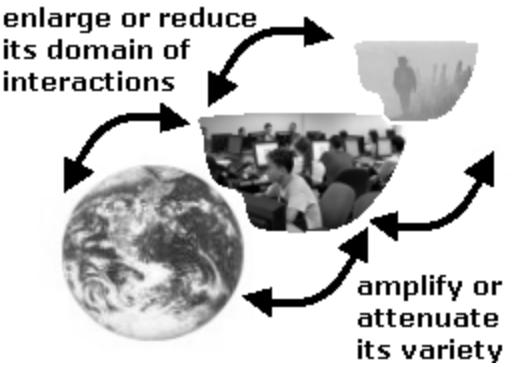


Figure 6: Collaborative Leaning Environments as a self-cognition organism



Taking the virtual learning environment as a cognitive system, its characteristics (members' roles, purposes, context, common interests, etc.) define its identity and its initial structure (interfaces, communication channels, design, contents, etc.) to keep the environment's existence. Participants also have their own characteristics (personality, skills, difficulties) and initial states (time, motivation, expectations, intentions, interests).

The key problem for a collaborative learning environment in maintaining itself as a lively cognitive system is to know how to manage its complexity and the context in which it finds itself.

Complexity, according to Morin's studies, has provoked an important discussion about the relationship between order and disorder and new ways to deal with this. Some aspects, such as the unforeseen, uncertainty, ambiguity, and subjectivity, are increasingly being studied in the social and natural sciences. Ordered and linear conceptions of universe, nature, and human civilization have been dismantled (Demo 2002; Morin & Kern, 1999). The sciences of chaos and complexity show us the profound role of disorder and the importance of knowing how to create new alternatives, to innovate, improvise, organize, and self-organize, to disorganize and reorganize, as a constant dynamic and non-linear process.

After reflecting about learning environments as a cognitive living system, it is important to discuss how knowledge can be built collectively. What does net of knowledge mean?

Theoretical Issues about Knowledge as a Network

Web of knowledge and knowledge in network are constructs that result from the flexibility, plasticity, interactivity, adaptability, cooperation, sharing, support, and self-organization that characterize the knowledge-building process (Moraes, 1999). The net metaphor seems to be the key to the emergence of knowledge as a new interdisciplinary work. To understand is to apprehend the meaning by seeing the relations among things. The more relations can be established between one topic and other areas of knowledge, the closer that topic will be to its thorough meaning, to its "completeness." Such relations connect different topics in a non-linear way. In other words, the meaning of a topic "X" can be apprehended through multiple relations established between "X" and other topics, "A", "B", "Y", "M", and "G", those being or not being the references in the topic that is studied (Machado, 2000).

There are six important principles about the concept of net and rhizome presented by Deleuze and Guattari (1987) and Pierre Levy (1994):

- Metamorphosis - there is the need for a constant change.
- Multiplicity - the components and interconnection have multiple scales.
- Heterogeneity - the structure is always different.
- Exteriority - the feeding information should come from outside.
- Acentrism - there is no beginning, no end, and not one center but mobility of the centers.
- Proximity - the interaction allows association of components.

The metaphor of network and rhizome allows to associate three theories and to conceive the building of knowledge as the result of biological, social, and technological process.

Maturana and Varela (1980) consider knowledge a biological phenomenon, of which knowing, being, and living are inseparable dimensions. The living being can develop knowledge:

- through the dynamic and flexible changes of the components (metamorphosis);
- as a process where components produce multiple dynamics of production (multiplicity);
- from the operation of different components (heterogeneity);
- as resulting of internal and external interactions to keep the structural congruence (exteriority);

- by configuring enterprise (re-)engineering practices for mutual orientation and self-organization (acentrism); and
- through the interaction that allows association of components (proximity).

Paulo Freire (1987) defines knowledge as a social process of conscious reading and rewriting of the world by the subjects themselves. People can develop knowledge:

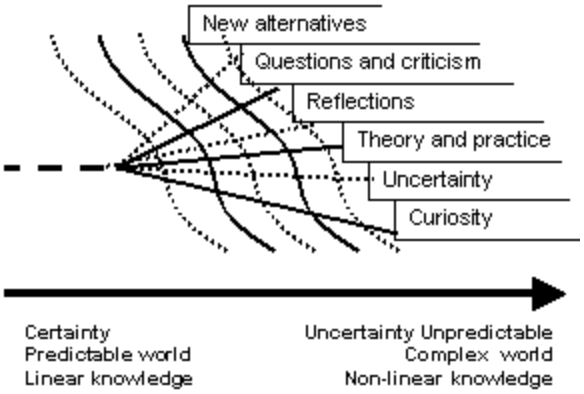
- by transforming the reality for an equal and just world (metamorphosis);
- through decodification as a multi-dimensional step where there is breaking down of the knowable object for critical analysis and future action upon this reflection (multiplicity);
- as a way to achieve critical consciousness through the consensual dialogue considering different opinions and points of view (heterogeneity);
- through dialectical movement of reflection and action managing the pluralities within, across, and outside communities with different interests (exteriority);
- by being co-learners—both teacher and students must participate in and be responsible for their learning process as social-historic subjects (acentrism); and
- by coming closer to the object and to each other. Humans are the only beings capable of being both objects and subjects of the relationships woven with others and with the history that we make and that makes and remakes us (proximity).

Pierre Lévy (1994) emphasizes that knowledge is a complex net where technical, biological, and human actors interact all the time. Web users can weave knowledge:

- in a continuously space of changing: the cyberspace;
- by building a network of information in multiple scales (multiplicity);
- by interconnecting different components: sounds, images, text, ideas, thoughts, etc. (heterogeneity);
- by feeding information even outside the web as experiences, practices, other examples lived (exteriority);
- by navigating and building diverse hypertext and journeys in the cyberspace without a specific beginning or end (acentrism); and
- by logging on and interacting with anybody, anywhere, and anytime (proximity).

In fact, those principles can be considered as the essence of Internet, non-linear access of information and non-linear building of knowledge. It also allows the association of an unimaginable amount of information routes. All those characteristics allow understanding of how the interaction can occur and how the environment can maintain itself.

Figure 7: Knowledge as a Contemporary Network.



This networking approach, based on a biological, social, and technical notion of knowledge, can offer a useful framework for conceptualizing the pluralistic and dynamic nature of cultural knowledge. Considering this aspect, it is necessary to recognize that knowledge can develop better within an unpredictable and complex world.

The knowledge must be built to reduce and to overcome uncertainty. Consequently, theories must be questioned and criticized in order to be substituted for a better one, and then, knowledge can be improved into a complex and more advanced level while it is deconstructed.

Moreover, questioning is not only to show emptiness and inconsistencies, it is also meant to see through other angles, points of view, different contexts, and multiple levels in order to create new alternatives.

In this way, it is essential to investigate how to engage co-learners into weaving a net of meaning collectively. How can environments elicit collective knowledge building as a network of meanings? What are the strategies for designing and mediating collaborative learning environments from a net of knowledge perspective? For that purpose, all data collected in the virtual learning environments were mapped and analyzed along with all the feedback comments.

Finding Results about Collective Building of Knowledge in VLE

The six environments created by students and teachers during the workshop were developed using just free software available on the Internet. Web pages and web maps were built using Nestor Web Cartographer; the discussion, using ForumNow; the information exchange, using Yahoogroups.

About collected data, it was found that:

- In the first weeks, teachers and learners whose role was to mediate the environment interacted much more than others. About 173 emails were sent:
  - 33% were sent by students: 9% activities doubts, 9% technical support, 8% suggestions and new ideas, 7% reflection about environment.
  - 67% were sent by teachers: 20% reflections and questions about the environments, 18% feedback (support and answers), 14% reflections and questions about activities, 13% incentive.
- After the first month, messages in forum were more frequent than e-mails, and students interacted much more. About 130 forum messages:
  - 28% were sent by teachers: 11% questions, 9% feedback and reflections, 8% incentive.
  - 72% were sent by students: 23% Theories (questions and reflections), 17% Maps and papers, 12% Nestor software, 10% others (incentive, absent reasons, etc.).
- Of the theories presented in the 19 papers and 15 maps: 27% references expected, 63% new references.

To analyze the content of these outcomes, a qualitative research approach was adopted, and investigation methods consisted of document analysis, interaction observations, and description and interpretation of the co-construction process. Over four months, data was collected during the workshop from six environments. The results were analyzed and the process was investigated. This allowed interrelations between subjects or between subjects and objects, in their multiple interfaces, to be better understood.

The focus of the study is on how virtual learning environments can be used to elicit collective building of knowledge. Six important issues could be observed:

- common and clear purpose;
- contextualizing;
- self-organization;
- argumentative dialogue;
- co-construction; and
- pleasure / well-being.

Common and Clear Purpose

In the beginning, teachers intended to find a way to weave theory and practice about Epistemology and Education. The students wanted to go deeper into some theories in order to improve their research.

The first week of the workshop was very difficult, because it was not the students´ spontaneous option, and the environment was new and unknown to them. Interaction was very poor. Although the aim of the workshop was to facilitate the process of researching and to allow a theoretical and practical approach through the software Nestor Web Cartographer, a common purpose among all participants had not yet appeared. It could be realized that just the workshop intention and authentic activities were not enough to guarantee the participants involvement.

For learners to become actively engaged with each other, they were invited to introduce themselves, to write about their interests, expectations, experiences, and preferences. When the students started to discuss and to build maps about their preferred theories, common interests were identified so they started to exchange maps and to share bibliographic references. Consequently, they became more involved, not only in the workshop but also in collaborative action.

This process allowed four themes of interests to emerge: interactivity, collaboration, autonomy, and pedagogical mediation. Then, they organized four working teams and started to build their learning environments using the same free resources.

After clearing up the purpose in their environments, the participants started to interact not only in their own working team, but also in others, bringing related issues. It could be realized that common purpose contributed to increased trust, to communicate with confidence. and to develop authentic presence. Expressing it clearly in their own environment allowed developing initiative, collaborative action, and continual learning.

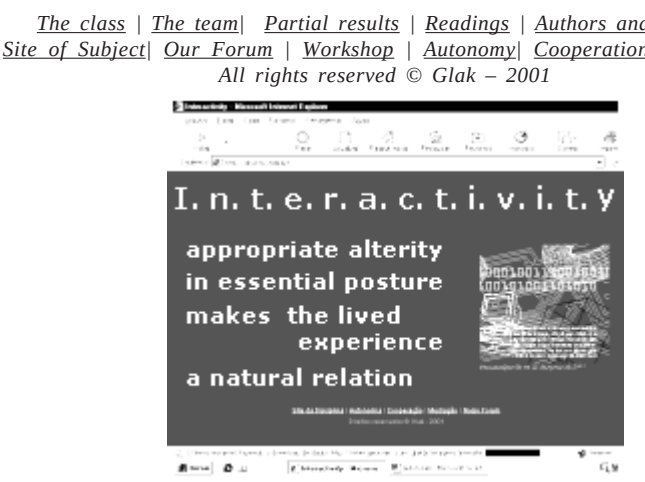
Contextualizing

Environments exist in their own particular context. Cognitive process occurs within the context of an environment. In order to understand the collective building of knowledge within the collaborative learning environments, it is important to know their contexts and the motivational aspects of their interactivity. It is through interaction that theory and practice, identity and meaning, collaborative and continuous learning can emerge and evolve-all of which interactively constitute context.

About virtual learning environments developed in the workshop, the participants wrote about themselves, inserted their pictures, described when, where, how, and why they had discussed and developed concepts. The more learners can relate their life experiences and what they already know about the context, the more meaningful will be what they will learn.

Contextualizing is a process to express or to make meaning from the context itself. Through a contextual learning environment, meaning can be developed and understood. Context in the environment allows not only production of meanings about the communal

Figure 8: Interactivity working team Website



world, but also formation of identities that help participants to discover their similar interests.

For instance, the working team organized by Adhara, Graffix, Krugger and Luyten about interactivity described how they could co-elaborate their own approach about this concept.

"Why did we discuss interactivity? When we met at PUC cafeteria, on Tuesday, 27th March 2001, we started to discuss the interactivity as Luyten had suggested. The main purpose was to find a general concept, since everybody had already read about some theories and had written their opinion. One of our conclusions was: who thinks about interactivity, thinks about multiple levels, because it is a broad concept and can be selected depending on who uses it. Then, we tried to summarize our view in one sentence:

- ***Appropriate alterity*** *is a concept developed by Graffix that expresses the capacity to see, to think, or to feel things in such a way that one feels almost as being the other,*
- ***in an essential posture*** *is what the Lyten in the group discussion introduced in order to relate the concept with the educational question and the media,*
- ***makes the lived experience****, underlined by Adhara, the only way for interactivity to occur,*
- ***a natural relation*** *is the mathematical view of Krugger´s of interactivity as relation that only exists when there are two elements in action."*

Practices and meanings are only fully contextualized within the context of their authentic use. The mutual relationships between context and content, individuals and environment, knowing and doing could be developed continuously from that which is known.

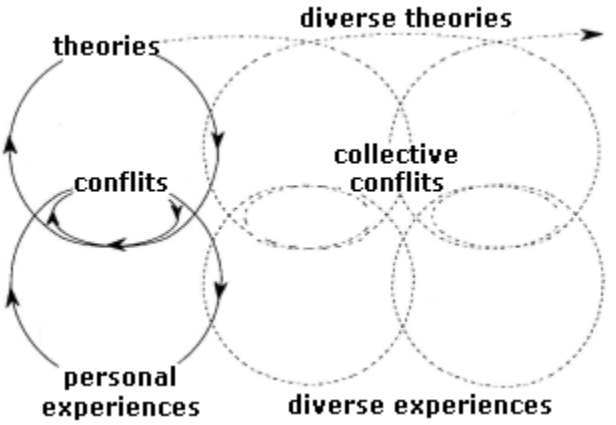
Self-Organization

There are seven important categories that describe the self-organization process, according to Whitaker (1995). The Workshop environments were analyzed from this point of view. The categories are:

- self-creation - the capacity that a VLE has to be originated by circumstances in which it occurs. Specific circumstances and attitudes such as: encouraging innovation, stimulating initiative, and supporting doubts allowed the participants to create collectively their own environments, maps and papers;
- self-configuration - the ability that a VLE has to actively define the arrangement of its constituent parts. Freeware resources such as: Nestor Web Cartographer, ForumNow, and Yahoogroups facilitated the students´ and teachers´ participation in the workshop and also the configuration of their environments;
- self-regulation - the ability that a VLE has to control the course of its internal transformations, typically with respect to one or more parameters. Each team could define its own interactions process, purpose, and tasks;
- self-steering - the ability that a VLE has to actively control its course of activity within some external environment or a general set of possible states. All participants could navigate in their environments through links, hypertexts, and maps selected and created by themselves;
- self-maintenance - the ability that a VLE has to actively preserve itself, its form, and/or its functional status over time. However, learners´ participation rhythm, number, and frequency of access were very different from one another. Roles were defined according to their interests by the learners themselves. Some participants became responsible for technical aspects of the environments, some for pedagogical mediation, and others for motivation of the group;
- self-(re-)production - the ability that a VLE has to generate itself anew or produce other systems identical to itself. Two environments (Epistemology and Computers Uses in Education, and Nestor Workshop) could give rise to another four VLEs (Autonomy, Cooperation, Pedagogical Mediation, and Interactivity).
- self-reference - the ability that a VLE has to value its essence, to make its character or its behavior meaningful to itself. All teams had autonomy to make decisions and agreements, to express their opinions, and to be a source of information and reference to themselves and to the others.

All these concepts are not mutually exclusive. Any approach to treating virtual learning environments as self-organizing entities should, therefore, consider which (or how many) of these connotations to include.

Figure 9: Argumentative interactions.



Argumentative Dialogue

Another important aspect of the interactions was the argumentative dialogue among learners. Interactions involve the attempt to resolve expressed conflicts of opinions with respect to proposals, theories, opinions, and justifications. Some special circumstances are required in order for argumentative interactions to be produced by learners.

Such circumstances mean encouraging students to express their ideas into a linguistic form as a preparation for debating, developing individualized texts, describing the verbal conflict situation, and individual reconstruction of the agreed conclusion and justification.

Learners are not naturally likely to argue spontaneously with each other, at least with respect to the subjects that they have not been in contact with yet. And sometimes, interpersonal conflicts or individual contradictions are not sufficient to provoke the incidence of argumentation.

It could be noticed that in the working team environments spontaneous argumentative dialogues resulted from common shared ground (theories read, papers written, maps built) related to the topic discussed. A conflict of opinions was openly declared and understood: participants knew their own arguments in the discussion. Participants had enough arguments at their disposal, and committed themselves to the debate: they have *something to argue about.*

The emergence of a critical discussion was predicted as soon as the appropriate dialogical attitudes ("pro"or "con") had been expressed and the communication between participants had been established. This implied that points of view had already been constituted, so students could discuss together, in pairs or in teams.

Argumentative interactions are an essential condition for development of a consensual and critical knowledge.

Table 1: Two types of knowledge by Nonaka and Takeushi (1995).

Tacit Knowledge (Subjective)	**Explicit knowledge (Objective)**
Knowledge of experience (body)	Knowledge of rationality (mind)
Simultaneous knowledge (here and now)	Sequential knowledge (there and then)
Analog knowledge (practice)	Digital knowledge (theory)

Table 2: Four modes of knowledge conversion by Nonaka and Takeushi (1995).

		to	
		Tacit knowledge	**Explicit knowledge**
from	**Tacit knowledge**	Socialization	Externalization
	Explicit knowledge	Internalization	Combination

Co-Construction

Teachers and students as co-learners become partners in collaborative learning. When they have a common and clear purpose, they become co-investigators. They can share experiences and pursue a search for knowledge together.

Co-learners invite everybody to participate in the construction of knowledge and the creation of the learning environment. However, they do not only exchange certainties about the subjects, but also questions and unresolved issues that provoke a real opportunity for everybody to learn with each other.

Thus, they are never sure about what the direction the discussion will take. Surprises are more likely. Issues they have not thought about are more likely to arise. Such unpredictable ideas lead them or set them free to think freshly about the subject.

Then, co-learners can feel that they have thoroughly explored and tracked something together. They feel freer to share their thoughts and ideas and consider the environment as their own space where everybody can be respected as a thinker and a learner.

When co-learners share their production in an opened learning environment, they can socialize with anybody outside the environment who is interested. New interactions can broaden the knowledge of individuals, groups, and environments. This process can be better understood from the spiral of knowledge theory developed by two Japanese researchers.

Nonaka and Takeushi (1995), both consultants and professors, stressed that organizational knowledge requires human/individual knowledge and starts with it. Knowledge is the basic unit of analysis to explain firm behavior. Organizations do not merely process knowledge – they also create it.

The authors explained that human knowledge can be classified into two kinds:

1. Explicit knowledge, which can be articulated in formal language including grammatical statements, mathematical expressions, specifications, manuals and so forth; and.
2. Tacit knowledge, which is hard to articulate with formal language, is personal knowledge hard to transfer.

The interaction between explicit and tacit knowledge is the key dynamic of knowledge creation by the individual, group, and organization. The two main dimensions of knowledge creation are: epistemological and ontological. And there are four major processes of knowledge conversion: Tacit–explicit, Explicit–explicit, Explicit–tacit, Tacit–tacit.

The most precious knowledge can neither be taught nor passed on. Tacit knowledge embraces values, ideals, and emotions, as well as images and symbols. The most powerful learning comes from direct experience. It is essential to learn with the body, not only with the mind. Children learn through trial and error. Tacit knowledge involves two concepts:

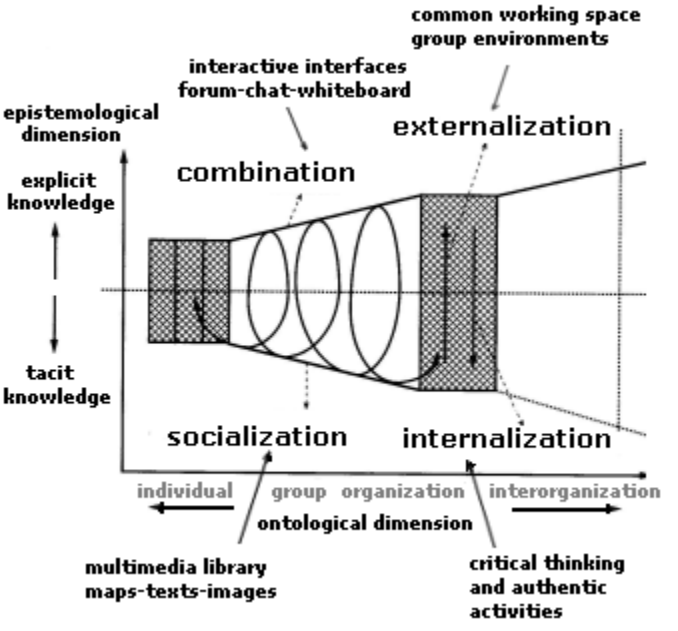
1. Know how: Technical dimension that encompasses the kind of informal, hard-to-pin-down skills or crafts and ”fingertips” feelings; and
2. The ”cognitive” dimension: Schemata, mental models, beliefs, and perceptions that reflect our image of reality (”what is”) and our vision for the future (”what ought to be”).

Both info and knowledge can be developed in a specific and relational context in that they depend on the situation itself and are created dynamically in social interaction among people.

Observing the discussion in the environments´ forum, Yahoogroups, and emails, it was possible to identify those four important moments (as seen in Table 2). First, participants *socialized*, exchanging previous opinions about the subject resulting from experience and previous knowledge (tacit knowledge). Second, conceptual issues related to the subject could be *externalized* through maps, texts, papers, and bibliographical references (explicit knowledge). Third, theory and practice could be woven; tacit and explicit knowledge could be connected, discussed, and *combined* through critical and consen-

Figure 10: Spiral of organizational knowledge based on Nonaka and Takeushi (1995) Theory.

Figure 11: Spiral of collective building of knowledge based on Nonaka and Takeushi (1995) Theory.



sual conclusion. Fourth, the theory and practice combined could be *internalized* (explicit knowledge became tacit knowledge).

Concerning the spiral of knowledge, Nonaka and Takeushi (1995) developed a theoretical framework by pointing out the two dimensions — epistemological and ontological — of organizational knowledge creation. As depicted in Figure 10, the epistemological dimension, graphically represented on the vertical axis, is where knowledge conversion takes place between tacit knowledge and explicit knowledge. And the ontological dimension, on the horizontal axis, is where knowledge created by individuals is transformed into knowledge at the group and organizational levels.

These four models allow us to understand the conversions between tacit and explicit knowledge: socialization, externalization, combination, and internalization. These four processes are not independent of each other, but their interactions produce a knowledge spiral when time is introduced as the third dimension.

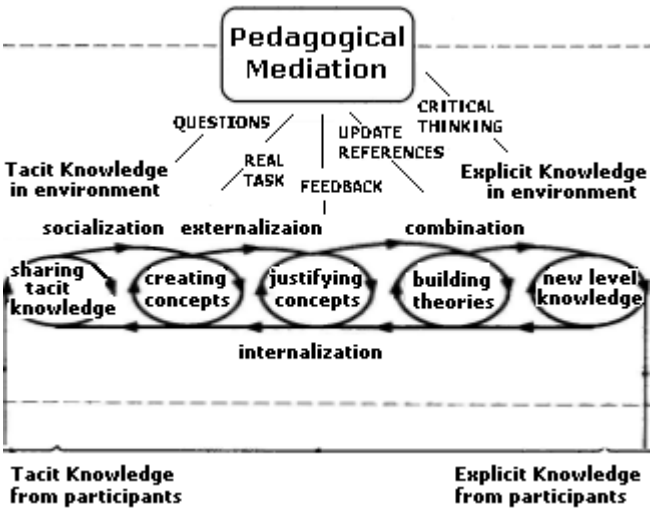
Another spiral takes place at the ontological dimension, when knowledge is developed; for example, the project-team level is transformed into knowledge at the divisional level, and possibly at the corporate or inter-organizational level. Again, the authors introduced time as the third dimension to develop the five-phase process of organizational knowledge creation: sharing tacit knowledge, creating concepts, justifying concepts, building an archetype, and cross-leveling knowledge.

The five enabling conditions promote the entire process and facilitate the spiral.

The transformation process within these two knowledge spirals is the key to understanding their theory. Innovation emerges out of these spirals.

The cyclical movement and organizational spiral can be observed in the environments since working teams started their production in an opened access site. Everything was shared and socialized on the Internet. Interactions occurred not only among researchers

Figure 12: Pedagogical mediation role.



and teams, but also with five other persons, researchers from Brazil, France, and the U.S. interested in the same subject. They accessed the environments site, wrote new information, and contributed to the discussion.

To guarantee this process, it could be observed that pedagogical mediation was essential to provoke reflection through questions, comments, articulations between personal experiences, theories, and new meanings . A friendly environment was important to establish a comfortable and motivating atmosphere to exchange ideas, uncertainties, doubts, new concepts, reflections, and criticism. Authentic activities based on common and clear purposes facilitate collaboration learning. Other important aspects are the quality of interactions, such as exchanging opinions, reorganizing and synthesizing comments collectively, reconstructing new concepts together, criticizing, and deconstructing approaches in groups in order to go deep into theories. It seems to be essential that the interactions are not only intensive but also meaningful to promote the collective building of knowledge.

Pleasure/Well-Being

One of the most important and necessary aspects noticed in the environments is pleasure and well-being. The meaning of "university," based on the medieval Latin word "*universitas*" describes a group of people getting together to learn for pleasure. Those who learn and those who teach should encourage the intellectual, cultural, and creative abilities of each other as a spontaneous and pleasant process. Thereby, co-learners can enjoy learning for pleasure. It contributes to self-esteem and self-knowledge.

About the environments developed in the workshop, it could be noticed that co-learners felt gladness and gratification in being authors of maps, papers, and their own environments. They experienced the excitement of freely discussing and debating ideas at nearly level ground with persons who became not only colleagues but friends.

The possibility of being subjects of their own knowledge, of creating and innovating, of leading discussions, and of being pedagogical mediators provides the impetus for such preparation.

This discipline Epistemology and Education comprises innovation and daring: practicing theories, creating an environment of responsibility among students. The opportunity given to share proposals, actions, is different from the usual learning. I am learning things from many angles...I could not evaluate everything that has been happening with me yet. Clearly, we are here the subject of researching experiment. I feel in this discipline, the chance of "looking within" and the invitation to "looking outside." I do not know if I am being very confusing, but I felt as student that you, professors, have awakened this reflective view. But, it is different when you provoke the reflection and when you allow interference. Is it a practice of detachment? Is it the change of paradigm, isn't it? I do not know, but it seems fantastic the way we are taking. Between the perplexity and the ecstasy, it becomes almost another research.... hehehehe)? :)))). (Ross 28/03)

Some Problems

Managing Time

Although one of the great advantages in virtual learning environments is communication at different times from different places, some participants revealed that such flexibility provokes intensive interactions and, consequently, time became a great problem. The challenge was managing time: feeding the environment, being involved with technical aspects, and weaving theory and practice in order to develop new concepts.

One way to minimize this problem is to invite the participants to an explicit conversation to create strategies for managing their time

Evaluating the Environment

Another difficult issue presented by participants was how to evaluate the environment, how could they know the quality of the productions and interactions. Some different kinds of feedback are necessary to help them calibrate their participation with their expectations. It could be noticed that talking about the quality of their communication was very important. The teacher can provide some feedback but it is even better if the teacher can encourage participants to develop a norm of providing feedback to each other about communication style, quantity, frequency, clarity, etc. Teachers can help team participants access more of their own feelings and reactions to messages in different media. This kind of self-organization is an important skill.

TechnoStress

Besides managing time and evaluating the environments, participants talked about TechnoStress.

There is technostress in the environment due to many interactions to take place through the computers. Very often I stay in front of computer instead of staying with my family. The flexible virtual class time frequently overcame my leisure time with my family, reading books by myself, or discussing face to face with colleagues. (Krugger 11/3 14h)

For Weil and Rosen (2001),

TechnoStress is our reaction to technology and how we are changing due to its influence. Over the past 15 years, as technology has become an increasingly prevalent part of our lives, we have watched TechnoStress develop and impact people in their personal lives, their family and their work environment. We are changing both internally and externally due to technology and these changes are not in our best interests physically, socially or emotionally. (p. 1)

The environment must stimulate a network of interpersonal relationship that is part of an effective collaborative learning interaction, but it is very important to know how to manage time. Participants must feel comfortable to discuss any problem and solutions, to make choices about what they need. It is very important not only to manage one's own learning, but also one's own well-being.

It is essential to keep up face-to-face contact with persons - family, friends, and even virtual colleagues. The network of interpersonal relationships can go further than virtual learning environments. It can be noticed that a meaningful virtual interactions can enrich face-to-face relationships.

Both authors, Weil and Rosen (2001), emphasize that it is very important to learn how to maintain humanity in a technological world. Technology provides us with a range of options that can enrich and enhance our lives. However, to fight TechnoStress, we must learn to drive and not be driven by technology.

Pedagogical Mediation

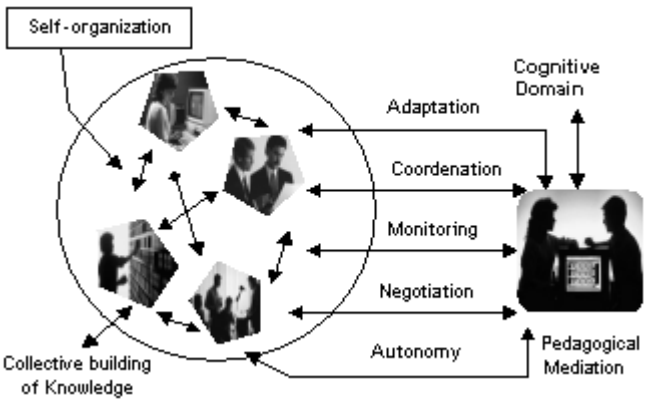
How to engage co-learners into weaving a net of meaning collectively?

The most important aspect of networking theory is to understand how to deal with complexity and uncertainty in order to benefit from and elicit collective knowledge building. Concerning this aspect, pedagogical mediation is the key to guide the environment to deal with unpredictable challenges.

Concerning complex interaction among biological, social, and technological components, the importance of pedagogical mediation is extremely relevant in order to elicit collective building of knowledge.

Considering VLE as a living organism and the importance of pedagogical mediation, six important aspects suggested by Britain and Liber (1999) were analyzed:

Figure 13: Pedagogical mediation and self-cognitive learning environments.



- *Negotiation*: How do learners negotiate their learning process with their teacher in order to elicit the collective building of knowledge? Is this a one off or a continuous process?

  Frequent (virtual and face-to-face) discussion moments about the process were some great opportunities to identify problems and to promote reflections and agreements.

- *Coordination*: Can learners collaborate in creating their learning? How?

  Small working teams stimulated learning, particularly the challenge to go deeper into their preferred subject.

- *Monitoring*: How does a teacher monitor whether learning is happening, so that, if necessary, remedial action can be taken?

  The continuous support was very important, in particular the register of the trajectory of the groups, facilitating the accompaniment of difficulties and advances.

- *Autonomy*: How can each student find his or her own resources and advance his or her own learning independently of others? Can individual students contribute their discoveries to the group?

  All production shared among co-learners stimulated and inspired new productions. Autonomy occurs in such a way that changed the initial circumstances of the subject, and this occurred due to the involvement of the participants.

- *Self-organization*: What space or tools are available to let the learners organize themselves as a group, outside of the teacher's purview?

  Easily available and free-of-charge resources, as well as proximity among colleagues inside teams, have facilitated self-creation of collaborative learning environments.

- *Adaptation*: Is it possible for the teacher to adapt the course and its resources in light of experiences gained during its operations?

  In order to adapt to the needs of the participants and the proposals of the subject and the workshop, many changes were achieved in the structure of the environment concerning activities, rhythm, and period of accomplishment, contents, supporting materials; mainly the discussion of purposes and feedback were a great incentive.

Collaborative Learning Environments: Some Conclusions and Future Trends

It is essential to find new ways to organize what is relevant and meaningful within the collaborative learning environment and help participants manage their research time better.

This means thinking carefully not only about the best interfaces, software, and contents, but also about the best methodologies for enabling collaborative learning and knowledge co-construction. Knowledge is not produced just from the technology and informational resources, but from the attitudes of the people who are trying to establish what, how, and why.

Some critics believe that cyberspace has a more profound impact on social relations than it does on information processing. It affects both identity and community (Dodge & Kitchen, 2001). Using and reflecting on the interactions, interrelationships, and co-constructions in cyberspace, we can explore who we are and how we are changing.

The complex identity of cyberspace is defined by characteristics such as: fast updating, diverse information, multiple connections, open resources, and a hypertextual and fluid space for interactions. These characteristics are related to the six network theoretical aspects: metamorphosis (changes), heterogeneity (diversity), multiplicity (multiple levels), exteriority (outside), acentrism (no center), and proximity (close elements). Considering these aspects, we can draw out some important principles about collaborative learning environments:

- *common and clear purpose articulated by the different participants*: when teachers and learners have a common and clear purpose, they become co-investigators.

Table 3: The Collective Building of Knowledge in Virtual Learning Environments

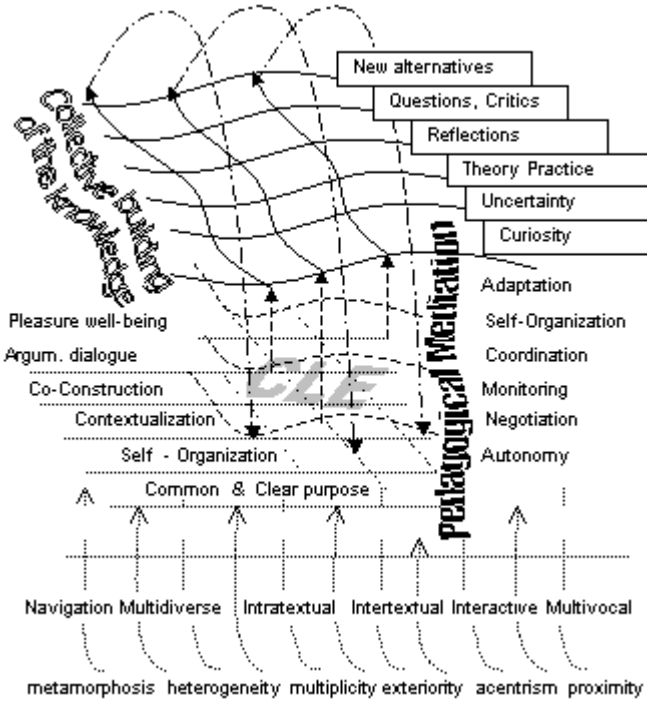
Network	**Collaborative VLE**	**WebSite Structure**	**Pedagogical Mediation**	**Collective Building of Knowledge**
Metamorphosis	Common & Clear purpose	Easy and simple Interfaces	Adaptation Promoting the VLE update continuously	Keeping curiosity
Heterogeneity	Self - Organization	Aesthetic design	Self-organization Creating circumstances for the participants to act.	Taking benefits from uncertainty
Multiplicity	Contextualization	Available resources	Coordination Guiding participants to go deeper in their projects	Connecting theory and practice
Exteriority	Co-Construction	Flexible architecture	Monitoring evaluating and self-evaluating by all participants	Reflecting from an opening view
Acentrism	Argumentative dialogue	Significant contents	Negotiation Managing process from many points of views	Reconstructing from questions and criticism
Proximity	Pleasure / well-being	Pleasant space to meet	Autonomy making the environment more pleasant and involvement	Discovering new alternatives

- *self-organization*: learners and teachers need to be responsible for organizing the environment, making changes and updating when they want to.
- *contextualization*: it is important to know the contexts of all the participants to create interactivity and a group identity. Participants require situational and cultural contexts in order to understand the meanings negotiated in the environment.
- *co-construction*: when teachers and students are partners in collaborative learning, they can build knowledge together.
- *argumentative dialogue*: this is an essential condition for development of consensual and critical knowledge.
- *pleasure and well-being*: co-learners enjoy learning for pleasure. It contributes to self-esteem and self-knowledge.

For that purpose, the CLE website should be:

- *Navigable*: learners need to explore the environment at their own pace, in a way that is comprehensible.

Figure 14: The Collective Building of Knowledge in Virtual Learning Environments



- *Multidiverse*: multidiversity improves communication and working. It enriches the co-construction with many points of view and diversity of information.
- *Intratextual*: structural links in our own website allow us to understand interrelated paths.
- *Intertextual*: links with other websites offer value-added information.
- *Interactive*: interactivity is the essence of communication. It is essential to create interactive spaces in which participants can engage (one verb is enough!), allowing a rich dialog between users and the environment.
- *Multivocal*: a variety of voices allow participants to make decisions, connections, and inferences.

Thus, CLE website designers should organize a structure with intuitive interfaces, aesthetic design, available resources, flexible architecture, significant contents, and a pleasant space to meet.

There are also requirements for teachers to facilitate the collective building of knowledge:

- *adaptation*: promoting the VLE update continuously;
- *self-organization*: creating circumstances for the participants to act collaboratively;
- *coordination*: guiding participants to go deeper into their projects;
- *monitoring*: evaluating and self-evaluating by all participants;
- *negotiation*: managing process from many points of views;
- *autonomy*: making the environment more pleasant, where learners can create collectively their own challenges.

These pedagogical mediations (actions) not only help students to interact more but also to reach their purposes in a meaningful way. They create a dynamic process to help students keep their curiosity, benefit from uncertainty, connect theory and practice, reflect on different points of view, and reconstruct ideas and thoughts from questions, reflections, and criticism.

So, it is probable that if, in the future, a professor suggests to his or her students using a virtual learning environment to promote discussion, collaborative learning, and collective building of knowledge, many of them will answer: "Yes!"

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Appendix

Freeware interfaces available in cyberspace:

Table 1: Html Editors

Netscape Composer	http://cannels.netscape.com/ns/browser/download.jsp
FrontPage Express	http://microsoft.com/dowloads/search.asp
Nestor Web Cartographer	http://www.gate.cnrs.fr/~zeiliger/nestor/nestor.htm
Others	http://www.setarnet.aw/htmlfreeeditors.html

Table 2: Servers

HPG	http://www.hpg.com.br
GEOCITIES	http://www.geocities.com
TRIPOD	http://www.tripod.com

Table 3: Chats

CJB NET	http://www.cjb.net
ICQ	http://go.icq.com/

Table 4: Forum

FÓRUMNOW	http://www.forumnow.com
INFORUM	http://inforum.insite.com.br/

Table 5: Group Lists

YAHOO	www.yahoo.grupos.com.br
GEOCITIES	www.geocities.com
ESCRIBE	www.escribe.com/

Table 6: Blogs

BLOGSPOT	http://www.blogspot.com/
IG	http://blig.ig.com.Br
WEBLOGGER	www.weblogger.com.br