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UNA METODOLOGIA PARA EL APOYO COMPUTACIONAL DE LA EVALUACION Y MONITOREO EN AMBIENTES DE APRENDIZAJE COLABORATIVO

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DEDICATORIA

A mi familia por su apoyo incondicional, sobretodo a mi madre y hermano que hoy ya no están conmigo pero fueron la luz que iluminó mi camino.

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RESUMEN

Uno de los requerimientos básicos para la educación del futuro es preparar a los estudiantes para que puedan participar en una sociedad de información, en la que el conocimiento se convierta en el recurso más crítico para el desarrollo social y económico. Las instituciones educativas están siendo forzadas a encontrar mejores métodos pedagógicos para poder soportar éstos nuevos cambios. En este desarrollo se espera que la tecnología computacional pueda jugar un papel muy importante en reestructurar los procesos de enseñanza-aprendizaje con el fin de estar mejor preparados para los futuros cambios de la sociedad. El Aprendizaje Colaborativo Apoyado por Computador (CSCL) es una de las ideas más provisorias para mejorar la enseñanza-aprendizaje con la ayuda de la moderna tecnología de información y comunicación. Una gran cantidad de estudios científicos en los últimos años han demostrado el alto grado de aprendizaje que es posible lograr cuando los estudiantes colaboran en sus tareas de aprendizaje. CSCL aún tiene que lograr su gran cometido. Su fortaleza reside en las virtudes del aprendizaje colaborativo. De esta forma el éxito del aprendizaje colaborativo no está directamente relacionado con el éxito de CSCL. Una de las razones corresponde a la falta de investigación en torno al impacto de la tecnología en los sistemas de evaluación y monitoreo del proceso de colaboración. La promesa del aprendizaje colaborativo es permitir a los estudiantes aprender en contextos relativamente realistas, cognitivamente motivantes y enriquecidos socialmente. Para poder lograr este cometido, se hace necesario, antes de implementar esquemas colaborativos computacionales, entender el proceso de colaboración que se genera al interactuar un grupo de trabajo, para posteriormente poder enseñar y mejorar este proceso. Dicha mejora requiere de la utilización de medios computarizados para poder lograr una evaluación más completa y un análisis más detallado. Basados en lo expuesto anteriormente, se propone desarrollar una infraestructura (“framework”) que permita
monitorear y evaluar el proceso de colaboración, tanto por parte de los estudiantes como por parte de los profesores, dentro de una actividad grupal.
SUMMARY

One of the basic requirements for education in the future is to prepare learners for participation in a networked, information society in which knowledge will be the most critical resource for social and economic development. Educational institutions are being forced to find better pedagogical methods to cope with these new challenges. In this development it is expected that computers could play an important role in restructuring teaching and learning processes to be better prepared for future challenges.

Computer-Supported Collaborative Learning (CSCL) is one of the most promising ideas to improve teaching and learning with the help of modern information and communication technology. A number of researchers in recent years have demonstrated the high degree of learning possible when students can collaborate in learning tasks. CSCL has yet to realize its great promise. Collaborative learning has a well-formulated theory validated by hundreds of research studies, translated into a set of practical procedures that teachers and administrators may use, and actually implemented in tens-of-thousands of classrooms throughout the world. One of the reasons corresponds to the lack of research about the impact of technology in the monitoring and evaluation of collaboration processes. Technology must to promote collaboration among group members creating shared experiences among them that support the type of interactions that are expected to promote learning. An improved process of collaboration should result in the development of end products of higher quality. In order to improve the collaboration process, it is necessary, initially, to be able to evaluate this process with a certain degree of precision with the intentions of being able to check other different processes of learning carried out by diverse groups of students. The developed computer model intends to improve the collaboration process through evaluation and monitoring, with group activities.
INTRODUCTION

We find ourselves on the educational frontier that demands an educational system being flexible, open, and adaptable to the learning conditions of the students. This force us to search for new methods that will aid us on the development of our students. In these reforms, technologies supporting computer-based processes and communications between persons have played an increasingly relevant role, hereby computers and the Internet became a crucial tool for development and change [Hepp00].

Society is changing rapidly evolving in the areas of knowledge and more specifically in the area of technology. This change affects the way people work and learn. There has been a lot on emphasis of the inherently cooperative nature of the processes and the businesses that have materialized by organizations made up of people [Furu95, John93].

Recently, knowledge is being recognized as one of the most important attributes to have within organizations. As we face an ever globalized and technological society, a new multicultural environment is opening through the many different means of telecommunication. The world of today demands that every individual possess effective and developed cognitive strategies that would allow him to compare and select the most appropriate and significant body of knowledge. Strategies such as “learning how to learn” and “learning how to think and process the multitude of information from a critical and reflexive point of view” not only allow an individual to retain information but also apply the information effectively to solve problems under different consequences. This process of adapting to the challenges of an exponentially changing world makes it ever more urgent to apply facilitating tools in the evolution of intellectual abilities.
In spite of the above, the required individual capacities do not show their importance until they face the requirements of social interaction. Social learning occurs by interaction, in the context of its labor and/or professional elaboration, group work, and cooperation and collaboration that are sustained in the formative social processes.

This less individualistic and more collective view is seen more often than not in cultural and traditional backgrounds that are based on the competitiveness required to reach certain goals placing individuals in complex situations in front of their peers. This predicament is what is challenging today’s educational system and is precisely what this thesis plans to investigate.

The increasing number of studies related to group participation strategies and cooperation, in recent times, are inserted in the new educational model where the traditional educational environments are questioned from as much as the perspective process as from the results. This opens a new field of investigation for the implementation of Information and Communication Technologies (ICT) that will support and sustain the fundamental interactive processes for collaborative learning.

The structure of the alternative learning environments presupposes a paradigmatic approximation that maintains the purposes of efficiency and affectivity in the formative processes. This is different to traditional learning environments that are structured in today’s school, technical, and university systems.

### 1.1 Collaborative Learning

Collaborative learning is one of the most remarkable and fertile areas of theory, research, and practice in education. The use of collaborative learning so pervades education that it is difficult to find textbooks on instructional methods, teachers’ journals, or instructional materials that do not mention and utilize it.
There are many definitions about collaborative learning. Three definitions offered by leading scholars are presented below, each of whom is widely known for their many years of work developing collaborative learning.

1.1.1 Johnson and Johnson’s Definition

According to these authors, collaborative learning exists when students work together to accomplish shared learning goals [John98, John00]. Collaborative learning takes many forms and definitions. Most collaborative approaches involve small, heterogeneous teams, usually of four or five members, working together towards a group task in which each member is individually accountable for part of an outcome that cannot be completed unless the members work together; in other words, the group members are positively interdependent. A vivid example of interdependence can be found in the relationship between language-minority and language-majority students in two-way immersion programs.

When collaboration is successful, synergy takes place, and the whole becomes greater than the sum of its parts. For collaborative groups to be effective, members should engage in teambuilding activities and other tasks that deal explicitly with the development of social skills needed for effective teamwork. Members should also engage in-group-processing activities in which they discuss the interpersonal skills that influence their effectiveness in working together.

1.1.2 Slavin’s Definition

All collaborative learning methods share the idea that students work together to learn and that key are responsible for their teammates’ learning as well as for their own. Three concepts are central to all students team learning methods: team rewards, individual accountability, and equal opportunities for success. Teams may earn certificates or other team rewards if they achieve above a designated criterion. Teams do not compete to earn scarce rewards; all (or none) of the teams may achieve the criterion in a given week.
Individual accountability means the team’s success depends on the individual learning of all team members. Accountability focuses the activity of the team members on tutoring one another and making sure that everyone on the team is ready for a quiz or any other assessment that students take without teammate help. Equal opportunities for success means that students contribute to their teams by improving their own performance. This ensures that high, average and low achievers are equally challenged to do their best, and that the contributions of all team members will be evaluated [Slav87].

1.1.3 Kagan and Kagan’s Definition

Spencer and Miguel Kagan and their colleagues have developed the Structural Approach to cooperative learning [Kaga94]. They describe four principles which are key to the structural approach:

- Simultaneous interaction
- Equal participation.
- Positive interdependence
- Individual accountability.

There are many potential benefits to encouraging cooperative learning:

1. Cooperative learning helps build higher-level cognitive skills as well as interpersonal skills [Mich92].

2. Cooperative learning helps students develop interpersonal skills [Slav87] such as: getting to know and trust team members; communicating effectively and clearly; providing support and challenging fellow team members; and engaging in constructive conflict resolution [John94]. In addition, these social skills may help students acquire a sense of social responsibility [Verm88].

3. A cooperative learning environment has a positive impact on student achievement [Ream90].
4. Cooperative groups have been shown to obtain significantly higher achievement scores compared to individualistic group, in a post-test [Sher86].

5. A study has shown that students in a cooperative group can learn material better than students who attempt to learn it individually [Yage85].

6. The experience of being in a cooperative group also gives rise to a feeling of having achieved success, which in turn enhances self-esteem. Students thus look forward to coming to school and meeting their classmates [Slav80].

7. Students learning cooperatively become active learners who want to contribute and discuss ideas with teachers [Davi90].

8. Students in a cooperative group assist each other to stay on task by discussing the problems that other members in the group are facing [John81].

9. Students in a cooperative group engage in higher-order thinking [Slav87] because they need to reorganize their thoughts and explain concepts to the other team members.

Although significant benefits arise from incorporating cooperative learning, there are also potential negative outcomes. Some of the negative effects are: the formation of dysfunctional groups; an inability to work together to deliver the desired outcomes of the task; and a lack of democracy within a group to form a consensus as to how a task should be carried out [Beck90].

The discipline of using cooperative learning effectively includes learning the interpersonal and small-group learning skills that students need to use in order to be successful in their work with peers. Because students need many skills in order to cooperate successfully, just telling students to “cooperate” is not sufficient. Sometimes teachers assume that students have these basic skills and they get frustrated when the simple direction “move into your groups” releases unsatisfactory levels of noise and disorganization. Teachers tend to become discouraged when students use put-downs,
display an obvious lack of interest in working with others, leave their groups and wander around the room [Shar87].

Collaborative learning is a discipline that begins with the understanding of the power and potential of diversity, and an understanding of the essential nature of community. This discipline requires careful teacher planning for regular and rich instructional opportunities that emphasize positive interdependence, simultaneous interaction, individual responsibility, reflection and planning, and a specific focus on the interpersonal and small-group learning skills that students need to learn to use to be successful group participants and learners.

### 1.2 Computer-Supported Collaborative Learning

One of the basic requirements for education in the future is to prepare learners for participation in a networked information society in which knowledge will be the most critical resource for social and economic development. Educational institutions are being forced to find better pedagogical methods to cope with these new challenges. In this development it is expected that computers could play an important role in restructuring teaching and learning processes to be better prepared for future challenges.

Computer-Supported Collaborative Learning (CSCL) is one of the most promising ideas to improve teaching and learning with the help of modern information and communication technology [Giff99, Kolo99, Muuk99, Stah99]. Actually, there is much research work about “cooperative learning” and “Computer-Supported Collaborative Learning”. However, several researches, both in the area of education and computer science, give different meaning to the terms cooperation and collaboration. Thus, terms such as cooperative learning, collaborative learning and even group learning are considered similar concepts in some studies, and different concepts in others. The same happens with the terms cooperative work, collaborative work and group work. This fact, perhaps, is due to the approach change that research in the area has undergone with time.
Dillenbourg et al. [Dill95a] claim that for many years, theories of collaborative learning have been focused on how individuals work in group, and only recently, they have focused on the group itself, trying to establish when and under what circumstances collaborative learning is more effective than individual learning. In this context, some independent variables have been identified and widely studied: the size and composition of the group, the nature and the objectives of the task, the media and communication channels, the interaction between peers, the reward system and sex differences, among others [Adam96, Dill95a, Slav91, Unde90, Coll01b].

A number of researchers in recent years have demonstrated the high degree of learning possible when students can collaborate in learning tasks [John86a, Kaga86, Slav88]. Computer-Supported Collaborative Learning (CSCL) has yet to realize its great promise. It currently rests on the strengths of cooperative learning. Cooperative learning has a well-formulated theory validated by hundreds of research studies, translated into a set of practical procedures that teachers and administrators may use, and which are actually implemented in tens-of-thousands of classrooms throughout the world. One of the reasons corresponds to the lack of research about the impact of technology in the monitoring and evaluation of collaboration processes. Technology must promote collaboration among group members creating shared experiences among them that support the type of interactions that are expected to promote learning.

CSCL appears when the instructional use of technology is shared with the use of collaborative learning groups. In summary, “collaborative learning” describes a situation in which particular forms of interaction among people are expected to occur, which should trigger learning mechanisms, but there is no guarantee that the expected interaction will actually occur [Dill99]. Hence, a general concern is to develop ways to increase the probability that some types of interaction will occur. Also it is necessary that both teachers and students assume new roles in a collaborative activity [Coll01a], and to define new schemes that permit to structure activities that involve collaborative elements.
1.3 ¿How to improve collaboration in learning environments supported by computers?

Kaye (1991) summarizes the six most important elements for collaborative learning:

- Learning is inherently an individual process, not collective, but it is influenced by a variety of external factors, including group and interpersonal interactions.

- Group and interpersonal interactions are related to the use of a language in reorganization and modification of common understandings, and to the building of individual knowledge structures. Therefore learning is a private and a social phenomenon at the same time.

- Learning cooperatively implies sharing knowledge, interacting, and exchanging roles.

- Collaboration involves synergy and assumes that somehow "the whole is bigger than the sum of the individual parts", it means that collaborative learning can produce gains superior to individual learning.

- Not all the attempts of learning cooperatively will be well succeeded. Under certain circumstances cooperative learning means loss of the process, lack of initiative, misunderstandings, conflicts, and discredit: the potential benefits are not always reached.

- Collaborative learning does not necessarily mean to learn within a group. It implies in the possibility of counting on the support of other people, and giving feedback in a non-competitive environment.

Proposals for the use of collaborative learning techniques supported by computers argue that under the practice of group activities, students have the opportunity to learn in group
processes, to learn personal strategies in contrast with other people’s, multiple perspectives of a same topic, leadership, management of task groups, and communication. The computer supports communication and collaboration, providing attendance to the coordination process, allowing the creation of situations impossible in the real world, monitoring of the actions of the members of the group, which can be used for the improvement of problem solution strategies, and for stimulating the improvement mental processes of knowledge acquisition. In spite of this, some authors mention problems or unexpected results from experiences with the use of computer supported cooperative learning environments.

As Santoro et al. [Sant99] mention, the problem of lack or low cooperation level within the environments can occur for the following reasons or a combination of them:

- **Culture** - One of the difficulties that determine non-positive results in the use of computer supported cooperative learning environments is that people are not used to working in-groups. For this reason, one of the objectives of this kind of environment is to develop this ability, besides the acquisition of some content. Aspects related to the culture of people, such as behavioral factors, age, sex and background could influence the way an environment is going to be used. For example, in a culture where discipline is lax, one cannot expect students to do their tasks without using a certain pressure for positive results.

- **Stimulus** - Some cooperative learning environments exclusively offer tools to give support to the execution of a task by a group of people. The failure of these environments is justified by the absence of mechanisms that favor functions of a group like cognitive activity, support to individuals and well-being of the group. An objective is proposed, cooperative tools are available, and the students are supposed to interact cooperatively to reach the objective, even though the environment does not induce them to this, which means, that there is no defined flow or process and the only way to achieve results is through team work.
• Context - Computer supported cooperative learning environments usually have specific educational objectives or organizational practice training goals, but besides them, they must be integrated within other activities in which students participate. For example, it will surely be quite difficult to use a cooperative environment in a context where competition sustains the relationships among the people. The environment should motivate common interests within the group, usually related to their everyday life, needs and preferences.

• Technology - There is no integration of tools within environments. In general, people have difficulties in the usage of several different tools. The integration problem could be solved by gathering the learning objectives and the actions within the environment. Also, the interfaces are still not comfortable, and do not explore specific mechanisms for cooperative work.

In recent years some research has been done about the study of collaboration processes and how to improve them [Barr99, Brna97]. Some of these studies are focused on how to teach/learn to collaborate, putting emphasis on “learn to collaborate” rather than “collaborate to learn”.

Most research on collaboration has attempted to measure its effects, generally through some individual pre-test/post-test gain with respect to task performance. Some specific effects have been described in terms of conceptual change [Amig90] or increased self-regulation. The choice of these dependent variables leads to two methodological issues.

The first issue could be stated as “effects of what?”. A collaborative learning situation includes a variety of contexts and interactions. Talking about the effect of such a broadly defined term would be as meaningless as talking about the benefit of taking a medicine, without specifying which one. One should not talk about the effects of collaborative learning in general, but more specifically about the effects of particular categories of interaction [Dill95a].
The second issue concerns the mode of evaluation. The effects of collaborative learning are often assessed by individual task performance measures. It has been objected that a more valid assessment would be to measure group performance. This validity can be understood in practical terms: more and more professionals have to collaborate and it is an important goal for any educational institution to improve students’ performance in collaborative situations.

1.4 The Role of the Computer

Dwyer investigated how routine use of technology by teachers and students would affect teaching and learning [Dwye94]. He found that cooperative and task-related interaction among students in the ACOT\textsuperscript{1} classrooms was spontaneous and more extensive than in traditional classrooms.

Baloian et al. [Balo02] have developed COSOFT [Balo95] which is especially aimed at supporting the cooperative/collaborative use of computer based learning material by teachers and students upholding the following activities: presentation of learning material, planning and authoring of lesson units, discussion and cooperative problem-solving, students’ individual work and problem solving, creation of new material during a lesson, and remote access to the learning material.

Richards et al. [Rich86], conducted several studies examining the use of cooperative, competitive, and individualistic learning activities at the computer. The studies included students from eighth grade through college freshmen and lasted from 3 to 30 instructional hours. The tasks were a computerized navigational and map-reading problem-solving task and word-processing assignments. Computer-assisted cooperative learning, compared with competitive and individualistic efforts at the computer,

\footnote{Apple Classrooms of Tomorrow\textsuperscript{TM}}
promoted (a) higher quantity of daily achievement, (b) higher quality of daily achievement, (c) greater mastery of factual information, (d) greater ability to apply one’s factual knowledge in test questions requiring application of facts, (e) greater ability to use factual information to answer problem-solving questions, and (f) greater success in problem solving. Cooperation at the computer promoted greater motivation to persist on problem-solving tasks. Students in the cooperative condition were more successful in operating computer programs. In terms of oral participation, students in the cooperative condition, compared with students in the competitive and individualistic conditions, made fewer statements to the teacher and, more to each other, made more task-oriented statements and fewer social statements. They are generally engaged in more positive, task-oriented interaction with each other (specially when the social skill responsibilities were specified and group processing was conducted). Finally, the studies provided evidence that females were perceived to be of higher status in the cooperative than in the competitive or individualistic conditions [Stan89, John86b].

In addition to the Richard’s work, there are a number of studies that have found that students using a combination of cooperative learning and computer-based instruction learn better than do students using computer-based instruction while working individually [Cox85, Dalt90, Hoop92, Hyth85].

There is a natural partnership between technology and cooperation. There is evidence that individuals prefer to work cooperatively at the computer. The introduction of computers into classrooms increases cooperative behavior and task oriented verbal interaction [Chem81, Webb84]. Working at a computer collaboratively with classmates seems to be more fun and enjoyable, as well as more effective to most students. Students are more likely to seek each other out at the computer than they normally would for other schoolwork. Even when students play electronic games, they prefer to have partners and associates. The computer may not only be a good place to cooperate but may also be a good place to introduce cooperative learning groups in schools.
For cooperation to take place, students must have a joint workspace. One of the promises of the computer is to allow students all over the world to create powerful shared spaces: super blackboards and super models. Instead of sharing a blackboard or a desk, people from a wide variety of locations can share a computer screen.

The future of technology-assisted cooperative learning will be greatly enhanced by developing both appropriate software and hardware to create workspaces that may be shared by all members of a group, all groups within the same classroom (or school), and all groups in a network that stretches throughout the world. Increasingly, work is being done in self-managing teams, networked electronically with other teams throughout the company and the world. The ability of the hardware to allow or even require people to work cooperatively is an important design issue. Developers of hardware need to think seriously about how technology can increase human cooperation within the education process and within the workplace. In addition, a challenge facing software programmers is to write groupware to support group rather than individual work. The availability of groupware will increase the productivity of joint efforts. In order to write such software, programmers need to understand the nature of cooperation and the five basic elements that mediate its effectiveness.

When collaboration is mediated via a computer system, the design of this system impacts on the collaborative process. This mediation has methodological advantages: the experimenter may have explicit control over some aspects of collaboration (e.g., setting rules for turn taking, determining the division of labour or distribution of activities). The effects of the computer as medium also have pedagogical aspects: to support the type of interactions that are expected to promote learning. Dillenbourg mentions three settings in which the computer influences collaboration: Two human users collaborate on a computer-based task, Computer-mediated collaboration and Human-computer collaborative learning [Dill95a].
Identifying domains for collaboration and applying the appropriate collaborative learning techniques for a given domain is a compelling research direction since there is a lack of framework that relates the collaborative learning techniques and the domains. Researchers can conduct empirical studies and find out the reasons why some domains are appropriate for collaborative learning while some are not. This distinction could be used to design a framework that would act as the reference point for a wider set of collaborative learning domains.

Collaboration is emerging as one of the promising learning paradigms in intelligent tutoring systems. Despite the complexity involved in the design and development of collaborative learning systems, more research efforts should be spent to explore the impact of evaluation strategies to provide better learning environments [John96, Kuma96].

The analysis of some CSCL tools shows us the existence of many environments that promote learning through collaborative projects. Frameworks for groupware development like Habanero [Haba96], TOP [Guer98] and GroupKit [Rose97], display the usefulness and technological scaffolding to increase productivity and quality. Many toolkits, middleware and frameworks provide support to the development of generic groupware tools, but there are few concerned with the educational domain.

The computer cannot only be a good collaborative tool, but could be a good way to introduce collaborative activities within a classroom. However, the way activities are proposed within a CSCL environment may not lead to collaboration, as several authors reported when they used their environments in real situations. Guzial points out that, in the case of CaMILE environment, simply disposing a discussion space for the students and defining a theme does not necessarily lead to a discussion among them [Guzd97]. The support to cooperation should be planned within the environment to encourage discussions. O'Neill affirms that if there is no real interdependence in collaborative tasks proposed within the environment, or, in other words, if there is no explicit
collaboration process, the challenge of stimulating collaboration will just be a bother. Besides, teachers usually plan their activities beforehand, so it becomes extremely important that the purposes of the environment be very clear for them [Onei94].

From our observation in the literature, the collaboration model is certainly an important component of successful CSCL environments, but only a small number of available environments address this issue. An example is CLARE [16], which is based on a process model called SECAI (Summarization, Evaluation, Comparison, Argumentation, and Integration) that metaphorically conveys the learners from an individual position to an integrated and collaborative perspective. The goal of the CLARE environment is to support learning of scientific text interpretation. It includes a collaboration model, but it does not permit to evaluate and monitor the collaboration process.

In order to obtain learning in a collaborative manner, it is necessary to define a collaboration process that allows to monitor it and to evaluate it, and to understand the way in which it works and later to be able to transmit it to the learners. If the collaboration process is improved, the quality and quantity of group learning will be increased. As Ewing mentions, it is necessary to know more in detail about the process that occurs when a group of people is trying to solve a problematic situation in a collaborative way [Ewin02]. It is necessary to provide support for the design of educational activities, and to have a set of appropriate elements for the development of educative frameworks, especially environments that support monitoring and evaluation of collaboration processes. Kuman mentions that the processes of collaboration should be evaluated based on a set of pedagogical guidelines that ensure that collaboration takes place at an appropriate pace, and with positive interactions from all the peers [Kuma96].

The promise of collaborative learning is to allow students to learn in relatively realistic, cognitively motivating and socially enriched learning contexts, compared to other tutoring paradigms like socratic learning, discovery learning, integrated learning, etc.
This can be done with the use of computational technology in order to obtain a more detailed evaluation and a deep analysis of the data.

### 1.4.1 Computer-Supported Intentional Learning (CSILE)

Marlene Scardamalia and Carl Bereiter at the Ontario Institute developed CSILE for Studies in Education [Scar89]. CSILE is the first network system to provide across-the-curriculum support for collaborative learning and inquiry.

Through the use of the CSILE software, students and their teachers create a communal database. Students can enter text and graphic notes into the database on any topic their teacher has created. All students on the network can read the notes and students may build on, or comment on, each other’s ideas. Authors are notified when comments have been made or when changes in the database have occurred. Various note formats and supports have been designed to enhance the potential of the communal database for collaborative knowledge building.

CSILE functions as a "collaborative learning environment" and a communal database, with both text and graphics capabilities. This networked multimedia environment lets students generate "nodes," containing an idea or piece of information relevant to the topic under study. Nodes are available for other students to comment upon, leading to dialogues and an accumulation of knowledge. Students have to label their nodes in order to be able to store and retrieve them; over time, they come to appreciate the value of a precise, descriptive label. In addition to receiving writing practice as they create their own nodes, students get practice reading the nodes generated by others.

In 1996, CSILE developed a software tool that permits access to the databases of CSILE. This commercial version is called Knowledge Forum, ([http://kf.oise.utoronto.ca/](http://kf.oise.utoronto.ca/)) and includes a complete kit of knowledge construction. This new product is a powerful tool that enables students and teachers to work collaboratively in the support of knowledge building. Knowledge Forum is an electronic
group workspace designed to support the process of knowledge building. With Knowledge Forum, any number of individuals and groups can share information, launch collaborative investigations, and build networks of new ideas…together.

Knowledge Forum allows users to create a knowledge-building community. Each community creates their own Knowledge Base in which they can store notes, connect ideas, and "rise-above" previous thinking. The note-taking, searching, and organizational features of this sophisticated tool allow any type of community to build knowledge, whether you are:

- An academic community at the school, district, or university level.
- An alliance of administrators or a parent-teacher community.

Users start with an empty Knowledge Base to which they submit ideas, share information, reorganize the knowledge, and ultimately "rise-above" to new understandings. Knowledge Forum makes information accessible with multiple vantage points and multiple entry points. Even the collection and display of the community's work can be organized in flexible visual displays. Your work is not limited to your individual organization; if desired, you can become part of a larger community and work in concert on related problems. Knowledge Forum users can connect to their Knowledge Base via:

- A local area network
- The Internet communications (users designate where on the Internet the Knowledge Base is stored, and the application connects to it via the Internet)
- A browser (Explorer or Netscape) using the World Wide Web

Knowledge building communities are exciting places where success depends on the careful cultivation of ideas and the constant use and re-use of the organization’s knowledge resources. So maximizing that knowledge production and making knowledge advances available to the community is critical.
True knowledge building communities depend on a specific organizational design, one that defines each person as a contributor. Knowledge Forum does just that. With the knowledge-building tools in Knowledge Forum, users pose questions, define their own goals, and collaborate with peers as they acquire and build the Knowledge Base.

### 1.4.2 Belvedere System

Belvedere is a graphical environment with advice on demand intended to support the development of scientific argumentation skills in young students ([http://www.pitt.edu/~suther/belvedere/](http://www.pitt.edu/~suther/belvedere/)). It is designed to help support problem-based collaborative learning scenarios with evidence and concept maps. With this software, middle school and high-school students learn critical inquiry skills that they can apply in everyday life as well as in science.

Originally developed by Dan Suthers and colleagues while at the Learning and Resource Development Center at the University of Pittsburgh, the third and fourth generations of Belvedere were engineered at LILT to support multiple representational views (tables and hierarchies as well as graphs) on evidence models. Belvedere 4, programmed by David Burger, also adds support for concept maps and causal models. Several other experimental versions of Belvedere also exist at LILT [Lesg95]. The most important benefits are:

- Diagrams make abstracts ideas concrete and keep track of work.
- Shared visual workspace coordinates collaborative learning.
- Computer coach helps students apply principles of scientific reasoning.

Belvedere helps students learn critical inquiry skills that they can apply in science and other subjects. Students use a web browser to access on-line materials that demonstrate how scientists gather and analyze information, including talking with other scientists, reading articles, going to conferences, running experiments, and doing field studies. Students use visual "knowledge mapping" software to construct "inquiry diagrams"
which aid learning in several ways. Constructing and displaying "inquiry diagrams," uses shapes for different types of statements and links for different kinds of relationships between these statements. Students can construct their own diagrams using the icons in the "palette" on the top.

1.4.3 Learning Through Collaborative Visualization Project (CoVis)

Traditionally, K-12 science education has consisted of the teaching of well-established facts. This approach bears little or no resemblance to the question centered, collaborative practice of real scientists. Through the use of advanced technologies, the CoVis Project at Northwestern University is attempting to transform science learning to better resemble the authentic practice of science [Pea96].

The CoVis Project explores issues of scaling, diversity, and sustainability as it relates to the use of networking technologies to enable high school students to work in collaboration with remote students, teachers, and scientists. An important outcome of this work will be the construction of distributed electronic communities dedicated to science learning.

The CoVis Project provides students with a range of collaboration and communication tools. These include desktop video teleconferencing; shared software environments for remote, real-time collaboration; access to the resources of the Internet; a multimedia scientist’s notebook; and scientific visualization software. In addition to deploying new technology, it works closely with teachers at participating schools to develop new curricula and new pedagogical approaches that take advantage of project-enhanced science learning.

“Collaborative Visualization” thus refers to the development of scientific understanding, which is mediated by scientific visualization tools in a collaborative context. The CoVis Project seeks to understand how science education could take broad advantage of these
capabilities, providing motivating experiences for students and teachers with contemporary science tools and topics.

1.4.4 Synergeia

Synergeia is a software system developed within the ITCOLE research project funded by the European Union in 2001-2003. The Synergeia system combines an asynchronous component named BSCL (Basic Support for Cooperative Learning) and a synchronous component named MapTool [Syne03].

Synergeia is designed to support collaborative knowledge building in classrooms of schools. It provides a shared, structured, web-based work space in which collaborative learning can take place, documents and ideas can be shared, discussions can be stored and knowledge artifacts can be developed and presented. Teachers can structure, seed and guide work in Synergeia to facilitate knowledge building in their classrooms [Stah02b].

Computer-Supported Collaborative Learning is related with the new learning theories and as we have seen before, CSCL applications appear to be one of the most promising ways for the application of technology and communication in the teaching/learning process. As Brinkerhoff et al. mention, evaluating and monitoring collaborative efforts are essential tasks if we are to be successful in coordinating programs for people [Brin85].

The purpose of educational methodology is to provide that assistance to the learner. The purpose of educational environment is to enable that provision. Consequently, the educational process can be reduced to a two-way interactive communication process between people who have roles as teachers and as learners. Such communication enables teachers to assist learners to solve problems that they would not be able to solve by themselves. Collaborative learning strategies require more social interaction and engagement between learners than do traditional methods [Rust97, Topp98]. As such,
collaborative learning strategies specially where constructively aligned with assessment [Bigg96, Boud00] produce deeper learning of concepts and theories, and the co-creation of knowledge. However, the process of restructuring learning from teacher-centered to student-centered is critical [Spi98]. Not only do content, process, and assessment require redesign, but also students and teachers are repositioned. Though studies have compared the effects on discussion and student performance of computer-supported or technologically-mediated learning versus traditional learning, face-to-face learning environments [Alav94], there has been less emphasis on understanding the collaborative learning processes themselves from within these environments. However, none of the systems explained before include elements about the monitoring and evaluation of collaborative processes.

Next we will present the problematic situations we have identified in order to define a mechanism to solve these problems with this thesis.

1.5 Problematic Situation

Based on what was said above, we plan to develop a framework that will include a collaborative environment that allows the monitoring and evaluating of the collaborative process of not only the students but also the teachers within a group activity. The whole mechanism of evaluation and monitoring will be essentially based on Computer Mediated Communication (CMC).

We have identified three problems regarding the evaluation and monitoring of the collaborative process: How to evaluate?, How and when to intervene?, and How to improve? All of which would be very difficult to answer without the aid of computer tools.
1.5.1 How to evaluate?

The typical evaluation of collaborative learning has been made by means of examinations or tests to the students to determine how much they have learned. That is to say, a quantitative evaluation of the quality of the outcome is done. Some techniques of cooperative learning use this strategy (e.g. “Student Team Learning” [Slav90], “Group Investigation” [Shar90], “Structural Approach” [Kaga90] and “Learning Together” [John75]). Nevertheless, little investigation has been done to evaluate the quality of the collaboration process.

1.5.2 How and when to intervene?

It has been agreed upon that before the collaborative learning be stated effective, it must follow certain guidelines and certain roles must be defined [Coll01a]. However, the definition of these guidelines and roles will not guarantee that learning will be achieved in the most efficient manner. It is necessary to define an outline of cooperation where the instructor knows when and how to intervene in order to improve the process of collaboration. As Katz mentioned, one of the main problems that the teacher must solve in this collaborative framework consists of identifying when to intervene and of knowing what to say [Katz99]. It is necessary for the teacher not only to monitor the activities of a particular student but also the activities of his peers to encourage some kind of interaction that could influence the individual learning and the development of collaborative skills, such as give and receive, help and receive feedback, and identify and solve conflicts and disagreements [Dill95a, John91, Webb96].

Just as important as how to evaluate, it is important to mention that how and when to intervene, are aspects that could be difficult to realize in an efficient manner if they are managed in a manual way, specially when taking into account that the facilitator could be cooperating with other groups of apprentices in the same class at the same time.
The use of computer tools allows the simulation of situations that would otherwise be impossible in the real world. As Ferderber mentioned, the supervision of humans cannot avoid being subjective when observing and measuring the performance of a person [Ferd81]. That is why the monitoring carried out by computer tools can give more accurate data as regards the performance of people.

One way to evaluate the effectiveness of a group is by monitoring and observing the interaction between the members of the group who work together. The observation will allow the teacher to obtain an understanding of the quality of the interactions between every member of the respective groups and the process of their task accomplishment. From the computer model that we intend to develop, the teacher will not only be able to observe the interactions between the participants but he will also be able to intervene whenever he feels it is necessary. The development of computer environments, where the interaction sequences can be analyzed, could determine at a certain point, for example, when a student is failing within the group and then analyze why. Johnson et al., mention that identifying, teaching and practicing skills are important but not sufficient to ensure that students develop high levels of interpersonal and small-group learning skills [John92]. Students must be given feedback about their use of skills; this feedback and reflection should be based on carefully gathered information about how students use their skills when they are working with others. Therefore, when students are working together in their cooperative groups, it is important for teachers to observe students’ use of interpersonal and small-group learning skills. Skillful observation is essential to the discipline of using cooperative learning skills [John92].

### 1.5.3 How to Improve?

This is an extremely important aspect to be taken into consideration in any evaluation mechanism. The idea is to be able to determine how to improve the faults of the group that were detected from a detailed analysis of their interactions in trying to carry out an activity in a collaborative manner. The objective is to somehow not only find the
weaknesses of the group—which is a difficult task in itself— but also with the aid of a computer be able to overcome those weaknesses.

1.6 Hypothesis

An improved process of collaboration should result in the development of end products of higher quality. In order to improve the collaboration process, it is necessary, initially, to be able to evaluate this process with a certain degree of precision with the intentions of being able to check other different processes of learning carried out by diverse groups of students.

The intended computer model intends to improve the collaboration process through its evaluation and monitoring, with group activities. The previously mentioned “on line” monitoring and evaluation cannot be finalized without the aid of computer tools.

1.7 Goals

The general goals of this investigation are the following:

- Develop a conceptual and computer framework that can be used in a diversity of environments and situations that would allow teachers, in a flexible manner, to evaluate and monitor the collaborative process within a group activity.

- Develop and test some computer tools that can be used to evaluate the collaborative process within the classroom.

- Develop and test some computer tools that can be used to monitor the collaborative process with the classroom.

- Define guidelines to evaluate the group process of collaborative learning.

The specific goals are:
• Develop a computer framework that includes a collection of computer tools and a database of information in order to evaluate and monitor the collaboration process in a group activity.

• Develop computer tools that will allow the teacher to monitor and evaluate the interactions among the members of the group who work together.

• Develop conceptual and computer models that will allow the teacher to make decisions on when and how to intervene in a collaborative activity.

• Create a collection of facilities to implement CSCL environments that have proved efficient support to monitor and evaluate the collaborative process.

• Describe a collection of Collaboration Indicators.

• Elaborate a system of patterns that will serve as a conceptual model to the development of the computer framework that will permit the monitoring and evaluation of the collaborative process of a group activity.

• Define a system of patterns of analysis for computer applications that will support the monitoring and evaluation of the collaborative learning process.

• Define a system of conceptual design patterns for computer applications that support the monitoring and the evaluation of the collaborative learning process.

• Elaborate a methodology for the design of computer applications that support the monitoring and evaluation of the collaborative process.

• Investigate a way to offer greater amounts of information and technical support to the tutor for some tasks such as the monitoring of the students while using computer tools.

• Develop a collection of computer tools that allow the monitoring of the collaboration process.
• Develop a collection of computer tools that include strategies of the generation and the resolution of conflicts among the members of a group of people in academic environments.

• Elaborate field tests in several classrooms with different groups of students and teachers with the final intention of evaluating the conceptual and computer framework proposed based on the previous goals.

1.8 Document Organization

In section 2 some important elements are presented concerning evaluation and in particular on how it was tackled by CSCL. In addition, some other related investigations in the field are referred to. Section 3 describes the development of collaborative applications focusing on existing frameworks that tend to support the development of computer aided collaborative applications. Section 4 presents the model of the development of computer aided collaborative applications focusing on the evaluation and monitoring of the collaborative process. The mentioned section describes everything that is related to the development of the evaluation of the collaborative process utilizing a collection of computer tools. Furthermore, the experiments utilized are presented with the intention to identify the weaknesses of the analyzed groups. In section 5, a collection of developed widgets is presented with the intention to improve one of aspects that is found to be critical in the evaluation of the experimented groups: the development of strategies. The tools designed and the experiments that have been materialised in order to determine the validity of the implemented products. Section 6 explains the elements that must be considered in order to design situations that are really considered to be collaborative, and it presents a guide of elements that must be integrated in a collaborative surrounding. In section 7, a terminology of patterns is presented that allows the design of the collaborative applications based on the evaluation and the monitoring of the collaborative process. Finally, the conclusions of the investigation and some recommendations of how to further develop the presented topic.
are presented. In addition, six appendices are included: cooperative learning methods, learning theories, logs of the experimented groups, models of developed interviews, and outlines of the pre-test and the post-test.
2. EDUCATION EVALUATION

It is a fact that the evaluation is a constant concern in the educational world at all levels, and a remarkable institutional and legislative development has been experienced recently along with an abundant amount of pedagogical literature and frequent investigations of their application [Cast02]. It is no secret that the importance which evaluation has lately acquired, in the educational world is of primary importance. It is nothing new to say that evaluation is one of the protagonizing issues in the academic environment and not because it is a “new” topic but because administrators, educators, parents, students and the society at large are more aware than ever of its importance and the repercussions that can arise at different levels when evaluating or being evaluated [Cabr02]. This can probably be most attributed to the existence of a greater conscience to reach higher levels of the quality of education and to make the most of the available resources of a society that has been continuously immersed in a cooperative and competitive dynamic which can no longer be detached from a world where education relies on computers.

2.1 The Evaluation Concept

The concept of evaluation is very broad and has many aspects. Evaluation can be developed with different objectives and under different perspectives. Likewise, there are multiple aspects that can be subject to evaluation in different surroundings. Evaluation is the process of determining significance or worth, usually by careful appraisal and study. At its core, evaluation involves the periodic collection and assessment of data about a specific project, program, or organization. There are two primary (and not necessarily exclusive) purposes for undertaking an evaluation:
Adaptive Management - Helping people obtain the information they need to manage their projects, programs, or organizations more effectively and efficiently. This process involves determining which actions worked and which did not - and why.

Impact Assessment - Helping people measure and document their results in terms of achieving desired changes in the system that they are working in.

### 2.1.1 Evaluation Types

In this aspect, a classical classification is the one that distinguishes between formative and summative evaluations [Gime95]. Evaluations which are conducted at or near the end of a teaching and learning experience, and which provide a retrospective view of the overall value of that experience are usually thought of as "summative". They yield information of particular value in identifying areas in need of large-scale, long-term development - development that will probably not take place until the following semester or the following year. Hence, the students who gave the feedback may not experience the benefits of it.

Evaluations, which are conducted during a teaching and learning experience, are often called "formative" evaluations. The information gathered by these means is of particular value in improving or maintaining the quality of the teaching and learning experience from day to day, or week to week. If a person acts promptly on information gathered for formative purposes, the students who gave him/her the information will experience the benefit and will appreciate his/her attention to their views and ideas. Information gathered for formative purposes may also be used to supplement or complement information gathered expressly for summative purposes [Gime85]. This is not exclusive of educational environments. In Software Engineering, the analysis and design methods use formative evaluations as a process that supports the information system development [Chin97].
2.1.2 Evaluation Strategies

Evaluation strategies mean broad, overarching perspectives on evaluation. They encompass the most general groups or "camps" of evaluators; although, at its best, evaluation work borrows eclectically from the perspectives of all these camps [Lato96]. Four major groups of evaluation strategies are discussed here.

Scientific-experimental models are probably the most historically dominant evaluation strategies. Taking their values and methods from the sciences -- especially the social sciences -- they prioritize on the desirability of impartiality, accuracy, objectivity, and the validity of the information generated. Included under scientific-experimental models would be: the tradition of experimental and quasi-experimental designs; objectives-based research that comes from education; econometrically-oriented perspectives including cost-effectiveness and cost-benefit analysis; and the recent articulation of theory-driven evaluation [Gime85].

The second class of strategies is management-oriented systems models. Two of the most common ones are PERT, the Program Evaluation and Review Technique, and CPM, the Critical Path Method. Both have been widely used in business and governments in many countries. It would also be legitimate to include the Logical Framework or "Logframe" model developed at the U.S. Agency for International Development and general systems theory and operations research approaches in this category.

The third class of strategies is the qualitative/anthropological models. They emphasize the importance of observation, the need to retain the phenomenological quality of the evaluation context, and the value of subjective human interpretation in the evaluation process. Included in this category are the approaches known in evaluation as naturalistic or 'Fourth Generation' evaluation; the various qualitative schools; critical theory and art criticism approaches; and, the 'grounded theory' approach of Glaser and Strauss among others [Brit97].
Finally, a fourth class of strategies is termed participant-oriented models. As the term suggests, they emphasize the central importance of the evaluation participants, especially clients and users of the program or technology. Client-centered and stakeholder approaches are examples of participant-oriented models, as are consumer-oriented evaluation systems.

With all of these strategies to choose from, how to decide? Debates that rage within the evaluation profession -- and they do rage -- are generally battles between these different strategists, with each claiming the superiority of their position. In reality, most good evaluators are familiar with all four categories and borrow from each as the need arises. There is no inherent incompatibility between these broad strategies -- each of them brings something valuable to the evaluation table. In fact, in recent years attention has increasingly turned to how one might integrate results from evaluations that use different strategies, carried out from different perspectives, and using different methods. Clearly, there are no simple answers here. The problems are complex and the methodologies needed will and should be varied [Carr96, Carr98].

The new evaluation perspective goes beyond the incorporation of qualitative models, which complement or displace the quantitative models, which are considered traditional or inadequate. The educational evaluation proposed by the current educational system is located at the "neuralgic" center of the teaching-learning process, and its dynamic influence affects all the elements that compose this process and revolve around it this process. The intention of this evaluation focuses in providing information to guide, regulate, and improve any educational process. It pretends a "formative following" which implies a pedagogical activity to assist in any possible difficulties. This requires a radical change in the traditional teaching methods [Cast02].

2.1.3 Dynamic Perspective

Evaluation is a process of three fundamental phases: the initial diagnostic, the formative process in itself, and the final evaluation or the results. Fig. 1 presents a platform for the
analysis of this perspective that follows the foundation given by Blásquez Entonado [Blaz98].

Fig. 1: Dynamic Perspective of Evaluation

In the initial evaluation it is recommended to insist, especially, on explaining the previous knowledge and the implicit theories that the students possess in order to offer new contents in such a way that they can be integrated in previous contents. This is the key to achieve significant learning that leads to some outcomes that are the expansion, differentiation, clarification or the in depth analyses of the students’ knowledge framework from the beginning of the teaching-learning process [Blaz98].

The strategies of evaluation, that correspond to each one of phases mentioned previously, present specific metrics:

- At the initial stage of evaluation it is pertinent that the teacher proposes problems, questions or specific aspects related from the answers of the students.
- The importance of the teaching of a teacher during the teaching-learning process can be evaluated through the use of instruments like conceptual maps [Nova84]. Good
teachers ask questions along the way that will push their students to reach metacognitive levels and to understand the importance of things in a more interesting manner.

- The final evaluation in part will affect the pertinence of the attributes, the validity of the cause-effect relation, and the capability of abstracting principles from the use of outlines or conceptual maps, free jobs, essays, etc.

2.2 Evaluation in CSCL

Evaluation is a very broad concept and that is why it is a must to state explicitly what elements or aspects we must consider and under what focus. An important problem arises from the fact that the CSCL does not define a unique vision on how to advance in this topic.

The domain is influenced by many educational theories (See appendix 2), all of which consider their own questions of evaluation and own means of fulfilling them. According to Latorre et al., evaluation can be considered as a process or a collection of processes to obtain and analyze significant information that support judgments of character on an object, a phenomenon, process or an event as an aid for an eventual decision on itself [Lato96].

We are looking for an assessment of the quality of the learning process, not its quantity. Robin Mason found that surveys, user interviews, empirical experimentation, case studies and computer generated statistical measurements are being used to evaluate computer conferencing [Maso92]. She rightly criticized them, as none tell us much about the quality of student learning taking place.
**Fig. 2: Stages and skills of the critical thinking process (with example indicators)**

<table>
<thead>
<tr>
<th>Garrison's CT stages</th>
<th>Henri’s critical reasoning skills</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Problem identification</strong></td>
<td>Elementary clarification</td>
</tr>
<tr>
<td>A triggering event arouses interest in a problem e.g. aroused interest, triggered a desire to understand, aware of issues</td>
<td>Observing or studying a problem, identifying its elements, observing their linkages e.g. identifying relevant elements, reformulating the problem, asking a relevant question, identifying previously stated hypotheses</td>
</tr>
<tr>
<td><strong>2. Problem definition</strong></td>
<td>In-depth clarification</td>
</tr>
<tr>
<td>Define problem boundaries, ends and means e.g. clarified subject, identified personal experience</td>
<td>Analyzing a problem to understand its underlying values, beliefs and assumptions e.g. defining the terms, identifying assumptions, establishing referential criteria, seeking out specialized information</td>
</tr>
<tr>
<td><strong>3. Problem exploration</strong></td>
<td>Inference</td>
</tr>
<tr>
<td>Ability to see the heart of problem based on deep understanding of situation e.g. explore new ideas, develop new solutions, understand issues, disentangle ideas</td>
<td>Admitting or proposing an idea based on links to admittedly true propositions e.g. drawing conclusions, making generalizations, formulating a proposition which proceeds from previous statements</td>
</tr>
<tr>
<td><strong>4. Problem applicability</strong></td>
<td>Judgement</td>
</tr>
<tr>
<td>Evaluation of alternative solutions and new ideas e.g. critical assessment, judge solutions, critically evaluate, assess practical knowledge</td>
<td>Making decisions, evaluations and criticisms e.g. judging the relevance of solutions, value judgements, judging inferences</td>
</tr>
<tr>
<td><strong>5. Problem integration</strong></td>
<td>Strategies</td>
</tr>
<tr>
<td>Acting upon understanding to validate knowledge e.g. previous knowledge, test solutions, and apply ideas, relating to other course tasks</td>
<td>For application of solution following on choice or decision e.g. deciding on the action to be taken, proposing one or more solutions, interacting with those concerned</td>
</tr>
</tbody>
</table>
Nor does assessing the system usability tell us much about the learning quality. Measures of usability help system designers improve their systems. They do not help teachers decide whether and how to use CSCL in classes. A useable system is a necessary but not sufficient condition for CSCL.

So what do we measure? Henri identified five dimensions for analyzing Computer-Mediated Communication (CMC): participative, social, interactive, cognitive and metacognitive dimensions [Henr92]. Briefly, the first three dimensions reflect the degree of active participation in the system, the social effects of taking part in CMC, and an analysis of the interactions taking place over the system. The cognitive and metacognitive dimensions relate to the psychological processes taking place during learning.

To evaluate this cognitive dimension of CSCL, a theory of critical thinking is necessary. Garrison's theory envisages critical thinking as a sequential problem-solving process with five stages: problem identification, problem definition, problem exploration, problem applicability and problem integration [Garr92]. Given this theory of critical thinking, it is possible to identify indicators of critical thinking at each stage. Example indicators are shown in Fig. 2.

Additionally, quantitative research in CSCL is difficult because it is hard to measure collaboration for a number of reasons:

- Effective collaborative learning depends on subtle social factors and pedagogical structuring, not just on simple tasks and technologies [Dill99].
- Collaborative learning technologies must go beyond generic groupware applications, and even the basic technology is not yet well developed [Stah02b].
- Settings of collaboration in classrooms and other groups are “messy” compared to classic laboratory research settings, full of intervening factors that cannot be controlled [Leon81].
• CSCL technology is complex, hard for users to learn and difficult to assess because it must be used by groups, not individuals [Muhl98].

• Interactions in experiments are unique, impossible to replicate in their details.

• Quantitative measures of collaborative interactions tend to lose the collaborative content [Stah02c].

A description of the related work with our proposed model is described below.

2.2.1 Related Work

Since the advent of computer supported collaborative work, the investigation of computer supported collaborative learning has been of major interest. It has been conclusively argued that a focus on the process of collaboration is necessary in order to understand the value of working together with peers for learning [Muhl99]. Collaboration is the mutual engagement of participants in a coordinated effort to solve a problem together [Rose91]. Various approaches for analyzing group learning interaction have been proposed. Some of them are presented below to have an overview of how this interaction is considered from different perspectives.

Barros and Verdejo [Barr99] have proposed an asynchronous newsgroup-style environment enabling students to have structured computer-mediated discussions online. Evaluating the interaction involves analyzing the conversation to compute values for the following four attributes: initiative, creativity, elaboration, and conformity.

Katz et al. [Katz99] developed two rule learning systems, String Rule Learner and Grammar Learner. These systems learn patterns of conversation acts from dialog segments that target particular pedagogical goals. Inaba and Okamoto [Inab97] describe a model that draws upon the ideas of finite state machines and utility functions. They used a finite state machine to control the flow of conversation and to identify proposals, while applying utility functions to measure participants’ beliefs with regard to the group conversation.
Muhlenbrock and Hoppe [Muhl99] have developed a framework system for computer-supported cooperative learning and working. The system has been used in determining conflicts in focus setting as well as initiative shifts in aggregation and revision phases during some collaborative sessions on problem solving.

Constantino-González et al. [Cons01] developed a system that evaluates a new approach to supporting collaboration that identifies learning opportunities based on studying differences among problem solutions and on tracking levels of participation.

Veerman et al. [Veer01] have assessed collaborative learning facilitated by computer-mediated communication (CMC) systems in academic education. They examined collaborative learning as a process of knowledge construction. They present four studies that took place as part of an academic course, in which students had to work collaboratively on complex tasks using a CMC system. The four studies involved different tasks, students, tutors and CMC systems. In each study, they analyzed how students constructed knowledge together and they related these findings to some main factors in the educational context: the role of the student, peer-student, tutor or moderator, and characteristics of the CMC systems used. The results showed that effective use of educational technology to support collaborative learning in academic education relates to these factors, including the modes of communication in asynchronous and synchronous CMC systems. Besides the need for more transparent and user-friendly CMC systems, asynchronous media can provide student groups with more options to think and reflect on information, to organize and keep track of discussions and to engage in large-group discussions compared to synchronous media.

Martínez et al. have defined a model where they have adopted a situated learning perspective, which emphasizes the interweaving between context and learning in such a way that one cannot be studied without the other. They proposed a mixed evaluation method that describes how to integrate sources of data and analysis methods of different
origin and nature in a common scheme that seeks for complementarity of these data and methods [Mart02].

Soller & Lesgold [Soll00] have developed an approach to analyze collaborative learning using Hidden Markov Models. Additional work is needed to understand how students communicate and collaborate, and to apply this knowledge to develop computational methods for determining how to best support and assist the collaboration learning process. This is our rationale: to propose a set of indicators in order to understand the collaborative learning process. In chapter 4 there is an explanation on how we defined our set of indicators, based on the stages of cooperative learning processes presented by Johnson and Johnson in [Adam96]. Fig. 3 represents the model which we pretend to develop based on a constant evaluation given that it has to be a dynamic, open, contextualized process that is carried out for a long period of time; it is not an isolated or punctual action. In addition, several successive steps of the mentioned process must be carried out in order to obtain the three essential and indispensable characteristics of all evaluations:

1. Obtain information: apply valid and reliable procedures to obtain systematic, rigorous, relevant and appropriate data and information that will become the foundation of consistency and reliability of the results of the evaluation.
2. Make judgements: the data obtained must secure the analysis and the valuation of the facts that we intend to evaluate, so the most appropriate judgement can be obtained.
3. Make a Decision: in accordance with the emitted evaluation of the available relevant information, we can make decisions that come along with every case.
As it has been mentioned in the hypothesis, our model pretends to evaluate the collaborative process with the final intention of improving it. That is why we shape the process in such a way that it can be evaluated with the intention of obtaining information that will allow us to make well founded judgments, with respect to the quality of the collaborative process of the analyzed groups, and as a result it will allow us to make decisions with the intentions of being able to improve some weaknesses observed in the groups. As mentioned by Castillo [Cast02], the main goal of the evaluation is the educational process of the students because this is the end product of the teaching-learning process. With the model we intend to use in this investigation it is possible to supply the teacher with enough elements of judgment to allow him to make decisions in a more confident manner. The mentioned evaluation must be guided, regulated and motivated in order to be conducted through the whole process in such a way that it will cause an improvement in the educative process.
3. DEVELOPING COMPUTER SUPPORTED COLLABORATIVE LEARNING ENVIRONMENTS

This section reviews the main approaches for the development of collaborative systems supporting education. We intend to define a collection of analysis and design patterns for the construction of collaborative applications that assist in the monitoring and evaluating of the collaborative process, and the way the mentioned patterns could interrelate.

3.1 Introduction

Computer-supported learning systems are difficult to successfully develop and put into production. Development difficulties arise mainly from the required diversity of expertise. Typically, key aspects of social and pedagogical sciences as well as distributed systems, artificial intelligence, communications and human-computer interaction are needed if the goal is to obtain good computer-supported learning systems. Specially demanding are collaborative learning applications, since they include features such as support for human-human communication, group dynamics and group memory.

Most collaborative applications are made of a set of inter-related modules, including access control, notifications, users administration, group interfaces, package distribution, information storage, work sessions, awareness support and user communication [Eide97], [Elli91]. Despite the fact that a few platforms for the construction of Web-operating collaborative applications exist, such as TOP [Guer99a], these meta-systems are not specifically intended for the development of learning applications. The next
section presents a description of the most important collaborative frameworks that focus on the education support.

### 3.2 Collaborative Frameworks

Becker & Blois have carried out a study on the applications of object oriented technology, in particular frameworks for the implementation of applications in the area of computer supported collaborative learning. They have accorded that the expected benefits are approximately the same as the field of software engineering in general: reuse as a way to improve the quality, the productivity, and cost reduction [Beck01]. They analyzed the contributions and the limitations of two techniques of reuse of the CSCL field: components and frameworks oriented to objects. Based on this analysis, they presented some initial ideas about the architecture based on the components needed to support the design of CSCL applications [Blois02]. The researchers identified three distinct groups of proposals to aid in the development of the environments of this field.

The first group refers to environments suited for e-learning that offer the possibility to teach a course and essentially provide tools that assist communication. This kind of environment tends to be less flexible and has the objective to assist in the implementation of new cooperative tools.

The second group refers to frameworks of application development in Computer Supported Cooperative Work (CSCW). In most parts these frameworks are very generic, that is to say that they do not possess specific fields such as education. Therefore, they do not provide mechanisms for the design of educational activities in the context of collaboration in learning and in the aspects related to learning, culture and evaluation.

The third group refers to the specific frameworks in the educational area, which unfortunately are few. Two different styles are found within this group: the development of components for the presentation of curricular content in applications that
are not necessarily collaborative, and the development of frameworks for the collaborative applications in education. The projects such as ESCOT [Digi00], itBeanKit [Elsa00] and e-Slate [Birb00] are examples of the former style of development. The objective of the development of software based on components is to develop applications comparing already existing parts. One component is a unit of composition of software applications that possesses a group of interfaces and a group of requirements and can be developed, acquired, and incorporated to the system and composed with other components independent of time and space. The models and platforms of components provide the appropriate mechanisms to manage the complexity of the problems that appear in the construction of applications for open systems and disturbances that can, for instance, be heterogeneity, asynchronism, dispersion, security breaches, tardiness and communication problems, etc. [Krie98].

Fig. 4: Constructivist Spiral: a model that serves as a basis for the framework

Some examples can be drawn out from the category of framework for the development of collaborative applications in education: DELFOS [Osun01], DARE [Bour01] PENCACOLAS [Blan99] and a model of cooperation based on projects [Sant01].
The main aim of this framework is to enable the construction of telematic applications for collaborative learning situations with a constructivist orientation. DELFOS defines a development process based on the principles of the participatory analysis [Chin97] and iterative design approaches, in which a formative evaluation based on interpretative methods plays a central role. In order to support this development process, the framework offers a series of five templates, which comprise situations, activities, roles, objects and interactions [Mart00]. The spiral in Figure 4 represents the model.

The properties of the learning situations, obtained with the use of the templates, are represented by means of a layered architecture. It represents the space where the student collaborates, constructs and acts in an active way. It includes the configuration of the elements that must be considered in a learning situation. The evaluation phase in DELFOS is based on an interpretative approach in which qualitative and quantitative data were used. This includes expectation and satisfaction questionnaires, laboratory experiments, interviews, and formal observation. The formal observation process showed the different points of view of developers and teachers: issues considered as positive results by the former were not very much taken into account by the latter and vice versa. The rest of the techniques aided to attain an integrated view of the evaluation. However, there is no detailed description of these elements, nor an adaptation to the CSCL peculiarities.

“DARE” stands for Distributed Activities in a Reflective Environment and has been designed to support multiple activities in an organizational context. It can be defined as a reflective groupware, trying to fill in the “great divide” between social and computer sciences by taking elements coming from these two domains for its design. DARE aims at offering specific contexts, designed for particular purposes, and used by particular communities of users. A particular context is called an activity-support. Each activity-support corresponds to the specific computer support offered by DARE to the users involved in a specific activity [Kuut91].
The general DARE architecture can be decomposed into three levels reflecting the specialization from the generic collective activity framework to the specific applications dedicated to a particular learning environment. This breakdown is presented in Figure 5. The foundation level, the composition level, and the user level can characterize the three levels.

![Fig.5: The three DARE levels.](image)

DARE has to support many different types of learning activities so that many different types of activity-supports can be created in the system. This model has taken into account the contributions from the Activity Theory as a foundation for a meta-level architecture supporting cooperative activities. This provides a “milieu” where the software components representing tasks, tools or roles are immerged and tighten together into a common theoretical framework. A particular attention has been put on the support for continuous changes realized by the users and at the run-time, thus satisfying a deeper tailorability and the expansiveness of the human activities. This is achieved by providing a reflection mechanism both at the conceptual and implementation levels [Bour00]. The integration of Computer Supported Collaborative Learning Activities into the broader framework of the Distributed Learning approach is a difficult challenge [Pea92]. This is not only due to the difficulty of articulating these CSCL Activities with other learning practices but also to the nature of most of the CSCL tools that are mostly designed to be used as standalone. The interoperability is poor and the integration of these CSCL tools inside larger platforms like Virtual Learning Environments or Virtual Campuses is often impossible. Some standardization bodies partly due to the weakness of their technological openness and to their lack of clear
standardized interfaces such as promote this. However, this technological viewpoint is only one face of the problem. At a higher level, the integration is prevented by the incompatibility between the involved conceptual models and design foundations. The general assumption of this model is that needs a common theoretical framework for designing CSCL tools and Virtual Campus platforms. However it does not include a mechanism to evaluate the performance of the students during a collaborative activity.

PENCACOLAS (Pen Computer Aided Collaborative System), a working prototype for teaching/learning collaborative composition, through pen-based computers. PENCACOLAS is a CSCL (Computer Supported Cooperative Learning) system designed to support the teacher's role, with significant advantages as compared to traditional classes because it facilitates to follow the different phases of the composition in real time. This is particularly important for the teacher in order to understand how the composition patterns develop, and how the writing skills, used by the students, improve. Besides, PENCACOLAS records all writing events, so that they can be analyzed a posteriori. Additionally, this kind of register, like a videotape, allows the students to think about their own writing process and facilitates the building of "electronic portfolios" for the assessment. Self-evaluation and co-evaluation are then possible, based on the history of what is learned and by what means. From the students’ point of view, this kind of feedback determines a major awareness of their development as writers and of writing as a recursive process. In response to the above requirements, PENCACOLAS automatically generates filenames that identify users, sessions, phases, etc. thus allowing easy searching. Therefore, we obtain not only final texts, but also a written interaction that registers the process of collaborative writing. This allows a deeper analysis of the communication (synchronous and asynchronous), following the graphic footprints of several aspects of the conversation, such as tone, feedback, management of turns and misunderstandings, and opening or closing communication channels [Gonz98].

Finally is the work carried out by Santoro [Sant01] in which she proposes a model for the development of cooperative learning environments based on projects. The proposed
model is a representation, in large parts, related with CSCL, such as cultural aspects and learning theories. Fig. 6 is a representation of the proposed model.

Fig. 6: Cooperation Model for Learning

This work is focused on the hypothesis related to environments of computer supported cooperative learning. More precisely, the environments that work closely with pedagogical projects, that will provide greater opportunities to strengthen and stimulate the cooperation among the participants of an activity providing supporting elements related to the context, culture, stimulus and technology. This work involves elements of evaluation both quantitative and qualitative, including individual as well as grouped elements. However, it does not offer a mechanism that allows the user to verify the learning process during a cooperative activity.

As it has been observed, there are few proposals for implementing mechanisms of learning evaluation. That is to say, few environments try to evaluate within the context of their own systems, whether exploring the information coming from the interactions
among the students or offering formal mechanisms of evaluation to be used by the teachers.

As it has been mentioned previously, the evaluation and the monitoring of the collaborative process within collaborative learning through the use of computer tools are uncharted territory. That is why the contribution of this work is twofold. First of all, it is a theoretical contribution by establishing a computer model of evaluation and the monitoring of the collaborative process in academic environments. Secondly, we intend to develop a collection of computer tools that support and allow, to a certain degree, the improvement of the collaborative process in academic environments.

By doing so, the computer model that we intend to develop will allow us to obtain better results of both teachers’ and also students’ activities. In the case of the teachers it will allow to define criteria to evaluate and monitor the collaborative process by giving timely and adequate information to decide when and how to intervene. Likewise, it will allow us to determine the degree of learning of each member of the group at any moment of the collaborative activity. In the case of the students, it will provide us with the necessary information to determine the degree of cooperation of each member and their level of knowledge.

The use of computer tools will give teachers or students timely information so that they can make correct decisions at the appropriate moment during the process in which the collaborative activity is being carried out. It is very difficult to monitor the work of several groups at the same time. However, if these jobs are carried out with the aid of a computer, it will be easier to obtain certain information that will help the teacher monitor all of the groups during an activity of a collaborative nature. Thus, it will allow the people involved to rely on effective mechanisms to make decisions, and, as a result it will allow the intervention in a more appropriate way in order to improve the collaborative activity.
In this work, we propose the development of an infrastructure to aid in the development of collaborative learning environments that allow the evaluation and monitoring of the collaborative process. The objective is to create a group of services (facilities) that permit the implementation of CSCL environments that provide the sufficient amount of assistance for the monitoring and the evaluating of the collaborative process. Our main contribution is the inclusion of a new model that contains aspects related to the area of education, and especially to the evaluation and monitoring of the collaborative process in a group activity. The infrastructure requirements will be based on the conceptual model expressed through a system of patterns of analysis and design.

Given that the computer infrastructure that we intend to develop is flexible, easy to manage, specific for the creation of educational computer environments, that allow the monitoring and evaluation of the collaborative process, we hope that it will give an answer to the lack of support and aid to the development of CSCL applications. Many tools (toolkits, middleware, frameworks) provide aid to the development of generic platforms, but few tools concentrate in the area of education. That is why the intended solution can contribute to the design of applications in the area of computer supported collaborative learning.

### 3.3 Pattern Languages

A pattern is a recurring solution to a standard problem. When related patterns are woven together they form a "language" that provides a process for the accurate solution of software development problems. Pattern languages are not formal languages, but rather a collection of interrelated patterns, though they do provide a vocabulary for talking about a particular problem. Both patterns and pattern languages help developers communicate architectural knowledge, help people learn a new design paradigm or architectural style, and help new developers ignore traps and pitfalls that have traditionally been learned only by costly experience [Gran98].
Patterns have a context in which they apply. In addition, they must balance, or trade off, a set of opposing forces. The way we describe patterns must make all these things clear. Clarity of expression makes it easier to see when and why to use certain patterns, as well as when and why not to use these patterns [Fowl99]. All solutions have costs, and pattern descriptions should state the costs clearly [Brug00].

From one point of view, there is nothing new about patterns since by definition patterns capture experience. It has long been recognized that expert programmers don't think about programs in terms of low level programming language elements, but in higher-order abstractions [Adel85]. What is new is that people are working hard to systematically document abstractions other than algorithms and data structures. In general, most people working on patterns are not concentrating on developing formalisms for expressing patterns or tools for using them, though a few people are. Instead, they are concentrating on documenting the key patterns that successful developers use, but that relatively few developers thoroughly understand and consistently apply in their daily work.

### 3.3.1 Pattern Origin

The first software patterns were written by object-oriented developers, so they focused on object-oriented design and programming [Gamm95] or on object-oriented modeling [Coad92]. Although there is still a lot of interest in object-oriented patterns, a new trend is patterns that focus on efficient, reliable, and scalable concurrent, parallel, and distributed programming [Copl96, Schm95, Buse96].

The majority of papers in this special issue follow the latter trend. McKenney’s paper on “Selecting Locking Primitives for Parallel Programs” describes a set of patterns used to build efficient operating systems for multi-processor platforms [McKe95]. Islam and Devarakonda’s paper on “An Essential Design Pattern for Fault-Tolerant Distributed State Sharing” focuses on a design pattern used to create reliable distributed software [Isla96]. Aarsten, Brugali, and Menga’s paper on ”Designing Concurrent and Distributed
Control Systems: An Approach Based on Design Patterns” presents a pattern language for developing distributed software for large-scale control systems [Aars96].

Another recent trend in the pattern literature focuses on management, sociological, and organizational issues. Two works in this issue address these topics. Cockburn’s paper "On the Interaction of Social Issues and Software Architecture" describes a pattern language that illustrates how social forces affect the decisions that shape the structure of software designs [Cock96]. Goldfedder and Rising’s paper on “Patterns: A Training Experience” discusses the organizational and sociological aspects of introducing patterns into a commercial software development environment [Gold96].

The study of patterns is well established in many other fields including architecture, anthropology, music, and sociology. Early adopters of software patterns were highly influenced by Christopher Alexander, who is a researcher at University of California, Berkeley, that has written extensively on patterns found in architecture for houses, buildings, and communities [Alex77].

As people have gained experience using patterns to document software expertise, new formats and new solutions have arisen to meet the unique challenges associated with developing software. For instance, many developers find it easier to understand design patterns by using software-centric visual aids such as class models and interaction graphs. Therefore, many pattern description formats use popular notations (such as Booch models and OMT) to concisely express their structure and dynamic behavior. In addition, pattern descriptions also commonly contain source code examples, written in the language of choice for the audience [Gamm95].

### 3.3.2 Elements of a Pattern

Several different formats have been used for describing patterns. The pattern description format used in Alexander’s work [Alex77] is called "Alexander form". The format used in GoF book [Gamm95] is referred to as "GoF form", and many others. Despite the fact
that patterns may have different formats, it is generally agreed that a pattern usually contains the following essential elements:

- **Name:** A word or short, meaningful phrase to describe the pattern. The pattern must have a meaningful name. This allows us to use a single word or short phrase to refer to the pattern. It would be very laborious to have to describe or even summarize the pattern every time we used it in a discussion. Good pattern names form a vocabulary for discussing conceptual abstractions.

- **Problem:** The specific problem to be solved. A statement of the problem which describes its intent: the goals and objectives it wants to reach within the given context and forces.

- **Context:** When to apply the pattern. The preconditions under which the problem and its solution seem to recur, and for which the solution is desirable. This tells us the pattern's applicability. It can be thought of as the initial configuration of the system before the pattern is applied to it.

- **Forces:** A description of the relevant forces and constraints. Forces reveal the intricacies of a problem and define the kinds of trade-off that must be considered in the presence of the tension or dissonance they create. A good pattern description should fully encapsulate all the forces, which have an impact upon it.

- **Solution:** Static relationships and dynamic rules describing how to realize the desired outcome. The description may encompass pictures, diagrams and prose that identify the pattern's structure, its participants, and their collaborations, to show how the problem is solved. The solution should describe not only static structure but also dynamic behavior. The static structure tells us the form and organization of the pattern, but often it is the behavioral dynamics that make the pattern "come alive". The description of the pattern’s solution may indicate guidelines to keep in mind (as well as pitfalls to avoid) when attempting a concrete implementation of the solution. Sometimes possible variants or specialization of the solution are also described.
3.3.3 Pattern Languages Examples

A collection of patterns forms a vocabulary for understanding and communicating ideas. Such a collection may be skillfully woven together into a cohesive "whole" that reveals the inherent structures and relationships of its constituent parts toward fulfilling a shared objective. This is what Alexander [Alex77] calls a pattern language. If a pattern is a recurring solution to a problem in a context given by some forces, then a pattern language is a collective of such solutions which, at every level of scale, work together to solve a complex problem into an orderly solution according to a pre-defined goal. A pattern language is a collection of patterns that can solve all the problems in a particular domain. It may include a method for connecting patterns into whole "architectures" for the domain [Appl01].

These some examples of pattern languages:

- Patterns for Experiential Learning [Ecks01]: Teaching requires flexibility. Therefore, each teacher needs a collection of effective techniques. These techniques can be captured in personal pattern language. This pattern language in progress proposes some successful techniques to assist with teaching and learning. For professional educators, these patterns may seem obvious, even trivial, because they have used them so often. But for those newer to teaching, they offer a way for experienced teachers to pass on their experiences.

- Patterns for Active Learning [Ecks02]: This pattern language in progress proposes some successful techniques to assist with teaching and learning. However, all educators both experienced and novice will benefit from the ideas contained in this language. But even experienced professionals will benefit a lot by learning from one another. Because “Nobody is Perfect” and furthermore everybody has developed their own little secrets to share. The pedagogical patterns project is working on collecting many types of patterns that can help teachers teach and students learn. This collection focuses on empowering the student through active learning.
• Patterns for Gaining Different Perspectives [Berg01]: This small pattern language consists of patterns that deal with the diversity of instructional techniques. Different learners learn differently, and so the effective instructor must be able to help students encounter material in different ways.

• Patterns for User Interface Design [Cora96]: Pattern language that can be used to generate software designs which are user centered, software designs that place the user's experience first and foremost. They concentrate on the place where a user interacts with the application: the user interface. Even if a software system is architected in such a way that its internal structure and operations are efficient, elegant and correct, it is ultimately the interface by which the end user judges its usefulness.

• A Pattern Language for Developing Object-Oriented Frameworks [Robe98]: Frameworks are reusable designs of all or part of a software system described by a set of abstract classes and the way instances of those classes collaborate. A good framework can reduce the cost of developing an application by an order of magnitude because it lets you reuse both design and code. They do not require new technology, because they can be implemented with existing object-oriented programming languages. Unfortunately, developing a good framework is expensive. A framework must be simple enough to be learned, yet must provide enough features that it can be used quickly and hooks for the features that are likely to change. It must embody a theory of the problem domain, and is always the result of domain analysis, whether explicit and formal, or hidden and informal. This work presents a pattern for developing frameworks.

• A Pattern Language for Workflow Systems [Mesz97]: This pattern language describes the process for creating any system, which includes workflow as part of its requirements. It includes patterns for identifying the workflow requirements, for defining the architecture of the system, and for implementing that architecture. The patterns are organized into three main sections, Requirements, Architecture and
Implementation. This is not to imply a strict timeline but to provide a partial ordering of the decisions to be made.

3.4 Proposed Model

The model that we intend to develop tries to represent the majority of the relevant aspects of the evaluation and monitoring of the collaborative process, thus making it easier for those that intend to implement a computer environment of this category to consider all the important aspects. In addition to this objective –facilitate the development of this kind of application- the model will be described by the use of elements that represent an area of study in CSCL. We pretend to expand each of these areas in depth that it will facilitate the representation through patterns.

Buschman et al. [Busc96], define some kinds of patterns: (a) Architectural Patterns: it expresses a fundamental structural organization or scheme for software systems. It provides a set of predefined subsystems, specifies their responsibilities, and includes rules and guidelines for organizing the relationships between them, (b) design patterns: it provides a scheme for refining the subsystems or components of a software system, or the relationships between them. It describes commonly recurring structure of communicating components that solves a general design problem within a particular context, and (c) Idiom Patterns: a idiom is a low-level pattern specific to a programming language. An idiom describes how to implement particular aspects of components or the relationships between them using the features of the given language.

Based on the previous definitions, we plan to define a number of patterns of analysis and design for the creation of collaborative applications that help the monitoring and evaluation of the collaboration process. Also, we will analyze the way in which these patterns can interrelate, allowing us to define a system of patterns for computer applications that supports the monitoring and evaluation of the collaborative learning process.
The system of patterns will be developed from the analysis that comes from understanding the collaboration process in a group activity. We will propose a system of patterns for the analysis and design of collaborative applications that will allow the monitoring and evaluation of the collaboration process. The conceptual model that we will develop takes into account the most important aspects of the collaboration process that allows us to accurately evaluate and monitor the group activity, and it will be described through conceptual patterns.
4. A MODEL FOR THE DEVELOPMENT OF SOFTWARE TOOLS IN ORDER TO SUPPORT THE MONITORING AND EVALUATION OF COLLABORATIVE LEARNING PROCESSES.

In order to support the monitoring and evaluation of the collaborative learning process, first it is necessary to understand that process. This understanding implies some mechanisms to evaluate it. The evaluation of that process is necessary, because it can help to identify some group weaknesses, and thus try to improve some attitudes towards group work.

One of the most important aspects in the evaluation of the collaborative process is the definition of some criteria to evaluate that process. A better collaboration process must lead to a better final outcome. In order to improve the collaboration process it is necessary to carry out a precise evaluation. That aspect could imply to determine, for example, under certain circumstances, which group has got the best performance in a collaborative activity.

This chapter is divided into 4 sections. In the first one, the collaborative learning process is defined. Then, some collaboration indicators are presented. The third section describes a set of software tools we have developed in order to measure the presence or absence of these indicators, and so to evaluate the collaborative process. Finally, some experiments will be presented.
4.1 Collaboration process definition

As has been mentioned before, in order to support the monitoring and the evaluation of the collaborative learning process, it is necessary to understand and model that process. Based on a definition proposed by Johnson and Johnson we define our collaborative process. They mention that a cooperative learning process is typically composed of several tasks that must be developed by the cognitive mediator or facilitator, and by the group of apprentices, defining naturally two categories of tasks [John75]. They affirm that during a collaborative task different activities among group members occur, such as: specifying the size of the groups, intervening, providing help.

In order to evaluate the cooperative learning process, the first part was divided into three phases according to its temporal execution: pre-process, in-process and post-process. Thus, pre-process tasks are mainly coordination and strategy definition activities and post-process tasks are mainly work evaluation activities. Both phases, pre-process and post-process, will be accomplished entirely by the facilitator. The group members will perform the tasks concerning the in-process phase, to a large extent. It is here where the interactions of cooperative work process takes place, so that the interest of this thesis concentrates on the evaluation of this stage. In order to specify this division, the structure of a cooperative learning activity as proposed by Johnson and Johnson in [Adam96] will be presented. The classification of each activity according to the identified stage\(^2\) will also be presented below:

1. Design the content and main tasks objectives to be accomplished by cooperative groups (pre-process).
2. Specify the size of the groups. It is suggested to be up to 6 people depending on the nature of the task and the available time (pre-process).
3. Arrange the groups. Designate the students to conform each group or allow them to form the groups at their will (pre-process).

\(^2\) Johnson and Johnson do not make this phase differentiation.
4. Arrange the room for the cooperative learning activity. The facilitator must be “attainable” by every group and their members can sit together without interruptions from other groups (pre-process).

5. Distribute the instructional material. This can be achieved in several ways (pre-process).

6. Design roles, such as: speaker, facilitator, recorder, executor, and observer (pre-process).

7. Specify the task directives: define the game rules (pre-process).

8. Apply strategies like positive interdependence of the goal, motivation of the peers and support for learning. Create a product related to a goal system where rewards are based on individual and group results (it is defined in the pre-process, but evaluated in the in-process phase).

9. Organize the intra-group cooperation, that is to say, define the collaboration strategies that are going to be used by the members of the group (pre-process; the definition of cooperation strategies occurs in the in-process phase).

10. Test the success criteria explaining the guidelines, limits and roles (pre-process, in-process and post-process phases). The success criteria must be defined at the beginning of the activity and must be reviewed during the activity to check if the common goal is being reached, and, after the activity, to check if the common goal was reached.

11. Determine the desired behavior (pre-process, definition of desired behavior occurs in the in-process phase).

12. Monitor the students, for example; verify that the previous point is fulfilled (phase of in process).

13. Provide assistance when someone asks for it (in-process phase): it is provided to the whole group by the facilitator or peers.

14. Intervene when groups have problems to collaborate (in-process phase).

15. Terminate an activity (post-process phase).

16. Evaluate the quality of learning accomplished by the students (post-process phase).

17. Encourage students to perform an evaluation on how well the group works altogether (at the end of the in-process phase).

18. Provide and foster feedback. Discuss how the activities could be improved (at the end of the in-process phase).
Table 1. Activities of a cooperative learning process.

<table>
<thead>
<tr>
<th>Pre-process</th>
<th>In-process</th>
<th>Post-process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design the contents</td>
<td>Apply strategies (positive Interdependence of the goal, motivation between pairs, aid to learn)</td>
<td>Inspect success criteria</td>
</tr>
<tr>
<td>Specify the group sizes</td>
<td>Intra-group cooperation</td>
<td>Present the activity closure</td>
</tr>
<tr>
<td>Arrange the groups</td>
<td>Test the success criteria</td>
<td>Evaluate the quality of learning</td>
</tr>
<tr>
<td>Arrange the room</td>
<td>Monitor</td>
<td></td>
</tr>
<tr>
<td>Distribute the material</td>
<td>Provide help (from facilitator and from peers)</td>
<td></td>
</tr>
<tr>
<td>Design the roles</td>
<td>Intervene in case of problems</td>
<td></td>
</tr>
<tr>
<td>Specify the game rules</td>
<td>Account of the group</td>
<td></td>
</tr>
<tr>
<td>Define the success criteria</td>
<td>Feedback</td>
<td></td>
</tr>
<tr>
<td>Determine the desired behavior</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 summarizes the activities and specifies the corresponding phases. These activities define the structure of any cooperative learning activity that takes place in small groups, and in synchronous learning scenarios (face to face, same time, same place). The main interest of this work is in the evaluation of the activities that correspond to the *in-process* phase. Based on these, some collaboration indicators will be defined below.
4.1.1 Metrics

In order to analyze each one of the indicators explained in the next section, some metrics are defined.

Table 2. Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Errors</td>
<td>Total number of mistakes made by the group member within a collaborative activity.</td>
</tr>
<tr>
<td>Solution to the problem</td>
<td>The group is able to solve a problematic situation.</td>
</tr>
<tr>
<td>Use strategy</td>
<td>Outline a strategy for the problem solution in an explicit way.</td>
</tr>
<tr>
<td>Maintain strategy</td>
<td>Use the defined strategy during the whole activity</td>
</tr>
<tr>
<td>Communicate strategy</td>
<td>Negotiate, reaching consensus and disseminate information about strategy.</td>
</tr>
<tr>
<td>Strategy messages</td>
<td>Messages that propose guidelines to reach the group goal.</td>
</tr>
<tr>
<td>Work strategy messages</td>
<td>Messages that help to make the most suitable decisions. These are sentences in the present tense and their goal is to inform the group about the current state of the group task.</td>
</tr>
<tr>
<td>Coordination strategy messages</td>
<td>Messages that correspond to activities whose main purpose is to regulate the dynamics of the process, and which are characterized by prescribed future actions.</td>
</tr>
<tr>
<td>Work messages</td>
<td>Messages received by the person who coordinates the activity.</td>
</tr>
<tr>
<td>Coordination messages</td>
<td>Messages sent by the person who coordinates the activity.</td>
</tr>
<tr>
<td>Success criteria review messages</td>
<td>Messages that review the boundaries, guidelines and roles of the group activity.</td>
</tr>
<tr>
<td>Lateral messages</td>
<td>The kind of particular messages (i.e. social messages, comments) and conversations that are not focused on the solution of the problem.</td>
</tr>
</tbody>
</table>
These metrics are indicators of system, user, and group performance that can be observed, singly or collectively, while executing group activities. Metrics –such as time, length of turn, and other countable events– are directly measurable and can often be collected automatically [Drur99].

The following table of metrics includes the observable data elements that were identified as useful indicators of system and group performance. Table 2 presents a list of the defined metrics.

### 4.2 The indicators

Based on the structure of a cooperative learning activity explained above (in-process phase), at first instance, an Index of collaboration was defined. That Index was the simple average of five identified indicators [Guer99b, Guer00a, Guer00b]. One of the most important problems we have detected corresponds is the definition of the percentage of every indicator. It is very difficult to determine which indicator is the most important one. Therefore, we present a refinement of that Index of Collaboration, defining a set of indicators whose main objective is to evaluate the collaborative learning process. Johnson and Johnson in [Adam96] base four of the indicators on the following activities proposed: use of strategies, intra-group cooperation, checking the success criteria, and monitoring. The fifth indicator is based on the performance of the group. Each one of these indicators is explained below. The Fig. 7 depicts the chosen indicators.

#### 4.2.1 Applying strategies

The first indicator tries to capture the ability of the group members to generate, communicate and consistently apply a strategy to jointly solve the problem. According
to Johnson and Johnson in [Adam96], to apply a strategy is “to produce a single product or put in place an assessment system where rewards are based on individual scores and on the average for the group as a whole”.

According to Fussell [Fuss98], the discussion of the strategy to solve the problem helps the group members to construct a shared view or mental model of the required goals and tasks to be executed. This mental model can improve the coordination, because each member knows how their task fits into the global team goals.

Fig. 7: List of Indicators

The learning potential of a team is maximized when all the students actively participate in the group discussions. Building involvement in-group discussions increases the amount of information available to the group, enhancing group decision making and improving the students’ quality of thought during the learning process [Jarb96].

In general, the specific measure to be considered for this indicator is subject-related. It estimates both the strategy the group applied and its success. Furthermore, the strategy should have a weight about four times larger than the one assigned to the success factor, because it is one of the most important elements for the task execution. Thus, the first indicator (CI1) should be built with 80% weight for the applied strategy and 20% weight for the success factor.
The strategy factor mentioned above was built from simple measures which could be obtained from the raw data. The 80% weight was explained as: 20% for whether or not the group was able to keep the chosen strategy during the collaborative activity, 30% for the quality of the strategy communication, 25% for the ability to maintain that strategy and 5% for other quality measures. The other quality measures can include aspects as time, movements, and so forth. The percentage of every component of this indicator was defined based on the observations of the experimented groups.

4.2.2 Intra-group cooperation

This indicator corresponds to the application of collaborative strategies previously defined during the process of group work. If each group member is able to understand how their task is related to the global team goals, then everyone can anticipate their actions, requiring less coordination efforts. A group achieves promotive interdependence when the members of the group perceive that their goals are positively correlated such that an individual can only attain their goal if their team members also attain their goals [Deut62]. In collaborative learning, these goals correspond to each member’s need to understand their team members’ ideas, questions, explanations, and problem solutions.

The CI2 indicator is defined as 80 % application of collaborative strategies and 20% providing help. Measuring the application of collaborative strategies implies the evaluation of coordination procedures and assessing the degree of joint understanding of the strategy. A good application of collaborative strategies should be observed as an efficient and fluid communication among members of the group. Good communication, in turn, means few, precise and timely messages (1 – (number of Work strategy messages)/(number of Work messages)). Providing help may be measured by the supporting messages from peers when someone requests them.
4.2.3 Success criteria review

This indicator measures the degree of involvement of the group members in reviewing boundaries, guidelines and roles during the group activity. It may include summarizing the outcome of the last task, assigning action items to members of the group, and noting times for expected completion of assignments. The beginning and ending of any group collaboration involve transition tasks such as assigning role, requesting changes to an agenda, and locating missing meeting participants. In the game, the success or failure of the group is related to the partial and global goals, which it is shown in the obtained scores (partial and global scores). This indicator also should take into account the number of messages concerned with the reviewing mentioned above.

This indicator reflects interest in individual and collective performance. CI3 is then computed with a 0-1 range, where 1 means the highest score in this indicator.

4.2.4 Monitoring

This indicator is understood as a regulatory activity. The objective of this indicator is to oversee if the group maintains the chosen strategies to solve the problem, keeping focused on the goals and the success criteria. If a member of a group does not sustain the expected behavior, the group will not reach the common goal. In this sense, the fourth cooperation indicator (CI4) will be related to the number of coordination messages, where a small number of messages means good coordination \((1 – \text{(number of Coordination strategy messages)/(number of Coordination messages)})\).

4.2.5 Performance

Baeza-Yates and Pino [Baez97] made a proposal for the formal evaluation of collaborative work. They take into account three aspects: Quality (how good the result of collaborative work is), Time (total elapsed time while working) and Work (total amount of work done). So, in our experiment, Quality can be measured by three factors:
few errors made by the group (related to the best score), achievement of the main goal (the group can solve the labyrinth) and few movements of the mouse (related to efficiency). The tool records the playtime from the first event (movement of the mouse or message sent by any player), until the group reaches the goal (cheese) or loss the game (a partial score goes down to zero). In this view, the “best” group does the work faster. The number of messages sent by group members measures Work. Based on that the fifth indicator is defined. The performance indicator (CI5), will be the average of the three aspects mentioned above (Quality, Work, Time).

The following section presents three software tools used as an instrument to evaluate the presence or absence of our indicators of collaboration

4.3 Software Tools

Since our goal is to study the collaborative learning process, this section will present some software tools developed to capture data from groups engaged in such type of learning under the model presented in the above section. The software tools are based on a small case in which a group of people have to do some learning in order to do a joint task.

4.3.1 Chase the Cheese

The game –called Chase the cheese– is played by four people, each with a computer. The computers are physically distant and the only communication allowed is computer-mediated. All activities made by the participants are recorded for analysis and the players are made aware of that [Coll02c].

The players are given very few details about the game. The participants while playing must discover the rest of the game rules. They also have to develop joint strategies to succeed. Therefore, people can only play the game once.
4.3.1.1 System functionality

Fig. 8 shows the game interface. To the left, there are four quadrants. The goal of the game is to move the mouse (1) to its cheese (2). Each quadrant has a coordinator—one of the players—permitted to move the mouse with the arrows (4); the other participants—collaborators—can only help the coordinator sending their messages which are seen at the right-hand side of the screen (10). Each player has two predefined roles: coordinator (only one per quadrant and randomly assigned) or collaborator (the three remaining).

The game challenges the coordinator of a quadrant in which the mouse is located because there are obstacles to the mouse movements. Most of the obstacles are invisible to the quadrant coordinator, but visible to one of the other players. In each quadrant there are two types of obstacles through where the mouse cannot pass: general obstacles or grids (6) and colored obstacles (7). This is one of the features of the game, which must be discovered by the players. The players must then develop a shared strategy to communicate obstacles location to the coordinator of the current quadrant. No message broadcasting is allowed, so players have to choose one receiver for each message they send (9). Since each participant has a partial view of the labyrinth, he/she must interact with his/her peers to solve the problem. In order to communicate with them, each player
has a dialogue box (8) from which she can send messages to each of them explicitly (one at a time) through a set of buttons associated to the color of the destination (9). For example, in Fig. 8, he/she can send messages to the players with blue, red and green colors.

Since players have a color associated to them, their quadrant shows the corresponding color (5). When starting to move the mouse, the coordinator has an individual score (11) of 100 points. Whenever the mouse hits an obstacle, 10 points decrease this score. The coordinator has to lead the mouse to the cheese (in the case of the last quadrant) or to a traffic light (3), where the mouse passes to another quadrant and his/her role is switched to collaborator and the coordinator role then, is assigned to the next player (clockwise). When this event occurs, the individual score is added to the total score of the group (12). Both scores, partial and total are hidden; if a player wants to see them, he/she must pass the mouse over the corresponding icon displaying the score for two seconds. If any of the individual scores reaches a value below or equal 0, the group loses the game. The goal of the game is to take the mouse to the cheese and do it with a high total score (the highest score is obviously 400 points).

4.3.1.2 Gathered information

The application has a structured chat-style user interface, through which the group conversation is held. The application records every message sent by any member of the group. Along with each message, it records the time of occurrence, sender, addressee and current quadrant (the mouse location –X and Y position– when the message was sent).

Fig. 9 shows an example of the information gathered by the application. In addition, it records the partial scores and total score by quadrant. The tool also registers the start and finish time of the game, the time spent in each quadrant, and the number of times each player looked at the partial and total scores by quadrant. Annex 3 includes all the log files.
4.4 Experimental Design

This stage has four phases. The group receives a brief description of the software tool. During the second phase, group members are assigned to network workstations, in separate rooms (synchronous distributed interaction). From then on, computer mediates all communication. During the third phase, the group will try to solve the labyrinth. Finally, the fourth phase corresponds to the gathering and analysis of data recorded by the tool. We also made a final interview to the participants to foster self-evaluation of the experience (See annex 4). This gave us a general overview of the problem perceived by each member of the team. The experimented groups are:

- A group of graduated students, from the course “Collaborative Systems” at Pontificia Universidad Católica de Chile, with some experience in collaborative work techniques (group 0).
• A group of people, randomly selected, who had not met before and, of course, they had never worked together (group 3).

• A group of friends who had worked as a group many times before the experience and who have a good personal relationship (group 4).

• Four groups of high school students from Cumbres de Santiago School, with an average age of 15 years. Two of these were randomly selected (group 1 and 2) and the remaining ones were friends (group 5 and 6).

• Four groups of graduate students from Universidad de Chile (Groups 7,8,9,10).

4.5 Results of the Experiment

As has been mentioned in the section 4.2, there is a set of indicators whose main objective is to evaluate the collaborative learning process. The next section will present the results analysis of each indicator got in the pre-experimentation phase.

4.5.1 Applying strategies

The first indicator tries to capture the ability of the group members to generate, communicate and consistently apply a strategy to jointly solve the problem. The objective is not only to show which group got the best or worst score, but to analyze each of the elements that are part of this indicator and to determine why some groups are better than others. Table 3 shows the results.

Group members are forced to closely interact with peers since each player has a partial view of the game obstacles. Therefore, the game presents a strict positive interdependence of goals. If the group is able to solve the game, we can say their members have built a shared understanding of the problem (see Dillenbourg definition of collaboration [Dill95a]). They must have understood the underlying problem: the coordinator does not have all the information needed to move the mouse in his/her
quadrant without hitting any obstacle, so he/she needs the timely assistance from her collaborators.

From the collaborative work viewpoint, effective groups have goals, which are clarified and modified as follows. There should be the best possible match between individual and group goals. They are also cooperatively structured so all members are committed to reach them.

The result show that groups are ineffective because communication was poor even though they have high “maintain strategy” scores. It can be inferred that members accept competitively structured imposed goals, so each member attempts to achieve his/her personal goal first.

It could not be found that conflicts of interest were solved through integrative negotiation and agreement, that is to say there was no a mediated process. It was common to observe that the first coordinator tried to impose her viewpoint and the rest of the group members simply followed her instructions.

The initial imperative messages were typically “Let’s label the columns with letters and the rows with numbers”, or “I will move first and then you are going to send me your coordinates”. It was not frequent to find messages that could induce the negotiation of a position, like: “I propose that our strategy be... do you agree?” or “What do you think?”

So, it could be observed that the communication was not two-way and open with the possibility of expressing feelings as well as ideas. On the contrary, it was usually one-way, where only ideas were expressed and feelings were ignored.

The group that got the best score was group 5 (CI1= 0.75), so, one might think that it is a good group in this aspect (applying strategies), but if we analyze this indicator in detail, it can be inferred that this was a good work group, but not a good collaborative group.

Group 5 was ineffective as collaborative group because the group could not build an effective communication method among its members in spite of the best score in the
maintenance aspect. In a collaborative activity, it is not only important to understand the problem, but to share that understanding among teammates, and this was the weakness of Group 5. Comparing this group with Group 8, which got the worst score (CI1=0.27), but used a better strategy (according to our quality metric) and it maintained it. Group 8 was one of the groups trying to promote some kind of discussion around the strategy definition; unfortunately, the final decision was imposed without participatory negotiation.

Table 3. Applying strategies results

<table>
<thead>
<tr>
<th>Group</th>
<th>Solution</th>
<th>Use</th>
<th>Quality</th>
<th>Maintain</th>
<th>Communicate</th>
<th>CI1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.62</td>
<td>0.62</td>
<td>0.36</td>
<td>0.69</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0.68</td>
<td>0.41</td>
<td>0.31</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0.95</td>
<td>0.65</td>
<td>0.26</td>
<td>0.68</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0.52</td>
<td>0.59</td>
<td>0.36</td>
<td>0.48</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0.87</td>
<td>0.64</td>
<td>0.37</td>
<td>0.71</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>1</td>
<td>0.74</td>
<td>0.74</td>
<td>0.43</td>
<td>0.75</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1</td>
<td>0.56</td>
<td>0.71</td>
<td>0.35</td>
<td>0.71</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0.5</td>
<td>0.60</td>
<td>0.32</td>
<td>0.47</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0.4</td>
<td>0.61</td>
<td>0.35</td>
<td>0.27</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0.4</td>
<td>0.65</td>
<td>0.35</td>
<td>0.28</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>0</td>
<td>0.5</td>
<td>0.62</td>
<td>0.34</td>
<td>0.48</td>
</tr>
</tbody>
</table>

It was common to find groups that even after defining a strategy for the first quadrant - with some members of the group understanding that strategy - did not obtain a high score. The explanation lies in the lack of strategy understanding by some members of the group. We could observe, e.g., a group in which two of the members understood the strategy, and in fact during the first two quadrants the partial results were very good. The problem appeared in the third quadrant, because the corresponding coordinator, who had not fully understood the strategy, began to make some movements according to her viewpoint, and obviously the group could not solve the labyrinth. In this case, the members who understood the strategy did not care to make sure the rest of the group understood it as well. So, it is not only important to understand the problem, but to be aware that the rest of the people can understand the problem situation during a collaborative learning activity.
The team learning potential is maximized when all group members participate in the group discussions. Building involvement in-group discussion increases the amount of information available to the group, enhancing group decision making and improving the participants’ quality of thought during the learning process [Jarb96].

For this reason, encouraging active participation could increase the likelihood that all group members understand the strategy, and decrease the chance that only a few participants understand it, leaving the others behind. Unfortunately, none of the observed groups behaved in this direction and therefore, one wonders if this aspect of learning is not spontaneous, at least in a first session of collaborative learning.

### 4.5.2 Intra-group cooperation

This indicator provides information about the application of collaborative strategies defined in above section. Table 4 shows the results. Concerning this indicator, it can be observed that almost all groups got a good score. These results show there was an interest to solve the problematic situation among all members of the groups. It was common to observe that when someone asked for their information about something, the other members of the group were able to solve doubts. Therefore, all questions –when asked– were solved by all group members.

Analyzing and observing the members’ actions, could be found a dialogue pattern. When a participant requested help, at least he/she received one answer from the rest of the participants. It is important to note that these answers were timely. One of these patterns is shown below.

Coordinator: *Can I move to the right?*

Player 2: *I don’t have obstacles.*

Player 3: *I don’t have obstacles.*

Player 4: *There is an obstacle in that position.*
All the answers were given in a small time interval. Thus, the coordinator could infer what movement he/she could make and all participants are helping to solve the problematic situation.

Table 4. Intra-group cooperation results

<table>
<thead>
<tr>
<th>Group</th>
<th>CI2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 0</td>
<td>0.69</td>
</tr>
<tr>
<td>Group 1</td>
<td>0.71</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.62</td>
</tr>
<tr>
<td>Group 3</td>
<td>0.61</td>
</tr>
<tr>
<td>Group 4</td>
<td>0.74</td>
</tr>
<tr>
<td>Group 5</td>
<td>0.84</td>
</tr>
<tr>
<td>Group 6</td>
<td>0.72</td>
</tr>
<tr>
<td>Group 7</td>
<td>0.80</td>
</tr>
<tr>
<td>Group 8</td>
<td>0.75</td>
</tr>
<tr>
<td>Group 9</td>
<td>0.75</td>
</tr>
<tr>
<td>Group 10</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Members of the group who are not influenced by promotive interdependence engage in promotive interaction; they verbally promote each other’s understanding through support, help and encouragement [John86b]. In the experiments, it was common to observe that if a member of the group did not understand the answer to a question or solution to a problem, his/her teammates gave special reinforcement, sending messages like: “Remember, you need to send me the location of your obstacles” or “You can not move”, to address his/her misunderstanding before the group moved on. Ensuring that each member of the group receives the help they needs from their peers is key to promoting effective collaboration interaction. Thus, for these groups it can be concluded all of them were good according to this indicator.

4.5.3 Success criteria review

This indicator gives information about the interest of members to check their roles, performance, and results in order to achieve the main goal. Table 5 shows the results.
In the game, the success or failure of the group is related to the partial and global goals. This is shown in the obtained scores (partial and global scores). This indicator also should take into account the number of messages related to the reviewing mentioned above. It reflects interest in individual and collective performance. In the experiment, the more concerned the player is with the goals of the team, the more checks to the scores he/she will do, and the more messages of this kind he/she will send.

This indicator provides an understanding of the performance analysis the group made during the group activity. Group processing and performance analysis exists when groups discuss their progress, and decide which behaviors to continue or change [John86b]. So, it is necessary that people evaluate the previous results obtained in order to continue, evaluating individual and group activities, and provide feedback. It is also necessary that members of the group take turns questioning, clarifying and rewarding their peers’ comments to ensure their own understanding of the team interpretation of the problem and the proposed solutions. “In periods of successful collaborative activity, students’ conversational turns build upon each other and the content contribute to the joint problem solving activity” [Webb92]. Unfortunately, this did not happen with the analyzed groups.

If we look at the results, it could be inferred that there were some groups who had a perfect performance in this indicator (groups 5, 6). However, if we observe in detail the objective of this indicator, and observe the group logs, it can be concluded that this aspect was not fulfilled as we would have liked. The results obtained are relative scores, that is to say, according to the analyzed groups, the best groups were 5 and 6, but that does not mean they are good groups.
Table 5. Success criteria review results

<table>
<thead>
<tr>
<th>Group</th>
<th>CI3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 0</td>
<td>0.2</td>
</tr>
<tr>
<td>Group 1</td>
<td>0.2</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.2</td>
</tr>
<tr>
<td>Group 3</td>
<td>0.5</td>
</tr>
<tr>
<td>Group 4</td>
<td>0.8</td>
</tr>
<tr>
<td>Group 5</td>
<td>1</td>
</tr>
<tr>
<td>Group 6</td>
<td>1</td>
</tr>
<tr>
<td>Group 7</td>
<td>0.2</td>
</tr>
<tr>
<td>Group 8</td>
<td>0.2</td>
</tr>
<tr>
<td>Group 9</td>
<td>0.2</td>
</tr>
<tr>
<td>Group 10</td>
<td>0.2</td>
</tr>
</tbody>
</table>

According to this indicator, it only reflects that we need to do additional experiments in order to determine the “ideal group”, and according to that group make relative comparisons. The groups with the best score were groups that reviewed the partial and total score during the process of collaborative activity, but that rarely or never interested in evaluating the results obtained in order to re-define the next movements, or to provide some feedback to the members of the group. It was unusual to find messages like: “We are losing, our score is decreasing, so we need to define our next movement”. Only two groups (5, 6) had some messages like “Our score has increased”, “We are losing”, but unfortunately, these groups did not stop analyzing their performance, to clarify issues and to define a new model of solving the problem situation.

4.5.4 Monitoring

This indicator gives an understanding of how the group maintains the chosen strategies to solve the problem. Table 6 presents the results. They show that members of the groups are interested in being consistent about the strategy, so there is a direct relation between this indicator and the aspect of maintenance within Applying Strategies Indicator (e.g., the group that got the best CI4, got the best score in the maintenance part of CI1). Also, it should be noted that the groups which best scored in this aspect were the ones that had a history of working together for some time, so they had good
relationships with each other. The numerical values for this indicator should be taken with caution, because they are not absolute values; they just serve to compare groups, they are comparative.

In cooperative learning groups, members are required to acquire group skills, such as how to provide effective leadership, decision-making, trust building, communication and conflict-management [John86b]. The combination of knowing how to manage intellectual disagreements and how to negotiate/mediate conflicts among participants’ wants, needs, and goals ensures that the power of cooperative efforts will be maximized.

The productivity of groups increases dramatically when members are skilled in how to manage conflicts constructively. Some groups participating in the experiment had worked together before, but still had the characteristics of “work groups” and were not collaborative groups. It was common to find, according to the analysis of the messages, that leadership was delegated and based upon authority, participation was unequal with high-powered members dominating.

<table>
<thead>
<tr>
<th>Group</th>
<th>CI4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 0</td>
<td>0.75</td>
</tr>
<tr>
<td>Group 1</td>
<td>0.80</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.80</td>
</tr>
<tr>
<td>Group 3</td>
<td>0.74</td>
</tr>
<tr>
<td>Group 4</td>
<td>0.78</td>
</tr>
<tr>
<td>Group 5</td>
<td><strong>0.86</strong></td>
</tr>
<tr>
<td>Group 6</td>
<td>0.85</td>
</tr>
<tr>
<td>Group 7</td>
<td>0.80</td>
</tr>
<tr>
<td>Group 8</td>
<td>0.82</td>
</tr>
<tr>
<td>Group 9</td>
<td>0.81</td>
</tr>
<tr>
<td>Group 10</td>
<td>0.83</td>
</tr>
</tbody>
</table>

These characteristics are typical of ineffective collaborative groups [Morr91]. The same analysis gave us an understanding of the role of the coordinator in every quadrant. Its function should have been to contribute to maintain the harmony within the group, avoiding negative discussions or conflicts, and promoting creative conflicts. Cooperation and conflict go hand-in-hand [John95]. The more group members care about achieving
the group goals, and the more they care about each other, the more likely they are to have conflicts with each other.

The way conflict is managed largely determines how successful cooperative efforts tend to be. For this reason, we can conclude that our groups still functioned as work groups. They had not acquired the collaborative status yet.

4.5.5 Performance

Our last indicator provides an understanding of the group’s achievement. It provides an evaluation estimate of the groups’ outcome, according to its definition in the previous section. Notice that the groups, which got the worst score, were the groups that almost got the best score for the other indicators (see Table 7). That observation provides a hint that the task performance of a group is not related with its learning. In these pre-experiments, quality can be measured by three factors: few errors made by the group (related to the best score), achievement of the main goal (the group can solve the labyrinth) and few movements of the mouse (related to efficiency). The tool records the playtime from the first event (movement of the mouse or message sent by any player), until the group reaches the goal (cheese) or loss the game (a partial score goes down to zero). In this view, the “best” group does the work faster. The number of messages sent by group members measures Work.

The analysis of these results shows the shared construction of a strategy to do group work is related to a successful process, to the individual construction of cognitive context, and to the experiences shared by the group members.

It could be indicating a tendency. Unfortunately, the studied groups were ineffective collaborative groups because they were weak in collaborative attitudes, and this aspect is reflected somehow in the wrong process of definition, adoption and use of strategies.
Table 7. Performance results

<table>
<thead>
<tr>
<th>Group</th>
<th>Quality</th>
<th>Time</th>
<th>Work</th>
<th>Cls</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.87</td>
<td>0.86</td>
<td>0.22</td>
<td>0.65</td>
</tr>
<tr>
<td>1</td>
<td>0.5</td>
<td>0.82</td>
<td>0.4</td>
<td>0.57</td>
</tr>
<tr>
<td>2</td>
<td>0.95</td>
<td>0.99</td>
<td>0.13</td>
<td>0.69</td>
</tr>
<tr>
<td>3</td>
<td>0.52</td>
<td>0.67</td>
<td>0.72</td>
<td>0.63</td>
</tr>
<tr>
<td>4</td>
<td>0.62</td>
<td>0.42</td>
<td>0.95</td>
<td>0.66</td>
</tr>
<tr>
<td>5</td>
<td>0.74</td>
<td>0.83</td>
<td>0.27</td>
<td>0.61</td>
</tr>
<tr>
<td>6</td>
<td>0.56</td>
<td>0.81</td>
<td>0.19</td>
<td>0.52</td>
</tr>
<tr>
<td>7</td>
<td>0.5</td>
<td>0.87</td>
<td>0.23</td>
<td>0.53</td>
</tr>
<tr>
<td>8</td>
<td>0.4</td>
<td>0.81</td>
<td>0.4</td>
<td>0.54</td>
</tr>
<tr>
<td>9</td>
<td>0.4</td>
<td>0.82</td>
<td>0.4</td>
<td>0.54</td>
</tr>
<tr>
<td>10</td>
<td>0.5</td>
<td>0.78</td>
<td>0.3</td>
<td>0.53</td>
</tr>
</tbody>
</table>

4.6 Other Software Tools

This section presents the design of other software tools we have developed in order to determine the collaboration level within a group, based on the indicators presented before.

4.6.1 MemoNet

This game is loosely based on the classic “Memory Game”, whose goal is to find the equal pair within several covered cards. This is repeated successively until there are no covered cards left. In the case of MemoNet, the idea is that four people try to find four equal cards from an initial set of ten different cards. All players have the same set of cards but ordered in different ways. A person draws one card each time. So, they need to collaborate in order to solve the problem situation. The card is removed when the four players have found it. The game continues until all cards are uncovered. The game is played in a distributed fashion, with communication allowed through a chat tool [Coll03].
4.6.1.1 System functionality

Fig. 10 illustrates the game user interface. Here we can see the messages sent by the different users through chat. Also we can observe the various actions performed by the other users: Santiago has selected the 2 of diamonds; Alexander the 9 of diamonds; Felipe the 10 of diamonds and Juan the 2 of diamonds.

When a user clicks on a card, it turns and appears as illustrated in the figure. Once 4 cards have been chosen appears a button with the “Next” label, if it is pressed, two events will occur: 1) In case of no success, all the cards will be given back; 2) In case of success, the cards will disappear from the screen. Since each participant has a partial view of the game, the player must interact with his/her peers to solve the problem. In that way, participants need to collaborate in order to solve the problem situation.

It is important to note that all the actions performed by the users are recorded in a log. The application records each message sent by any member of the group. Along with the
message, it registers the time of occurrence and the sender. The tool also registers the start and finish time of the game.

4.6.1.2 Teacher’s Interface

Fig. 11 illustrates the teacher interface. In the chat area it is also possible to clearly watch all the messages sent by the players. Players can send a message to any of their peers or to all of them. We can also observe in the data area the letter selected by each player in the last play.

Fig. 11: Teacher’s user interface of MemoNet.

Messages sent by the teacher to the players are written in an independent window. They appear to the receiver as mechanical alerts of the program to a particular fact, similar to the “paper clip” of Aid service of Microsoft Word. An alert message unfolds as it shows in Fig. 12.

Fig. 12: Teacher’s message
4.6.2 ColorWay

The third game is called Color Way. The game has a 6 x 4 board of colored squares. Each player can see their own obstacles (with her color). Each player has a token with their color, and this token can progress from the lower row to a target located on the upper row. The player can move the token using the arrows and back buttons only through gray squares, which are not currently used by another token. Another restriction to make movements is given by the progress of the other tokens: no token can go to row n if there is a token in row n-2. In a way similar to MemoNet, this game provides communication through chat [Coll03].

Fig. 13: User Interface of Color Way.

4.6.2.1 System Functionality

In order to move the piece that corresponds to each very player, which is seen by its assigned color, the player must click one of the arrows indicating the direction of the movement. The button labeled “Back” must move backwards as a result of a wrong movement. Fig. 13 shows that the chat zone has a comment from the players. Also we can observe the green player (second column) has moved and has to wait until the other
player moves. In that way, they need to collaborate in order to find a solution at each level. Also it is shown that, when backing down, player Felipe, reduces his score by 5 points. This happens whenever a player backs down and the score is only reduced to the player who has backed down.

4.6.2.2 Teacher’s Interface

Fig. 14 illustrates the teacher interface. In the chat area it is possible to clearly watch all the messages sent by the players. Again, the teacher can send a message to an individual player or to all of them. In the data area we can see each player’s grid, and the displacements that each one of them has made. The displacement is denoted by the letter “y” and the gasped places to move are indicated with the number “1”.

Fig. 14: Teacher’s user interface of the Color Way game.

Fig. 15: Teacher’s message.
Messages sent by the teacher to the players are written in an independent window. They appear to the receiver as mechanical alerts of the program to a particular fact, similar to MemoNet. An alert message unfolds as it shows in Fig. 15.

4.6.3 TeamQuest

TeamQuest is a collaborative game which is played by four people, each one with a computer [Coll03c]. The computers are physically distant and the only communication allowed is computer-mediated. All activities by participants are recorded for analysis and players are made aware of that. The game goal is to go from an initial to a final position through a labyrinth, with the highest possible score, avoiding obstacles and picking the necessary items to carry out the mission on the way. The time spent on the trip is also considered only in case of a tie [Coll03b].

4.6.3.1 System functionality

Players are given very few details about the game. The participants must discover most of the game rules while playing. They also have to develop joint strategies to succeed. TeamQuest is a labyrinth with obstacles. The players of a team must reach a common goal satisfying sub-goals in each of the four game stages. Each player is identified with an avatar and name. The main screen has three well-defined areas: labyrinth, communication and information (see Fig. 16).

The labyrinth area has four quadrants, each one assigned to a player who has the “doer” role (active player), while the other three players are collaborators in that quadrant. In a quadrant, the doer must move the avatar from the initial position to the “cave” that allows entering the next quadrant. On the way, the doer must circumvent all obstacles and traps on the map (which are not visible to all players). Moreover, the doer must pick an item which is useful to reach the final destination. The user interface has many elements showing awareness: the doer’s icon, score bars, items which were picked up in each quadrant, among others (see Fig. 16).
The communication zone (right side of Figure 16) has several windows with the face that characterizes each participant avatar. To send messages each participant has an interface with a writing window, a receiver selector, and a send button. In addition, there are three other windows, similar to the writing windows, which display the messages written by the other players. The information zone shows information about the game status, obstacles, traps, individual views of the game, and the final game results.

Finally, the game score is computed based on the individual score of each player, shown in the score bars. These individual scores start with a predefined value and are reduced or increased when a player collides with a trap or gets a reward (life potions). The final group score is the sum of the individual scores. Therefore, the common goal of this activity is to get to the final position (the cave), with the highest possible score, by crossing the four quadrants, and getting in each quadrant the necessary items to carry out the mission. Each member of the work group has only a portion of the information about traps, which is necessary for the task to be completed, the members’ for need information to be shared in order for the group to achieve its goal. That aspect corresponds to the positive resource interdependence, that relies on the fact that each individual owns specific resources needed for the group as a whole to succeed [John98].
The difficulty level of the game—which can be adjusted– is relatively high. Therefore the group must define and apply a good strategy in order to solve the labyrinth.
5. A MODEL FOR THE DEVELOPMENT OF SOFTWARE TOOLS IN ORDER TO IMPROVE THE COLLABORATIVE LEARNING PROCESSES.

The analysis of the results presented before shows the shared construction of a strategy to do group work is related to a successful process, to the individual construction of cognitive context, and to the experiences shared by the group members. It could be indicating a tendency. Unfortunately, the studied groups were ineffective collaborative groups because they were weak in collaborative attitudes, and this aspect is somehow reflected in the wrong definition process, adoption and use of strategies. In these experiments, although all groups were deficient in the strategy definition, those that tried to define and communicate a strategy got better results in CSCL activities. Based on this preliminary information, this chapter explores whether the impact of a consistent use of a strategy can produce good results during this kind of activities.

Our hypothesis claims that a good use, definition and adoption of strategies should imply good collaboration, which in turn it is known to lead to good learning. This hypothesis is emphasized in the case of groups just formed or with little collaborative experience.

We have designed one widget to support discussions within the learning group and another one to support the monitoring of the tasks done by the group [Coll03d]. These widgets are intended to improve the strategic aspect of group work and thus provide a way to validate the hypothesis. Both widgets were embedded in a tool called TeamQuest, which is a labyrinth type collaborative game that was explained in Section
4.6.3. Two versions of this tool were used during the experiments, one with widgets and another one without them. The performance of the learning activities was measured using the indicators

5.1 Monitoring

One way of assessing the effectiveness of the groups is to monitor and observe the members' interactions as they work together. Observation gives the teacher an understanding of the quality of each group's interaction and its progress on the assignment. In the proposed model, the teacher can not only observe the interactions among members of the group, but can also intervene at any time he/she considers necessary. In that way, the teacher can become another member of the group. It is important to note this kind of intervention is invisible for the members of the group, in the sense that even if the participants know that the teacher is observing them, they can only interpret every action the teacher does as a hint that the system gives to them [Coll03]. According to Johnson et al., one of the most important aspects of collaborative learning is to “monitor students’ to learn and intervene within the groups to provide task assistance or to increase students’ interpersonal and group skills” [John98]. A teacher systematically observes and collects data on each group as it works. When assistance is needed, the teacher intervenes to assist students in completing the task accurately and in working together effectively. A tutor is needed to structure the process, to give advice when needed and to promote deep understanding. If students and tutors are communicating mainly through a computerized learning environment, tutors have to learn new ways to support students. Even if the efforts to structure collaboration increase the probability that productive interactions will occur, there is no guarantee that the interactions do actually occur. For that reason, it is necessary to have some external regulation in order to satisfy the occurrences of those kinds of interactions. One way to provide that kind of regulation is through the cognitive mediator.
The role of cognitive mediator is not to intervene at the task level, but to guarantee that all the group members participate, by frequently asking questions such as: What happened?, or What does it means? [Coll01a]. The role of the cognitive mediator is to maintain the focus of the discussion guiding students through the knowledge construction process. As the collaboration progresses, the state of interaction is evaluated and remedial actions may be proposed to reduce discrepancies between these states. The assumption is that both the contents and the pattern of the sequence of messages reflect the degree of collaborative learning. In this aspect, the point is not to provide the right answer or to say which member of the group is right, but to perform a minimal pedagogical intervention (e.g. provide some hint) in order to redirect the group work in a productive direction or to monitor which members are excluded from the interaction [Dill99]. Therefore, it is necessary to include an interface permitting to monitor the group work. It must have the option to “observe” all the actions performed by the group members and the possibility to send messages to the various participants of the collaborative activity. Also, the software tools developed under the proposed model, must have an option to present the partial results of the collaborative activity in order to promote some kind of interaction among members of the group.

While observing students work with computer applications, teachers can see the choices students are making on the monitor, ask questions regarding students' learning goals and decision making, and make suggestions for revisions when needed. With this model, applications can be designed to provide a window which provides information about the ways in which students construct meaning -their misconceptions, conjectures, and the connections they make among ideas [Coll90]. Teachers can use this information to revise and refine instruction.

In order to satisfy the aspects mentioned above, it is necessary to clarify how and when the teacher must intervene. Table 8 includes a set of situations teachers must ask when they are monitoring the process during collaborative work.
Table 8. Set of situations the teacher must monitor.

<table>
<thead>
<tr>
<th>Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>One of the members of the group solved the problematic situation?.</td>
</tr>
<tr>
<td>One of the members of the group does not understand the problematic situation?.</td>
</tr>
<tr>
<td>One of the members of the group is performing an incorrect action?.</td>
</tr>
<tr>
<td>There are many “conflictive-situations” and the members of the group are not capable of handling them?</td>
</tr>
<tr>
<td>There are no “conflictive-situations”?</td>
</tr>
<tr>
<td>Members of the group do not send any kind of messages?</td>
</tr>
<tr>
<td>A large percentage of the messages that one of the members of the group is sending are not related with the solution of the problem?</td>
</tr>
</tbody>
</table>

5.1.1 Implementation

TeamQuest has, besides the four players, a fifth role called the wizard, e.g., Isenhart in Fig. 16. At the beginning of the game, this wizard tells the group a story before the labyrinth resolution to motivate them. An example of these stories is the kidnapping of a princess who must be freed by the group avoiding mortal traps and by killing a dragon (fantasy positive interdependency). During the play, the wizard gives tips and suggestions to the players. They perceive it then as an intelligent agent on their side. What game players do not know is that another person – a cognitive facilitator – can also be connected. This fifth “player” has a user interface similar to the other ones and can monitor everything that is happening in the session. The facilitator can also send messages to the whole group or to a player in particular. Therefore, the facilitator can help the group to define, discuss or improve the strategy used to solve the problem. The group members generally think that it is the wizard who sends the facilitator’s messages.
The cognitive facilitator proposed in TeamQuest can be a teacher or any person with experience in the collaborative work. This person has an important role as a stimulating agent in the process of the group members’ incorporation of general behavior patterns. Some of these patterns are: definition of an initial strategy, and the periodic review of the obtained partial results. The facilitator’s influence is expected to be large on groups with little experience in collaborative work. If participants acquire these behavior patterns, the facilitator can decrease his/her influence. In such a case, this means the participants have learned how to collaborate. It also means perhaps that they will not need a facilitator to improve their strategies in the near future.

5.2 Negotiation Table

The second aspect is to realize that some conflict is perhaps inevitable - and maybe even desirable. Part of what students are learning in a group project is how to negotiate differences and deal with other people to reach a common goal. Groups sometimes become stronger as they work through the conflicts that arise with the clash of different ideas and work habits. As Miller, Trimbur, and Wilkes point out, “excessive conflict can certainly interfere with performance. Paradoxically, excessive harmony can do the same, because members of the best groups tend to be critical of one another's work or at least to tolerate an in-house critic; they tend also to impose high standards on themselves” [Mill94]. Of course, this kind of creative tension does not worry most teachers as much as the potential personality conflicts that sometimes causes bitter feelings and unproductive groups. For this reason, the model includes a scheme, which creates conflicting conditions among members of the group. The notion of conflict is the basis of the social-cognitive theory of human-to-human collaboration [Dois84].

According to this theory, the benefits of collaborative learning are explained by the fact that when two individuals disagree at some point, they feel a social pressure to solve that conflict and the resolution of this conflict may lead one or both of them to change their viewpoint. This can be understood from the “multiplication” perspective, because a
conflict between two or among several agents is originated by the multiplicity of knowledge. It appears, however, that learning is not initiated and generated by the conflict itself but by its resolution, that is, by the justifications, explanations and so forth, that lead to a jointly accepted proposition.

It is important to consider how to deal with conflicts. As it has been mentioned before, some conflicts arise out of the fact that students do not necessarily know how to work in-groups. After years of developing individual skills in competition, students need to learn how to trust other group members, how to delegate, how to negotiate, and many other team skills. Helping students understand group dynamics can also prevent conflicts. Miller et al. identify personality characteristics and learning styles as two areas that shape the dynamics of the group, and encourage teachers to accommodate these differences by providing groups with ways of dealing with conflict as it arises. They argue that, although educating students about group processes takes class time that might be spent on course content, spending a class period discussing group work skills can make a major difference in the success of the project. “We should teach the skills that we are grading. Thus, such a session should include a briefing on the necessity for and logistics of good communication and organization and give participants an opportunity to discuss the various kinds of talents and individual differences or preferences that different people bring to tasks” [Mill94]. They suggest activities such as small groups solving a simple puzzle and reflecting on the group process afterwards, students role-playing group interaction and discussing scenarios as a class, or reading and discussing information about the characteristics of different work styles and personality types, and how to accommodate these differences.

No matter how well we prepare, variables outside your control ensure that conflicts will sometimes occur. Keeping in touch with the progress of the groups -through periodic progress reports or team assessments, for example- allows you to identify problems within the groups as they arise. If a group is having trouble resolving a problem, you
will want to decide how active a role you are willing to play to help the students handle the situation.

The process of confrontation and conflict among members of the group, rather than being viewed as a disadvantage, brings about fundamental cognitive restructuring [Sher98]. Brown and Palicsar note the important role of the skeptic in group discussions: “by forcing the group to defend or elaborate solutions, a more mature resolution will emerge” [Brow89]. They also argue that situations, which encourage dissatisfaction with the existing state of knowledge, tend to foster conceptual change. Environments that encourage questioning, evaluating, and criticizing the status quo are considered to be fruitful breeding grounds for restructuring knowledge.

The negotiation table is a discussion environment. Group members can use it during a break. Breaks may be done at any time during the play. They provide opportunities for analysis of the work done, thus allowing the definition and reinforcement of the common goals. Establishing common goals is part of constructing common grounds, since actions cannot be interpreted without referring to the shared goals, and reciprocally, goal discrepancies are often revealed through disagreements on action [Dill99]. Members of a group do not only develop shared goals by negotiating them, but they also become mutually aware of these goals.

The strategy the group must use to solve the problem is not the same if individually decided by each group member. If it is going to be shared, the strategy has to be decided somehow and then communicated, understood, and - to some extent- has to be agreed upon by all members of the group [Clar94]. As Dillenbourg & Self mention, if strategic decisions are necessary, they will be object of explicit agreement like any other decision made by the members of a group [Dill95b]. Hence, the first need is a shared environment in which communication and discussion is possible. Statement, definition and discussion of strategies may then occur. Moreover, the tool should stimulate this
discussion in several occasions. Of course, the break should not be penalized: while using the negotiation table, the play chronometer remains stopped.

5.2.1 Implementation

The user who creates a new game session accesses directly to the negotiation table and becomes its main user. He/she is responsible to coordinate the first activity of the game, which is to give a name to the group (positive interdependence of identity). Subsequent players entering the game are directed to the negotiation table.

Fig. 17. User interface of TeamQuest negotiation table

The negotiation table has a chat tool, which allows group members to discuss in order to reach an agreement. The controls marked with (1) and (2) in Fig. 17 are parts of this tool. Typically, a player begins the group naming by making a proposal and the discussion then starts. The discussion finishes when the group members have agreed on the name. Then, the main user inserts the agreed group name in the designated area (marked with (3) in Fig. 24). The rest of the players must indicate in their windows if they accept or reject the group name. The normal users have a similar but not identical user interface than the one of the main user. The normal user window does not have the button marked with (4) in Fig. 17, but they have two other buttons to accept or reject the proposed group name in the area (3).
Once all participants have agreed on the group name, the game can actually start. The main user will push the play button and automatically the user interface of the play scenario is shown to the participants (marked with (5) in Fig. 17). This is the front door of the game.

A group is never forced to have an explicit working strategy before solving the labyrinth. It is expected the players themselves realize this need and use the negotiation table at will. All interactions will be done through text-based dialogs.

Researchers in linguistics, pedagogy and artificial intelligence have argued that dialog may be best regarded as a type of joint activity [Clar96, Cohe94]. Participants derive explicitly or implicitly a common set of beliefs about the activity, and they drive towards mutual understanding of their intentions and actions -a process referred to as grounding [Clar90]. As Paek and Horvitz mention, in a joint activity it is not enough to just produce utterances; speakers must check that their utterances were attended to and that listeners are still engaged in the activity at hand [Paek99]. In that sense, the negotiation table provides an environment that supports dialogs, discussions and interchange of ideas. This tool is available at any time by just making a “click” at the play scenario. If the group members consider the defined strategy is not working, they can revise it or redefine it using the negotiation table.

On the other hand, discussion and other interaction activities are promoted or at least not punished by stopping the chronometer while the team is at the negotiation table. Thus, TeamQuest tries to promote the existence of active players working on the definition, maintenance and review of strategies to carry out collaborative activities. Bloom and Broder say the major difference between the successful and the non-successful problem solvers in their extent of thought about a problem is in the degree to which their approach to the problem might be passive or active. A passive problem solver typically reads the problem, chooses one way to solve it and keeps trying this way even if it fails. These people are not good for collaborating. On the other hand, a more active problem
solver re-analyzes frequent problems and backtracks to alternative solution paths in order to improve their strategy [Loch85]. This strategy can only be partially set up at the outset of collaboration, it has to be negotiated and probably revised as work progresses. In this context, the negotiation table provides a mechanism to regulate the interactions.

In order to explore the influence of strategy use on the collaborative process results, the experiment specified in [Coll03b] was repeated in a controlled scenario. The new experiment involved the same tool, but two widgets were included. These widgets were designed to promote and enhance the use of a strategy during the collaborative process. The next section describes the new experiment.

5.3 Experimental Design

A new experiment was made with the same tool (TeamQuest). This tool was used in the experiments mentioned in section 4.6.3, which have shown group deficiencies in the definition and use of a strategy to carry out the play. After that, additional elements were designed and included in the software tool with the goal to improve the use of strategies. These elements were called negotiation table and monitoring window. Two experimentations were made using these new elements. The experimented groups had available the TeamQuest negotiation table feature. This would confirm the hypothesis that claims that a good use, definition and adoption of strategies should imply good collaboration, which in turn it is known to lead to good learning. This hypothesis is emphasized in the case of groups just formed or with little collaborative experience.

5.3.1 Experimentation

It includes one of the two widgets: the negotiation table. The participants of the first experiment were students from four schools from Popayán – Colombia: Politécnico Empresarial Andrés Bello, Comfacaucha, Champagnat, and Empresarial del Cauca. Twenty students were selected from these schools. All of them were high school seniors (12th grade) and were familiarized with computer usage. The participants of the second
experiment were freshmen undergraduate students from Electronic Engineering at Universidad del Cauca - Colombia. For the first experiment, twenty students were selected from this university. The students selection took into account the previous groups and work settings in order to have comparable results. The experiment lasted three consecutive days, working three hours each day. Five 4-people groups were assembled. One of the groups was a control group. The goal of the experiment was to check if groups using the negotiation table improved their abilities to adopt strategies to solve the labyrinth or not.

The groups from the first experiment were numbered 11 to 14, while the control group received number 15. Groups No. 11 and 12 used TeamQuest with the widget, whereas groups No. 13 and 14 used standard TeamQuest. The groups from the second experiment were numbered 16 to 19, while the group control received the number 20. Groups No. 16 and 17 used TeamQuest with the widget, whereas groups 18 and 19 used standard TeamQuest. Groups 1-10 were the old groups, using the standard TeamQuest (results of their work were reported in Section 4.5 above). The performed activities are described below.

5.3.1.1 Experimentation Process

The experimentation process involved three stages: pre-test, test and post-test. There was no computer support for pre- and post-test. The test involved the use of computers and TeamQuest. The control group participated in the pre- and post-test.

For the first experiment, the work was done on February 14, 15 and 16, 2003, 8:00 AM-11:00 AM, whereas the second experiment was on May 7, 8 and 9, 2003, 8:00 AM-11:00 AM. The activities carried out in each stage are briefly described below.

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Stage 1 (pre-test). The goal of this stage is to evaluate the participants’ abilities to carry out collaborative tasks. This basic knowledge helps the experimenters to improve their understanding of the results. The activities involved in this stage are the following:

- Make an introduction (15 minutes). The experimenters introduce themselves and explain the goals of the experiment.

- Apply 16PF\(^3\) test to determine each participant’s personality characteristics (45 minutes) (See Annex 5). Fig. 18 shows the application of the 16 PF.

- Define groups and distribute materials (10 minutes).

- Develop the collaborative activity. It is based on the “group investigation” technique [Shar94]. This technique involves the following sub-activities:

---

\(^3\) The 16PF® Questionnaire is used by organizations and human resource professionals to assess the 16 personality factors. The assessment measures levels of Warmth, Reasoning, Emotional Stability, Dominance, Liveliness, Rule-Consciousness, Social Boldness, Sensitivity, Vigilance, Abstractedness, Privacy, Apprehension, Openness to Change, Self-reliance, Perfectionism and Tension. Five additional global factors are also measured: Extraversion, Anxiety, Tough-mindedness, Independence, and Self-control.
• Each group receives the same folder with information concerning the subject of investigation (See Annex 6). Each group member is responsible of a part of the subject. The group must organize the available information within 20 minutes. Each group decides where to work: inside or outside a spacious room.

• Each person must then study their assignment in 30 minutes.

• Afterwards, the group meets again. Each member makes a presentation about their part of the subject to the rest of the members of the group (40 minutes).

• Finally, a knowledge acquisition test on the subject is applied to all groups. A randomly chosen group member represents his/her group. His/her grade will be the group grade (20 minutes). This evaluation method was explained during the introduction.

The evaluation process was done immediately before Stage 1 was concluded. The evaluators were the same people each time. The range for the final grade was from 0.0 (lowest) to 5.0 (highest). Fig. 19 shows some pictures of the performed work during the pre-stage in both experiments.

Fig. 19: Pre-Test work
**Stage 2:** The second stage involves the test activity using TeamQuest for the groups described at the beginning of this section. A control group does not participate in this activity. The activities involved in this stage are the following tasks:

- Define groups (30 minutes).
- Do the collaborative activity TeamQuest (90 minutes).
- Make a survey and ask for final comments (30 minutes).

Group members are distributed in two computer laboratories. Teaching assistants are available to help in case of any technical difficulty. Fig. 20 shows some pictures of the work with TeamQuest.

![Fig. 20: TeamQuest experience](image)

**Stage 3:** Finally, the post-test tries to assess if group members have improved their collaboration abilities through the use of TeamQuest, with and without the widget. The way in which this stage is evaluated is the same as for stage 1. The activities involved in this stage are the following:

- Define groups, one of which is the control group (10 minutes).
- Develop a “group “investigation” activity, following the same sequence presented while describing stage 1. The subject to be evaluated is changed in order to maintain similarities between both stages (See Appendix 7).

5.3.1.2 Results

Table 9 and 10 show the results obtained by the groups of the first experiment and the second experiment respectively, during pre-test and post-test. Table 11, on the other hand, presents the results of the test; these results must be compared with the results of the previous experiment (presented in Section 4.5).

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>3.0</td>
<td>4.2</td>
</tr>
<tr>
<td>12</td>
<td>3.5</td>
<td>3.8</td>
</tr>
<tr>
<td>13</td>
<td>3.6</td>
<td>3.5</td>
</tr>
<tr>
<td>14</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>15 (Control)</td>
<td>3.4</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Table 10. Results of the second experiment in the pre- and post-test stages.

<table>
<thead>
<tr>
<th>Group number</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>3.8</td>
<td>4.2</td>
</tr>
<tr>
<td>17</td>
<td>3.7</td>
<td>4.5</td>
</tr>
<tr>
<td>18</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>19</td>
<td>3.6</td>
<td>3.5</td>
</tr>
<tr>
<td>20 (Control)</td>
<td>3.6</td>
<td>3.6</td>
</tr>
</tbody>
</table>

These results show groups No. 11, 12, 16 and 17 obtained the best results, that correspond to the groups that used the negotiation table option in the first and second experiment respectively.

5.3.1.3 Analysis of results

The previous experiment did not include the monitoring option. This was because we did not want to influence the results of the collaborative process measured by the indicators (a facilitator would be involved). Nevertheless, we did some additional experimentation trying to get an idea on the usefulness of the widget.
It could be checked that according to what we expected, the participants were not aware of the input provided by the facilitator. They thought they received suggestions from an intelligent agent (the wizard) and accepted them most of the time. This was natural, since the wizard does provide help on game actions and their consequences. Facilitators do not have to cheat on this: simply their role is similar to that of the wizard and thus, their language is similar.

Table 11. Results during the test stage 4.

<table>
<thead>
<tr>
<th>Group</th>
<th>IC1</th>
<th>IC2</th>
<th>IC3</th>
<th>IC4</th>
<th>IC5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.69</td>
<td>0.69</td>
<td>0.20</td>
<td>0.75</td>
<td>0.65</td>
</tr>
<tr>
<td>1</td>
<td>0.31</td>
<td>0.71</td>
<td>0.20</td>
<td>0.80</td>
<td>0.57</td>
</tr>
<tr>
<td>2</td>
<td>0.68</td>
<td>0.62</td>
<td>0.20</td>
<td>0.80</td>
<td>0.69</td>
</tr>
<tr>
<td>3</td>
<td>0.48</td>
<td>0.61</td>
<td>0.50</td>
<td>0.74</td>
<td>0.63</td>
</tr>
<tr>
<td>4</td>
<td>0.71</td>
<td>0.74</td>
<td>0.80</td>
<td>0.78</td>
<td>0.66</td>
</tr>
<tr>
<td>5</td>
<td>0.75</td>
<td>0.84</td>
<td>1.00</td>
<td>0.86</td>
<td>0.61</td>
</tr>
<tr>
<td>6</td>
<td>0.71</td>
<td>0.72</td>
<td>1.00</td>
<td>0.85</td>
<td>0.52</td>
</tr>
<tr>
<td>7</td>
<td>0.47</td>
<td>0.80</td>
<td>0.20</td>
<td>0.80</td>
<td>0.53</td>
</tr>
<tr>
<td>8</td>
<td>0.27</td>
<td>0.75</td>
<td>0.20</td>
<td>0.82</td>
<td>0.54</td>
</tr>
<tr>
<td>9</td>
<td>0.28</td>
<td>0.75</td>
<td>0.20</td>
<td>0.81</td>
<td>0.54</td>
</tr>
<tr>
<td>10</td>
<td>0.48</td>
<td>0.80</td>
<td>0.20</td>
<td>0.83</td>
<td>0.53</td>
</tr>
<tr>
<td>11</td>
<td>0.70</td>
<td>0.80</td>
<td>0.80</td>
<td>0.83</td>
<td>0.60</td>
</tr>
<tr>
<td>12</td>
<td>0.68</td>
<td>0.80</td>
<td>0.80</td>
<td>0.82</td>
<td>0.59</td>
</tr>
<tr>
<td>13</td>
<td>0.48</td>
<td>0.62</td>
<td>0.20</td>
<td>0.74</td>
<td>0.64</td>
</tr>
<tr>
<td>14</td>
<td>0.48</td>
<td>0.64</td>
<td>0.20</td>
<td>0.75</td>
<td>0.65</td>
</tr>
<tr>
<td>15</td>
<td>0.48</td>
<td>0.64</td>
<td>0.20</td>
<td>0.74</td>
<td>0.64</td>
</tr>
<tr>
<td>16</td>
<td>0.71</td>
<td>0.80</td>
<td>0.80</td>
<td>0.82</td>
<td>0.60</td>
</tr>
<tr>
<td>17</td>
<td>0.73</td>
<td>0.80</td>
<td>0.80</td>
<td>0.80</td>
<td>0.61</td>
</tr>
<tr>
<td>18</td>
<td>0.69</td>
<td>0.62</td>
<td>0.20</td>
<td>0.74</td>
<td>0.63</td>
</tr>
<tr>
<td>19</td>
<td>0.68</td>
<td>0.69</td>
<td>0.20</td>
<td>0.75</td>
<td>0.63</td>
</tr>
<tr>
<td>20</td>
<td>0.68</td>
<td>0.62</td>
<td>0.50</td>
<td>0.74</td>
<td>0.60</td>
</tr>
<tr>
<td>Average</td>
<td>0.57</td>
<td>0.71</td>
<td>0.44</td>
<td>0.78</td>
<td>0.60</td>
</tr>
<tr>
<td>Stand Dev.</td>
<td>0.16</td>
<td>0.08</td>
<td>0.31</td>
<td>0.04</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Of course, this ambiguity means that facilitators have to follow strict rules concerning when to monitor and what actions to suggest. The role of the wizard and facilitator is to maintain the focus of the discussion, guiding students through the knowledge constructing process. The assumption is that both the contents and the pattern of the sequence of messages reflect the degree of collaborative learning. In this aspect, the idea

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4 Lowest score is 0.0, highest score is 1.0 and minimum approval is 3.0
is not to provide the right answer or say which person is right, but to perform a minimal pedagogical intervention (e.g., provide hints). This intervention is to redirect the group work in a productive direction or to monitor which members are left out or excluded from the interaction in order to define a strategy [Dill99].

The participants selected for the new experiment were chosen as similar as possible to those of the previous experiment. They belong to schools with the same socio-economic profile, they have a similar knowledge background and are of the same age. Group definition was made in such a way as to have members from all schools, without any previous acquaintance for each group.

The group with best performance for most collaboration indicators from both experiments was Group No. 5. They are students from the same school and they have worked together for some time. It is then no surprise they have implicit strategies. An interesting conclusion is the very good results of groups using the negotiation table in the new experiment. The groups were composed of students who did not know each other beforehand.

Another interesting conclusion appears when taking into account the results from the 16PF test. As mentioned above, this test evaluates personality features and individual ability [Catt95]. The students with the best individual characteristics and predisposition to work in groups belong to group No. 13 and No. 18. In fact, the groups with the best collaboration results did not include the best 16PF achievers. One can conclude that the only free variable when considering the new experiment is the use of the negotiation table. Of course a scientifically valid final conclusion should involve a larger number of groups and a statistical test.

The way of stimulating strategy adoption presented in this paper could also be used in other collaborative environments requiring strategies for the achievement of a task or development of a product. Similar widgets could be created for this purpose.
In order to measure the presence or absence of the indicators presented above it is necessary to design some collaborative scenarios. The design of a well-specified scenario could induce to collaborative activities within a group. Therefore, it is important to define every activity carefully, in order to promote collaborative activities. The next section will explain a proposed model that includes a set of elements that must be performed in order to specify scenarios to promote collaborative activities. These scenarios must include elements that permit to evaluate and monitor the collaborative process according to the indicators explained above.
6. COLLABORATIVE SCENARIOS

Instead of designing systems that compensate for metacognitive deficiencies by becoming increasingly directive, it is suggested to develop systems that support the learner’s metacognitive activities (or even better, that develop their metacognitive skills) [Dill92]. Hewitt et al. state that a computer-supported learning environment can serve not only as an on-line conferencing facility but also as a true learning environment if it enables participants to represent a problem from multiple perspectives, to build knowledge communally, and to examine knowledge and refine design elements at different levels of abstraction [Hewi97].

As Dillenbourg mentions, in collaborative learning environments particular forms of interactions are needed to trigger the desired learning mechanisms [Dill99]. There is, however, no guarantee that those interactions occur. Hence, the idea is to develop mechanisms that increase the probability that they will happen. One of these ways is designing well-specified collaborative scenarios. It is necessary therefore, to design the learning task and the learning environment. Dillenbourg offers an excellent account of collaboration in learning processes from a cognitive psychology perspective [Dill99]. He is especially interested in problem-based tasks and looks at both paired and group-based collaborations. He mentions that there is an indirect connection between a collaborative learning situation and its learning outcomes. There are important intervening variables: situations generate interaction patterns; interactions trigger cognitive mechanisms; mechanisms generate cognitive effects. What the learners do is important. They cannot be directly influenced, but it is possible to try to create scenarios, which are conducive to promoting helpful interactions.

The design of the learning task needs to draw on the best we know about how people learn, on a deep knowledge of academic subject matter and/or vocational competencies,
and on knowledge of the learners. A task needs to be sufficiently well-specified so that the chances of a learner engaging in unproductive activity are kept within tolerable limits. The learning environment is the physical environment or physical settings within which learners work [Stee02].

Fig. 21 depicts the model proposed. This model pretends to support collaboration through two approaches: structuring the situation in which the collaboration takes place (set up initial conditions and structuring the collaboration), and, structuring the collaboration itself through coaching or self-regulation (maintaining the collaboration).

Fig. 21: Collaborative Scenarios Model Proposed

- **Set-up of initial conditions:** A first way to increase the probability that some types of interaction occur is to carefully design the situation. Numerous independent variables have been studied in order to determine the conditions under which collaborative learning is efficient. A set of elements to consider in order to specify the initial characteristics of the groups have been defined taking into account Banoon’s proposal [Bano89].

- **Structuring the collaboration:** The teacher cannot simply ask students to start projects and encourage peers to learn together. He must specify a scenario. Such scenario must include several phases. At each phase, the team has to produce something and the team members have some role to play. The proposed scenario
includes three characteristics: activities, people, and objects. As Jerman et al. mention, coaching collaborative interaction means supporting or managing the group members’ metacognitive activities related to the interaction. For example, one might help students manage their interactions by assigning roles, detecting conflicts and misunderstandings, or proposing suitable tasks for each participant, given their level of expertise [Jerm01].

- Maintaining the collaboration among members of the group is a regulatory activity that can be performed by the cognitive mediator or by the same members of the group. This activity corresponds to the central part of the evaluation and monitoring of the collaborative process.

It is not only important to design the software tool and the task, but to consider other aspects such as teacher’s participation, learning goals, etc., in order to have a collaborative environment. As Newman mentions, the computer could be used as a medium or resource for collaborative learning. The computer can help students communicate and collaborate on joint activities, providing assistance in the collaboration process. This mediation role of technology emphasizes the possibilities of using the computer not simply as an individual tool but as a medium through which individuals and groups can collaborate with others [Newm98]. These issues indicate that in order to support collaborative learning it is necessary to consider different aspects such as: the context in which learning takes place, the interactions that happen in these contexts, and the way these interactions are chained over time.

The next section presents a pattern for the design of collaborative activities, including the most important elements that must be included during a collaborative task.

### 6.1 Pattern for the design of Collaborative Applications

Context: In order to obtain learning in a collaborative manner, it is necessary to define a collaboration process that allows to monitor and to evaluate it, and to understand the
way it works and to be able to transmit it to the learners at a later stage. If the collaboration process is improved, the quality and quantity of group learning will be increased. As Ewing mentions, it is necessary to know details about the process that occur when a group of people is trying to solve a problem situation in a collaborative way [Ewin02]. It is necessary to provide support for the design of educational activities, and to have a set of appropriate elements for the development of educational frameworks, especially environments that support monitoring and the evaluation of collaboration processes. Kuman mentions that the processes of collaboration should be evaluated based on a set of pedagogical guidelines that ensure that collaboration takes place at an appropriate pace, and with positive interactions from all the peers [Kuma96].

6.1.1 Problem

¿How to define a computational framework that permits to establish the necessary mechanisms for evaluation and monitoring of the collaborative process?

Empirical research has shown that collaborative learning by itself is not an effective method of learning [Dill99]. The teacher cannot simply tell the students to work on a project and encourage them to just learn together. Collaborative Learning is more effective if the individuals and the group can work in well-designed scenarios. Also, some research has shown that the structure of the shared spaces has an influence on the nature of collaboration, and, from a prescriptive point of view, there is an interest in implementing common working spaces that will passively facilitate the common task through suitable designs.

Considering that the processes of collaborative learning depend on time factors, both contextual and physical, several conditions have been investigated, such as the composition of the group, individual pre-requisites, characteristics of the task at hand, and the context of the collaboration. However, it has been discovered that these conditions do not have simple effects on learning results, but rather interact with others in complex ways, and therefore it is necessary to pay special attention to the different
aspects of the interaction, to carefully observe the collaborative activity [Dill99]. Thus, it is important not only to consider the design of the structure of the collaborative space, the sum of activities that define the collaborative task, but also to understand the process of collaboration that takes place when developing a collaborative activity. One way to understand this process is modeling and evaluating it.

One of the most important aspects in evaluating the process of collaboration is defining the criteria for evaluating such process. An improvement in the collaboration process should bring about the development of end products of higher quality. In order to improve the process of collaboration it is first necessary to evaluate this process with a certain degree of accuracy so that different learning processes taken on by different group of learners can be contrasted.

Based on this premise, this pattern includes aspects of the design of the collaborative activities, as well as of the evaluating and monitoring of the collaborative process.

In defining the Activities, it is necessary to specify the group of people that will make up the group, the required a conditions of collaboration, the Nature of the activity, the Type, and the mechanisms that provide Positive Interdependence and Coordination.

Similarly, through the evaluation of the collaboration process, certain weaknesses of the groups can be determined, and thus, supportive mechanisms and feedback can be provided to them. Through a continuous evaluation and monitoring process, the initial conditions can be re-defined, changing certain activities in order to achieve an environment of greater participation and interaction among the members of the group, which can have a positive effect on the collaboration mechanisms.

6.1.2 Components

1. Name: Activities
1.1 Context: In collaborative environments, several activities are proposed so students can achieve the desired results, that is, acquire knowledge through the development of a collaborative task.

1.2 Description: The activities specify the work that the members of the group must perform during the collaborative task. Such activities can be designed with methods that promote a collaborative learning environment using computer tools, such as the environment proposed by Gallardo et. al [Gall02].

1.3 Solution: Plan the activities so that the students change from an individual to a group perspective. That is to say, to move from an exploration and analysis scheme to a scheme of sharing information, discussion and consensus.

The activity must be designed so that the only way to solve it is through the collaboration of all the members of the group. Therefore, its design has to include elements that will guarantee positive interdependence and good collaboration schemes. Being a member of a group is not sufficient to promote higher achievement - there has to exist positive interdependence among all group members (this would be the case if, e.g., the performance of any group member affected the grade received by all group members). Positive interdependence makes each member feel willing to work hard in order to make sure that the whole group is successful. It is needed to have individuals interact with one another while they work. Positive interdependence in cooperative situations goes beyond motivating students to work hard and it facilitates the development of new insights and understandings through promotive interaction (it exists when individuals encourage and facilitate each other's efforts to achieve and complete tasks and to produce in order to reach the group's goals) [Coll03e].

It is necessary to specify and clearly define the activity, describing its Nature, Type, people in charge, and conditions for collaboration. Ideally, the designed activities, as mentioned by Dillenbourg [Dill99], should generate interaction patterns that activate
cognitive mechanisms. It is important to mention that we cannot directly influence this, but we can create situations or activities that promote valuable interactions.

1.4 Known uses: Case studies carried out in an environment like Zebu [Ties99] force us to conclude that it is necessary to provide the teacher with supportive mechanisms for the planning and visualization of the proposed activities, of how the activities should take place within the collaborative process, and the way in which the students should participate. The objective of the proposed supportive mechanisms is to support the teacher in the planning of interrelated learning activities that must stimulate the students’ participation in a process of progressive commitment towards the fulfillment of the task.

2. Name: Group of People

2.1 Context: They represent collections of users in collaborative systems and are generally associated to the functions undertaken to execute an activity.

2.2 Description: Specify the roles of the participants in a collaborative activity. It is important to differentiate the role of the Facilitator and that of the Learners. What needs to be done in this component is to analyze how to define or identify effective mechanisms that can help in the selection and distribution of the work teams. The importance of the definition of roles in collaborative environments consists in that different users possess different levels of knowledge, as well as access to different information sources. Each member of the group, Facilitator or Learner acquires certain knowledge about a determined domain starting from the different perspectives as the collaborative process develops. In order to achieve effective collaboration, it is necessary that the roles of both the Facilitators and Learners change.

2.3 Solution: For the collaborative activity to be successful, it is essential to clearly define the tasks to be undertaken by each of the members of the activity. It is necessary to define coordination policies in order to provide different interface mechanisms to
each type of user for effective decision making. Specific awareness mechanisms must be
specified for each type of performer of the activity. The function of these mechanisms is
to provide necessary information about the development of the activity and about the
performance of each member making it possible to intervene if necessary. Another
important aspect that needs to be considered is in regards to the characteristics of the
group that participates in the collaborative activity. The group heterogeneity covers
several independent variables such as: size of the group, gender and group members
differences. The size specifies the number of participants within a collaborative activity.
Generally speaking, the smaller the group, the more each member talks and the less
chance is there that someone will be left out. Also, smaller groups require less group
management skills and can usually come to decisions faster [Kaga92]. Gender, specify
the male/female group composition. Some studies have found the influence of this factor
important within a collaborative learning process [Coll02a].

3. Name: Facilitator

3.1 Context: Different people can participate in a collaborative activity, of which some
are essential for its development. An example of this is the facilitator, who must
structure the activities and must be able to monitor the collaboration process.

3.2 Description: The facilitator is the person in charge of defining the initial work
conditions, the one who plans the objectives of the activities, and who defines the
conditions of success. In general, the facilitator is the one who creates interesting
learning environments and activities that link new information to the previous
knowledge providing opportunities for the collaborative work and offering the students a
variety of real tasks. To carry out these tasks, it is necessary to have the capacity to
determine when and how to intervene, as well as have good task planning.

3.3 Solution: For an effective decision making, it is essential to define coordination
policies. We have proposed that in order for the collaborative learning to be effective, it
is necessary to follow certain guidelines and define certain roles [Coll01a]. But the sole
definition of these guidelines and roles does not guarantee that the learning will be done in the most efficient way. It is necessary to define a collaboration scheme, that allows the instructor to know when and how to intervene in order to improve the collaboration process.

The teacher needs to be able to monitor not only the activities of one student, but also the activities of the other members of the group encouraging some type of interaction that can influence the individual learning, and in the development of collaborative skills, such as to give and receive, help and obtain feedback, and to identify and solve conflicts and disagreements. That is why the Facilitator must have access to all the shared objects of those are participating in the activities.

In this way, he can send messages to help some of the members of the group when he recognizes problematic situations. The type of help provided must not be the solution to the problem, but to provide mechanisms that encourages the creation of an ideal state of collaboration.

4. Name: Learner

4.1 Context: In collaborative learning environment, the main role of learner is to interact with other students, in order to obtain certain knowledge or some kind of skill.

4.2 Description. He has a key role in the development of the collaborative activity. He is responsible for the completion of the activities through which goals will be achieved and for the solving of the problems defined by the Facilitator. His main objective is the cooperative gathering of knowledge about a problem situation.

4.3 Solution: The different roles of the learners must be specified during the collaborative activity. Each group member must be assigned a role, which can actually be executed. The roles must not be fixed; the roles of the learners must be rotated while the activity is on-going because the exchange of roles is very positive in collaborative learning activities [Dill95a]. Johnson and Johnson based on a collaborative learning
scenario, suggest four types of roles: reader, expert, mediator and secretary [John98]. Each group member has a designated role which they are to perform. For example, a reading passage can be divided into sections. Members of a pair read the first section silently. Then, one person summarizes the section and the other makes connections between the section and other materials the class has studied. These roles can rotate.

At the same time, based on the collaborative learning scenario established by Johnson and Johnson [John98], four types of roles are suggested: reader, expert, mediator and secretary. The reader is in charge of reading the problem and explaining it clearly to the group. The expert is in charge of constructing the solution to the question assigned to him and to inform the rest of the group about it. The mediator is in charge of ensuring the even participation of all group members, as well as of controlling the time in the group. Finally, the secretary is the person who records all the solutions obtained by the group.

5. Name: Positive Interdependence

5.1 Context: Several studies have identified three essential characteristics of a collaborative activity: positive interdependence, equal participation and individual accountability.

5.2 Description: Positive interdependence is the heart of collaborative activities that define collaboration and transform group work into teamwork. As Johnson et al. [John93] mention, the essence of a cooperative group is the development and maintenance of positive interdependence among team members. Being a member of a group is not sufficient to promote higher achievement; there has to be positive interdependence among all the group members [John93]. It is a key feature that has been emphasized by scholars concerned primarily with promoting students’ academic achievement and cognitive development [John95, Slav90].
Positive interdependence simply means that group members feel that they sink or swim together. In other words, what helps one group member helps them all, and what hurts one group member hurts everyone in the group [John95].

Group goals and tasks, therefore, must be designed and communicated to students in ways that make them believe they sink or swim together. When positive interdependence is solidly structured, it highlights that (a) each group member's efforts are required for group success and (b) each group member has a unique contribution to make to the joint effort because of his or her resources and/or role and task responsibilities [Smit96, Coop90]. Doing so creates a commitment to the success of group members as well as one’s own and thus it is the heart of cooperative learning. If there is no positive interdependence, there is no cooperation.

In spite of the vast amount of suggestions on how to promote positive interdependence, there are no guidelines on how to structure collaborative scenarios that promote positive interdependence using software tools.

5.3 Solution: Design activities that permit to foster different kinds of positive interdependencies among members of the group [Coll03e, Guer02]. High positive interdependence within a cooperative group means the group members feel personally responsible for contributing their efforts to accomplish the group goals.

They are also aware that there are negative consequences when failing to do one’s own part. Johnson et. al, have defined nine types of positives interdependencies [John93]:

- Goal Interdependence: Students must perceive they can achieve their learning if and only if the other members in the group achieve their goals
- Role Interdependence: Each member is assigned roles that are inter-connected and which assign specific responsibilities that the group needs in order to complete the joint task.
• Outside Enemy Interdependence: Teacher puts groups in competition with each other. In this way, group members feel interdependent and do the best to win the competition and be above other groups.

• Resource Interdependence: Each member has only a part of the information, resources, or materials needed for the task to be completed and the members' resources have to be combined in order for the group to achieve its goal.

• Identity Interdependence: Group members have to find and agree upon an identity, which can be a name, a motto, a slogan, a flag, or a song.

• Reward Interdependence: A joint reward is given for successful group work and members’ efforts to achieve it. When the group achieves its goals each member receives the same reward, sometimes teachers give students a group grade, an individual grade from a test and bonus points if all members achieve the set goals.

• Fantasy Interdependence: The teacher gives students an imaginary task. Students have to come up with solutions for extreme situations such as endangered life or handling very powerful future technology.

• Task Interdependence: Work has to be organized sequentially. Students have to divide the work and must be linked with each other. As soon as a team accomplishes its portion of the task, the next team can proceed with its responsibility, and so on.

• Environmental Interdependence: Students are bound together by the physical environment in which they work. So the teacher has to find an environment that unifies students.

Some recommended activities are:

• use only one piece of paper or just one set of materials for the group giving each member a separate job or role, giving all group members the same reward or giving each person only part of the information [Kohn93],
redirect instructor-directed questions posed by individual students back to the students’ team;

• have teams seek help from other teams before asking the instructor for it;
• let the last team receiving help provide it to the next team requesting support,
• have group members consistently use team responses (e.g., all teammates raise their hands before the instructor responds; teammates provide a choral response to instructor-posed questions; all teammates sign their names on completed group tasks); and
• let students consistently use team language in the classroom ("we" and "our" vs. "I" "me" or "mine"), among others.

6. Name: Nature of the Task

6.1 Context: In a computer supported collaborative learning environment, the purpose of the proposed tasks must be that a group undertakes them as a collaborative effort.

6.2 Description: It specifies the characteristics of the collaborative activity. The characteristics of the task in some way define the degree of interaction that can exist among the group members. The lack of information about the objectives, the rules and the collaboration environment can result in that a given task not be properly undertaken. The collective development of an activity requires the integration of all participants, and therefore, it is necessary that the learners be very aware of the steps that are needed to be followed to achieve the objectives and of their role within this process.

6.3 Solution: When defining the nature of the task, the following aspects must be taken into consideration:

• Period of collaboration: Specify the time interval in which the collaborative activity will occur. The interval can be specified in minutes, hours, days, weeks, months or years.
• Setting of collaboration: It is the place where the collaborative activity will be held. It may be the classroom, workplace, home, etc.

• Type of activity: Specify the type of activity that will be performed by the members of the group in order to solve a problematic situation. Examples are: puzzle solving, editing a newspaper, writing a letter, etc.

• Rules: Specify the rules of the group activity. These rules permit to mediate the subject-community relationship, and refer to the explicit and implicit regulations, norms and conventions that constrain actions and interactions within the activity system [Enge87]. These rules permit to review boundaries and guidelines of the group activity, and according to Collazos et al., these rules correspond to one of the indicators of collaborative learning process [Coll02c].

• Nature of Collaborators: Specify the types of interaction that occur. For example, three types of interaction can occur in a certain case:
  
  • Peer to peer interaction.
  
  • Teacher-student interaction.
  
  • Student-computer interaction.

• Goals: There are activities performed by the group corresponding to the main goal, and activities performed by every member of the group, corresponding to the partial goals. One of the most commonly heard objections to having students work in groups is that some group members will end up doing all the work and all the learning. This can occur because some students try to avoid working or because others want to do everything [Kaga92]. Thus, encouraging everyone in the group to participate is a real concern. All people should feel they are individually accountable for the success of the group.

• Conditions of collaboration: Specify the kind of mediation. It could be physically co-present or computer-mediated.
7. Name: Shared Objects

7.1 Context: Collaborative learning environments allow students to work together, sharing virtual spaces where to interact.

7.2 Description: Shared objects represent the space where the participants exchange information. These environments cannot reproduce all the actions that take place in a space of face-to-face interaction. That is why collaborative learning environments must provide the means to facilitate the necessary information for effective decision making in a problem situation. Awareness is a concept related to the mechanisms that guarantee that people can understand or can be aware of the process itself and of the interaction among all the participants of a given activity.

7.3 Solution: The notion of what is going on within the group as a whole represents a true collaborative learning concept. Thus, it is necessary to provide a representation of the group members within the working space, so all members of the group can have the following information:

- Where are the other members of the group?
- What are the other members doing to complete the task?
- What have the other members done?
- What will the other members do to solve the task?

This representation can be graphic, an icon or through elements of virtual reality. Another element that can be included is the perception with regard to the learning being done by each of the group members. This is what we have come to call Shared Knowledge Awareness (SKA) [Coll02b], which is a refinement of the Knowledge Construction Awareness. (KCA) [Collo3c]. The goal of KCA is to promote meta-cognitive skills. SKA is consciousness of the shared knowledge of the students that carry out a collaborative learning activity, working in-groups.
This shared knowledge is more than the shared understanding of the problem. The shared knowledge is composed of the understanding of several aspects of the collaborative work, including coordination, strategy communications, monitoring, and shared comprehension of the problem.

8. Name: Coordination

8.1 Context: Coordination is a term used to describe a number of actions or mechanisms available in a shared environment, whose objective is to manage the interdependence among the participants.

8.2 Description: In collaborative learning environments, that have an educational objective, coordination must serve as help to define the types of work, allowing all members to have access to the shared knowledge or carry out the collaborative activities. Coordination is related to the support, the definition and the execution of the group and individual tasks. In defining the tasks, procedure rules are established. In executing the tasks, assistance is required not only in terms of instruments but also regarding information and concepts. There are many cooperative systems that provide guidelines for the structuring of social interactions within the context of shared spaces [Farn00].

8.3 Solution: The environment must allow the establishment of rules of cooperation and of procedures among the individuals, guaranteeing that all participants share the knowledge or are committed to the collaborative task. The environment must provide assistance to the participants in the sense that to develop a task also implies to acquire, share or work on the construction of some type of knowledge. According to Johnson-Lenz, another aspect of coordination has to do with the ways of maintaining the group stimulated, mechanisms that incentivate participation and communication [John91]. Guidelines must be provided that serve as help mechanisms and that directly observe the actions that are taking place within the group, analyzing and interpreting actions, messages and all kinds of situations that happen with the idea of providing the necessary information for adequate decision making.
9. **Name: Integration mechanisms.**

9.1 **Context:** The means used by the individuals to integrate a group will characterize their relationship. In integrated groups, people tend to act in a coordinated way. Non-integrated groups do not fully reach their objectives.

9.2 **Description:** Integration can be measured by the degree of cohesion to operate in a coordinated way. The first step for the integration and establishment of common goals is a mutual understanding among all group members. An integrated group is one in which its members are committed to work and feel responsible for the group.

9.3 **Solution:** To provide mechanisms that facilitate understanding of the group’s objectives and the means to keep participants of the collaborative activity informed of the objectives of each activity and their responsibility towards it.

10. **Name: Conflicts and Decision-Making**

10.1 **Context:** During the collaborative learning sessions, conflicts may arise among the group members, creating problems in the execution of the tasks.

10.2 **Description:** In the context of collaborative learning environments, negotiation is an auxiliary mechanism related to Coordination that forces apprentices to make decisions about the execution of some tasks, which in term forces them to elaborate a solution for a proposed problem, thus promoting learning. Negotiating implies discussing and deciding. In this type of interaction, people express their opinion and allow the others to accept it. This process implies several cognitive mechanisms such as inference, logic, deduction, etc. [Barr94].

The decision making process requires defining and analyzing different alternative solutions proposed by the group members, identifying a number of possible alternatives for the execution of a collaborative work. This process is important not just for the cognitive development of the learners, but also for the acquisition of social skills.
Conflicts or disagreements arise from different perspectives that bring about verbal interactions in order to resolve the conflict. Social factors can help the group find a solution. There is a greater possibility of this happening due to differences than because of the need for a solution to an intense conflict. The verbal interactions generated during the resolution are what promotes learning [Dill99].

10.3 Solution: Stahl says that collaboration requires divergence (stating of ideas) and convergence (negotiation, synthesis, and consensus) [Stah99]. That is why the model must be flexible to allow negotiating mechanisms where the participants can communicate and participate in the making of decisions.

- Communication. Define mechanisms to support communication among members of the group, such as chat boxes, messages boxes, etc. Delvin and Rosenberg emphasized the importance of communication in individual knowledge and cooperative practices such as sign language with hands in face-to-face communication [Delv96]. The participants of a work group must communicate in order to accomplish tasks that are independent, incompletely described or require negotiation [Fuss98]. It is important to define mechanisms where students have the opportunity to understand what they have heard, read and also to express themselves in relevant tasks. The idea is not simply to provide mechanisms for communication, but also for negotiation. Negotiation is an essential component of collaboration. Through negotiation of knowledge, a group of knowledge workers or collaborative learners determine what knowledge they must build and accept as a group. [Stah02a].

- Participation. The idea is to define scenarios, where members of the group have the same opportunities to participate in order to solve the problematic situation. The complexity of the activities must be designed in a way that the work performed by every member of the group must be the same. It is important to notice that just because one person in the group is talking or performing any other activity, it does not mean that each member of the group has the same chances to talk and to
intervene in order to solve the problematic situation. Kagan and Kagan, have defined equal participation as one of the principles which are key to the structural approach to cooperative learning [Kaga94].

11. Name: Evaluation

11.1 Context: Evaluation in collaborative learning involves a number of actions organized with the purpose of obtaining information about the knowledge acquired by the learners.

11.2 Description: The typical evaluation of collaborative learning has been made by means of examinations or tests to the students to determine how much they have learned. That is to say, a quantitative evaluation of the quality of the outcome is done. Some techniques of cooperative learning use this strategy (e.g. “Student Team Learning” [Slav90], “Group Investigation” [Shar90], “Structural Approach” [Kaga90] and “Learning Together” [John75]). Nevertheless, little investigation has been done to evaluate the quality of the collaboration process.

The evaluation must function as an instrument that gives possibility to the teacher to analyze the collaborative activity in a critical way. Also, must provide the possibility to detect the main weakness of a certain group, in order to define some mechanisms to support their members.

There is a growing number of experiences in qualitative evaluation in CSCL environments [Wass00, Slat02]. However, there are some open-end questions regarding the application of qualitative methodologies in the evaluation of real situations. The first one is the high cost that these methods imply which can make it impossible for teachers to apply them since they are already very busy with their present classroom activities. Additionally, it has become necessary to adapt qualitative methods to new space-time situations and computer-aided interactive ways that appear while using CSCL environments.
11.3 Solution: In a collaborative learning environment, it is necessary to record all of the activities that occur within the group when solving a problem situation. All the mechanisms that allow the recording of all the activities should be provided, so that they can be reconstructed after performing an in-depth analysis of messages, actions and all kinds of events that have occurred. Basically, every collaborative application must save and share the data obtained by the users.

Besides, the collaborative applications need to be provided with a way to visualize the information due to different points of view that can be had of the same data by different kinds of users. The teacher can determine what kind of data he needs in order to evaluate a particular aspect of this collaborative process. That is why it is necessary to provide an object of information for each object of data. This meta-object should have certain features or information such as date of creation of the object, the name of the examiner, the name of participants, addressee, sender of messages, text of shared message, time of the delivery, and actions carried out indicating which object performed a particular event.

The introduction of computers gives new sources of information through the recording of the users’ activity or using techniques of screen shot and others that can help to reproduce the collaborative activity. The model that is being proposed in this thesis will be based on the analysis of the dialogue and the actions obtained from the shared space which is presenting in the following.

11.3.1 Type of recorded information

This section deals with the data that have been recorded in order to be later processed with the aid of a computer. Two possible sources of information have been identified: dialogue and actions occurred in a shared space: Dialogue and Actions in the shared space.

a.) Dialogue
The use of dialogue as a source of data for analysis has been crucial for two main reasons. On one hand, the number of CSCL systems that use some form of conversational exchange, and on the other hand, the importance given to language as a means of building knowledge.

Many CSCL systems are supported by interfaces of Computer Mediated Communication (CMC), such as chat boxes, discussion forums, etc. They all provide the researchers with an easy-to-find source of data. Likewise, the analysis of dialogue has been crucial in the study of collaboration in the last few years, due to the importance given to language as a means of building knowledge [Mart00b]. The main problem of this point of view is that the state-of-the-art processing of natural language does not allow to automatically codifying the intervention of the participants in a collaborative activity. However, this alternative is one the most important elements of the qualitative evaluation [Stak95, Rorr99].

Processes of accountability or clarification have traditionally used the use of either log files or record systems. Nowadays, the use of these systems to perform studies of evaluation is becoming widespread. For instance, the use of the registration of web server accesses, in the man-machine interaction [Hild00], or on the same CSCL. In Meinstad [Meis00], both System Log Analyzer and TRA (TWW Room Analyzer), which performs reproductions of events produced in a collaborative tool called TeamWare, are described. This kind of instrumentation provides a high degree of transparency but of low reliability due to the fact that the provided information may neither be needed nor be expressed on the level of appropriate abstraction. The information that needs to be recorded, with regard to messages the members of the collaborative group have sent and received is shown in table 12.

<table>
<thead>
<tr>
<th>Position</th>
<th>From</th>
<th>To</th>
<th>Message</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
</table>

Table 12: Information requested (Messages)
The first field, Position, stores the information with regard to the location of that member of the group, within the collaborative activity, who has received some message. The second field, From, refers to the name or the alias of the person in charge of sending the message. The To field, refers to the name or alias of whom has received the message. Message, stores the information dealing with the sent message, and finally Date and Time record both the date and time of the delivery.

Consequently, the developed applications need to allow the recording of the information of the elements above mentioned, in order to be able to evaluate the collaboration process accurately in accordance to previously mentioned indicators in section 4.2. Incidentally, in this way the purpose is not only to quantify the occurrences of a particular category such as metric or messages, but also to get the sense which participants in a certain process give to their actions. From the information obtained from the data of chart 12 -Application of Strategies, intergroup cooperation, monitoring and performance- it is possible to determine the value of four of the five indicators proposed in section 4.2. It is impossible to determine the value of the other indicator (review of success criterion) with the information obtained up to now. Now, the structure of the files that needs to be included in order to obtain this outcome will be described below.

b.) Actions in the shared space.

One of the usual components of a CSCL system is a space of shared work in which the users interact, sharing objects, solving problems, etc. These environments tend to have a framework based on easy to identify elements that users can work with through direct manipulation interfaces. Muhlenbrock [Muhl98] considers these spaces of shared work as a way of objective production of Joint Problem Space (JPS) [Rosc95], as a reflex of collaborative activity of a group of people facing a common objective. Muhlenbrock’s approach deals with problem solving oriented systems. Other shared work environments are focused on enabling the sharing of information and creating communication among a
group of people, such as the BSCW system (Basic Support for Cooperative work) [BSCW00]. The actions about the documents in this space allow indirect interactions that can be analyzed. Table 13 shows the information that must be recorded in order to evaluate the remaining indicator.

Table 13: Information requested (Movements)

<table>
<thead>
<tr>
<th>Position</th>
<th>Action</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
</table>

The first field stores the information regarding the position of the group member who has performed some action on the shared workspace. The second field, describes the action performed and finally appears the date and time when of the activity was done.

One of the limitations of this approach is that the semantics of the actions is lower and with fewer metrics than a dialogue, which on one hand enables the automatic analysis since it is easier to interpret, but, on the other hand, it has a limitation not only of the analysis but also, in general, of the interfaces based on action which tend to need be supported by the dialogue either face to face or though a computer.

In summary, the model proposed in order to be a useful tool for the design of applications that help teachers to facilitate the evaluation and monitoring of the collaborative learning process, must include the participation of the teacher during the collaborative learning process. It must also include a strategy that generates conflicts among members of the group and a mechanism to record every message sent by the members of the group.


12.1 Context: In order to understand the collaborative process, it is necessary to define, show and evaluate it.
12.2 Description: A cooperative learning process is typically composed of several tasks that must be developed by the cognitive mediator or facilitator, and by the group of learners, defining naturally two categories of tasks. In order to evaluate the cooperative learning process, we divide it into three phases according to its temporal execution: pre-process, in-process and post-process [Guerr00].

Table 14: Structure of Cooperative Learning Activity.

<table>
<thead>
<tr>
<th>Pre-process</th>
<th>In-Process</th>
<th>Post-Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design the contents</td>
<td>Application of strategies (positive interdependence of the goal, motivation between pairs, aid to learn)</td>
<td>Inspect success criteria</td>
</tr>
<tr>
<td>Specify the group sizes</td>
<td>Intra-group cooperation</td>
<td>Present the activity closure</td>
</tr>
<tr>
<td>Arrange the groups</td>
<td>Test the success criteria</td>
<td>Evaluate the quality of learning</td>
</tr>
<tr>
<td>Arrange the room</td>
<td>Monitoring</td>
<td></td>
</tr>
<tr>
<td>Distribute the material</td>
<td>Provide help (from facilitator and from peers)</td>
<td></td>
</tr>
<tr>
<td>Design the roles</td>
<td>Intervention in case of problems</td>
<td></td>
</tr>
<tr>
<td>Specify the game rules</td>
<td>Self-evaluation of the group</td>
<td></td>
</tr>
<tr>
<td>Define the success criteria</td>
<td>Feedback</td>
<td></td>
</tr>
<tr>
<td>Determine the desired behavior</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thus, pre-process tasks are mainly coordination and strategy definition activities and post-process tasks are mainly composed of evaluation activities. Both phases, pre-process and post-process, will be accomplished entirely by the facilitator. The group members will perform the tasks concerning the in-process phase, to a large extent. It is here where the interactions of cooperative work processes take place. Thus, our interest concentrates on the evaluation of this stage. In order to specify this division, we present
the structure of a cooperative learning activity identified by Johnson and Johnson in [John96].

Table 14 summarizes the activities and specifies the corresponding phases. These activities define the structure of any cooperative learning activity that takes place in small groups, and in synchronous learning scenarios (face to face, same time, same place). We are interested in the evaluation of the activities that correspond to the in-process phase.

In addition to these activities, Johnson and Johnson mention some social skills that develop when students participate in collaborative activities. These skills are: commitment, empathy and motivation, tension release and motivation, sustenance, tension release and the expression of feeling of the group.

The activities concerning the evaluating system are in the second stage: Process. It is necessary to describe mechanisms that enable us to determine the quality of the process carried out by a work group dealing with a collaborative activity.

12.3 Solution: a group of indicators has been defined that allow the evaluation, to some degree, of the collaborative process [Coll02c]. These indicators are the following:

- Applying Strategies: The first indicator tries to register the ability of the group members to generate, communicate and consistently apply a strategy to jointly solve the problem.

- Intra-group Cooperation: This indicator corresponds to the application of collaborative strategies previously defined during the process of group work.

- Success criteria review: This indicator measures the degree of involvement of the group members in reviewing boundaries, guidelines and roles during the group activity.
• Monitoring: This indicator is understood as a regulatory activity. The objective of this indicator is to oversee if the group maintains the chosen strategies to solve the problem, staying focused on the goals and the success criteria

• Performance: Measures the quality of the proposed solution in terms of Quality, Time and Work.

That is why it is necessary to provide as many elements and needed information as possible to enable the accurate evaluation of the collaborative process, based on the indicators mentioned above.

13. Name: Feedback

13.1 Context: In a collaborative learning environment the feedback that is given is essential for the success of a collaborative activity.

13.2 Description: Feedback allows one to identify the weak points of each group with intention to improve them. After analyzing the collaborative process, some of the most important weaknesses in a work group can be determined in order to improve them, establishing new mechanism that involve developing new collaborative activities that enable to focus specifically on the weakness in a group.

13.3 Solution: In a collaborative learning environment all the necessary means should be provided so that the people who evaluate can determine accurately how and when to intervene. Once the collaborative process analysis has been done, the environment should provide the information needed about the weak points of the group. Underlying nearly all-collaborative learning experiences is a distinctive set of assumptions about what teaching is what learning is, and what the nature of knowledge is. Perhaps the most pivotal of these is the assumption that knowledge is created through interaction, not transferred from teacher to student. Hence, it typically -and logically- follows that instructional activity must begin with students' current levels of background knowledge, experience, and understanding. It also follows that the teachers’s role is to create a
context in which learners can make the material their own through an active process of discovery [Bruf93].

Fig. 22: Monitoring and Evaluation for Collaborative Applications Pattern

Consequently, this model includes two aspects: the participation of the teacher during the collaborative learning process, and the inclusion of a strategy that generates conflicts among members of the group. Next, these aspects will be explained in detail. Figure 22 shows the model of the pattern.

The following section shows the description of a design pattern for the collaborative applications that allow us to carry out the evaluation and monitoring of the collaborative process.
One of the objectives stated in this thesis is to develop a collaborative framework that will support the evaluation and monitoring of the collaborative process. As Roberts et al. mention, frameworks should be implemented only when many applications are going to be developed within a specific problem domain, allowing the time savings of reuse to recoup the time invested to develop them [Robe96]. They describe a method for designing frameworks based on developing abstractions by generalizing from concrete examples. A framework is a reusable design, so it can be developed by looking at the things which it is supposed to be a design of. The more examples we can look at, the more general our framework will be.

The Fig. 23 describes the relationship between patterns in the pattern language. Our work is based on this model. We designed a language pattern after developing three
software tools (Chase the Cheese, MemoNet, ColorWay). The last one (TeamQuest) was implemented following the pattern described below.

Evolving Frameworks describes a common path that frameworks take, but it is not necessary to follow the path to the end to have a viable framework. In fact, most frameworks stop evolving before they reach the end. In some cases, this is because the frameworks die; they are not used any more and so it is not necessary any more to change them. In other cases, it is because it is better for the frameworks to stay more white-box [Robe96].

The framework includes 3 components: Evaluation, Results and Feedback. These elements are explained below.

### 7.1 Pattern 1 - Evaluation.

The evaluation of collaborative learning implies a number of organized actions with the intention of obtaining the information about the learning assimilated by the learners.

The problem and solution given for this pattern have been shown in section 6.1.2.11.

#### 7.1.1 Static Structure

The evaluating pattern is divided into three collaborative categories: View, collection, and log. The view shows parts of the objects (logs) stored in the collection. Collection stores the objects (logs) produced by the participant groups in the collaborative activities. Logs are the data produced by the group of users. Fig 24 shows a UML diagram with relations between the components of the pattern.
7.1.2 Dynamic Structure

The main scenario is to somehow create new logs and stores them in the same collection. In this scheme the collection should have been updated with the respective views. This can be seen in fig. 25.

Fig. 24: Class Diagram Evaluation Pattern

7.1.3 Implementation

A View defines the way in which data can be visualized. It features information in reference to the name and description of the view. In addition, it has a Type field indicating the style by which the information will be shown. It features methods to show the information and update it.
The Log corresponds to each of the objects that stores the information of the whole collaborative activity. A Collection defines the repository of the logs. It has a single field, a descriptor and it contains methods that allow the installation of a log in the collection, opening, closing, creating, erasing and modifying of a log.

Finally, the Log stores the information referring to the date when an activity is performed and identifier of the group that is performing it. It also has the following methods:

- **Put_D()**: put the date when an collaborative activity is performed
- **Put_G()**: put the identifier of the group performing this task.
- **M_sent()** has the number of messages sent by the group during collaborative activity.
• M_received( ): has the number of messages received by the group during collaborative activity.

• T_executed( ): has the number of tasks performed by the group during collaborative activity.

• Get_M( ): gives the number of messages communicated in all of the activity.

• Get_T( ): gives the number of tasks performed during collaborative activity.

It is worth mentioning that there are two kinds of Logs, those that store messages during the activity, and those that store tasks performed over the shared objects. Each of them needs to be differentiated. The former ones store information about the sender and recipient of the message, the sent or received text, the time when the message was sent and the position that the shared object had. Likewise, the Log of actions stores the information about the person who performs the action, the object in which event takes place and the location that the shared object had.

7.2 Pattern 2 - Process Outcomes

In order to understand the collaborative process, it is necessary to define it, to show it and evaluate it.

The problem and solution given for this pattern have been shown in section 6.1.2.12.

7.2.1 Static Structure

This pattern is of only one type: Process Outcome. This type of pattern stores the information about the scores obtained by the groups performing this collaborative activity based on the above-mentioned elements. Fig 26 shows a UML chart of this pattern.
7.2.2 Dynamic Structure

The chart of sequences to get the outcome will be shown. Fig 27 shows this process in detail.

7.2.3 Implementation

Outcome Results stores information about the quality of the process developed during the execution of a collaborative work. It records the date of the task and the identifier of the group. It has an Obtain-id method that gives back the value of some indicator given by a parameter that corresponds to the score given to the group performing the collaborative task under this indicator. Deliver allows the deliberation of every indicator in accordance to the number of messages and tasks performed.

This class has 5 kinds of indicators: Ind1: Applying strategies, Ind2: Intragrupal cooperation, Ind3: Success criteria review, Ind4: Monitoring and Ind5: Performance. Every indicator has its own mechanism to assign the score. This pattern uses the class
Log, where all the information about movements and actions is stored, in order to estimate the values of these indicators.

Fig.27: Sequence Diagram to obtain Process Outcomes.

It is important to define the metrics that allows a more accurate evaluation. These metrics may include the number of sent/received messages, time in performing the task, number of errors, etc.

7.3 Pattern 3 - Feedback

In a collaborative learning environment, feedback is an important element in order to obtain the success of a collaborative activity. Both the problem and solution have been explained in section 6.1.2.13.
7.3.1 Static Structure

This pattern is of only one type that can be seen in Fig 28, which shows the kind of tasks enabling to re-define the group of tasks in order to solve another collaborative situation focusing on the weakness found in the evaluation of the collaborative process.

Fig. 28: Class Diagram of Feedback Pattern

<table>
<thead>
<tr>
<th>Feedback</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value_1</td>
<td>Nature_Task</td>
</tr>
<tr>
<td>Description_Activity1</td>
<td>Interdependence</td>
</tr>
<tr>
<td>Value_2</td>
<td>Type</td>
</tr>
<tr>
<td>Description_Activity2</td>
<td>Collab_Conditions</td>
</tr>
<tr>
<td>Value_3</td>
<td>Define ()</td>
</tr>
<tr>
<td>Description_Activity3</td>
<td>Update ()</td>
</tr>
<tr>
<td>Value_4</td>
<td></td>
</tr>
<tr>
<td>Description_Activity4</td>
<td></td>
</tr>
<tr>
<td>Value_5</td>
<td></td>
</tr>
<tr>
<td>Description_Activity5</td>
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<tr>
<td>Get_Value (id)</td>
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<td>Get_Description (id)</td>
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7.3.2 Implementation

This pattern features only one kind: Feedback. It stores information about the value of each indicator and a description of the proposed activity in order to improve this aspect within a collaborative task. In addition, it features two methods that allow us to obtain the value of each indicator and the description of the proposed task. It is worth mentioning that the information obtained supplies information about some weaknesses of the evaluated group. And thus new tasks can be planned to help solve these troublesome aspect. This information is delivered at the end of the collaborative task. It is possible, as it was previously mentioned in the description of the facilitator, that an individual could be observing what the group is doing during the activity. That is why it is recommended that the application that is being used include mechanisms of monitoring that allow the facilitator to observe the activities the students are performing while they are solving a problem situation. The Tasks clearly specify and define the
activities, describing their Nature, Type, those responsible and the conditions of collaboration. Likewise, a new activity can be re-defined and an already existing one modified.
8. CONCLUSIONS

As mentioned before, the evaluation and monitoring of the collaboration process within collaborative learning, using computational tools, is an almost unexplored area. Hence, the contribution from our work is twice as significant. First of all, it is a theoretical technical contribution, establishing a computational model for the evaluation and monitoring of the collaboration process in academic environments. Second, its intention is to develop a set of computational tools to support and allow to some extent an improvement of the collaboration process within academic environments.

In this manner, the computational model that we expect to develop will provide better results in faculty and students activities. For the faculty, it will allow to define criteria to evaluate and monitor the collaboration process, providing prompt and accurate information to make decisions about how and when to intervene, and also to some extent, to be able to determine the degree of learning achieved by each participant at any stage of the collaboration activity. For the students, it will allow, among other things, to provide the necessary information to determine the degree of each participant/member’s collaboration and their level of knowledge.

The use of computational tools provides prompt information to the professor or student, so that they can make the correct decisions at the right time during which the collaboration activity is being performed. It is very difficult to monitor the work of several groups at the same time. However, if this work is performed with computational help, it will be easier to provide certain information, which will allow the professor to monitor all the groups during an activity of a collaboration type. In this way, the people involved will have more adequate mechanisms to make decisions and, therefore to intervene in a more appropriate way with the purpose of improving the collaborative activity.
In this study we present a proposal for the infrastructure development to support the development of collaborative environments for learning, which will allow evaluating and monitoring the collaboration process. The objective is to create a set of facilities, which allow the implementation of CSCL environments, which provide enough support to the monitoring and evaluation of the collaboration process. Our most important contribution is the inclusion of a new model which is related to the educational field, and especially with the evaluation and monitoring of the collaboration process in a group activity, whose infrastructure requirements will be based on a conceptual model expressed through a system of analysis and design patterns.

Given that the computational infrastructure that we pretend to develop is flexible, manageable, and specific to the construction of computational educational environments, which allow monitoring and evaluating the collaboration process, we estimate that it provides an answer to the lack of support for the development of CSCL development. Several tools (toolkits, middleware, frameworks), provide support to the development of generic platforms. However, very few concentrate on the educational aspect. In this way, the solution we suggest could contribute to the design of applications in the collaborative learning field supported by a computer.

Understanding group dynamics and the collaborative process of decision making and learning in-groups are both interesting research fields and the basis for new tools to support the findings. In the case of collaborative activities, performing a task well means not only having the skills to execute the task, but also collaborating well with teammates.

In this thesis some software tools have been presented which allow to make experiments on the subject of collaborative work. It is possible to gather information about them in order to evaluate the cooperation processes occurring in the group work. For their evaluation five cooperation indicators have been proposed. It is not claimed that these are the only or best indicators that could be developed for this purpose. These indicators
are not independent either; e.g., there is a relationship between the monitoring indicator and the maintenance of the strategy, and another one between intra-group cooperation and communication of the strategy. The important conclusion is that these five indicators have provided some insight into the collaborative work done by the groups. They can be used to detect group weaknesses in their collaborative learning process.

The analysis of the results suggests that the shared construction of a strategy to fulfill a group work –understood and adopted by every member of the group– is related to a successful process, to the individual construction of cognitive context, and to the experience shared by the group members. Also, it enhances the elaboration process of strategies and facilitates its application. This fact is reflected in the performed language utterances: these are homogeneous, direct and unambiguous when referred to the common problem features.

The studied groups were ineffective collaborative groups because they were weak in collaborative attitudes. Students have two responsibilities in cooperative learning situations, according to Johnson and Johnson: 1) learn the assigned material, and 2) ensure that all members of the group learn the assigned material [John78]. The second aspect is something that never occurred during the collaborative learning processes of our groups. Of course, nobody told the group members they should have a collaborative attitude. Many hypotheses can be developed to explain why these attitudes did not appear spontaneously: perhaps the students initially thought the game was very easy, or maybe they felt pressured to play instead of stopping to think carefully what to do, etc.

One could guess that a reduced number of work messages would imply a better coordination within the group and thus, one would find few coordination messages. This would occur because many messages would have an effect of cognitive overload, disturbances, etc. Our results support this relationship between the number of work messages and the number of coordination messages. However, again, well-coordinated groups are not necessarily collaborative groups.
It is also important to note that the personal style and individual behavior of every member of the group influence the cooperative work processes. In our groups, we can observe stability in the performance of the tasks accomplished by each of the group members, in both role types: coordinator and participant. This stability is also observed in the personal styles and communication styles.

Further work is needed to study the influence of many variables we did not isolate in this experimentation. Such variables may be genre (whether or not this factor has an effect on the results), age, culture, homogeneous vs. heterogeneous groups concerning the previous variables, etc. Other experiments could also be made changing the game. One of these changes may be to allow the broadcast messages, or allow the group to slightly modify the rules of the game (e.g., forcing the coordinator to receive all the messages from the members before enabling moves).

Finally, as reported before, one of the deficiencies found in the analysis of the interactions among group members of the previous experiment was participants’ inability to state, use and discussion of strategies. This was a key obstacle for effective and efficient collaborative work. This thesis also presents a similar experiment with a negotiation table and a monitoring window presenting initial evidence that groups using these widgets have a better performance.

Using monitoring mechanisms allows the teacher to guide the students about the development of strategic abilities to get a good collaboration process. The teacher’s role must be very clearly defined in these activities. A collaboration scenario must be defined; the teacher has to know when and how to intervene with the goal of improving the collaborative process. As Katz mentions, one of the main problems for a teacher in a collaborative environment is to determine when to intervene and what to say [Katz99]. It is clear that at least the following collaborative abilities should be stimulated: to give and to receive, to help, to receive feedback, to identify conflicts or disagreements.
One of the proposed hypotheses that claims that good use, definition and adoption of strategies should imply good collaboration has proved to be true in the final experiments. Further work is needed to definitely make a general conclusion applicable to Collaborative Learning. Meanwhile, the same type of stimuli and widgets could be developed for other collaborative scenarios.

The goals proposed were reached developing a set of indicators and a set of software tools that proved to be effective to monitor and evaluate the collaboration processes. Also, a system of patterns was elaborated that serves as a conceptual model to the development of a framework that supports the monitoring and evaluation of the collaboration process in a educational environment.
REFERENCES


[Delv96] DELVIN, K., & ROSEMBERG, D., Language at work: analyzing communication breakdown to inform system design. CSLI Lecture Notes, No.66, 1996.


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[Haba96] HABANERO: http://havefun.ncsa.uiuc.edu/habanero/


[Syne03] SYNERGEIA, http://bscl.gmd.de/


APPENDIX 1: COOPERATIVE LEARNING TECHNIQUES

1. STUDENT TEAM LEARNING

Student Team Learning (STL) is a set of instructional techniques based on years of research on cooperative learning at the Johns Hopkins University. The basic idea behind the Student Team Learning techniques is that when students learn in small, carefully structured learning teams and are rewarded based on the progress made by all team members, they help one another learn, gain in achievement and self-esteem, and increase in respect and liking for their classmates, including their mainstreamed classmates and classmates of other ethnic groups.

There are many forms of cooperative learning now in use. The most extensively evaluated of these are Student Team Learning methods developed and researched at Johns Hopkins University. Student Team Learning methods have been included by the National Diffusion Network in their Educational Programs That Work. These processes offer strategies for inclusion, improved academic achievement in standardized testing, and emphasize cross-curricular connections. All Student Team Learning methods have been compared to traditional methods in more than 55 studies of high methodological quality lasting from six weeks to more than two years, and have been found to produce the following outcomes:

- Enhanced academic achievement for high, average, and low achievers
- Improved race relations and other social relationships.
- Greater acceptance of mainstreamed students.
- Improved self-esteem.
- Better attitudes toward the subject and toward school in general.
- Improved time-on-task.

1.1 Student Team-Achievement Divisions (STAD)

STAD is the simplest and most widely applicable of the Student Team Learning methods. It can be used in grades 2-12 in every subject. In STAD, the teacher follows a cycle of teaching, teamwork, and individual assessment. Teams earn certificates or other
forms of recognition based on the degree to which all team members have improved over their past performances [Slav90].

1.2 Teams-Games-Tournaments (TGT)

Like STAD, TGT is applicable to all subjects in grades 2-12. In TGT, the same cycle of activities is used as in STAD, except that instead of taking individual assessments, students compete in academic tournaments with members of other teams to add to their team scores. The excitement of the academic games adds to the team emphasis of STAD, and the two programs are often combined. It includes 5 steps:

- The teacher presents a lesson via lecture, a textbook, etc.
- Heterogeneous teams of four or five students study together in preparation for individual taking a quiz on the material presented by the teacher.
- Students leave their teams and go to tournament table.
- At the tournament tables, students take turns reading aloud and trying to answer the questions on the cards. The correct answer is on the back of the card.
- Students return to their teams and calculate the average number of each person earned.

1.3 Team Accelerated Instruction (TAI)

TAI is a comprehensive approach to cooperative learning in mathematics, grades 3-6. TAI combines cooperative learning with individualization, to allow teachers of heterogeneous math classes to bring low achievers quickly up to grade level and to provide acceleration beyond the usual curriculum for high achievers. TAI materials completely replace traditional textbooks with special materials designed specifically for the program. In TAI, students are assigned to heterogeneous teams in which they help one another learn. The teacher presents lessons that emphasize concepts, real life problems to teaching groups composed of students from different teams who are at the same point in the curriculum. Students return to their teams and work on individual materials, which follow up the teacher's lessons.

1.4 Cooperative Integrated Reading and Composition (CIRC)
Unlike STAD, TGT, and Jigsaw II, which are "generic" methods adaptable to any subject and grade level, CIRC is a comprehensive approach to instruction in reading, composition, and spelling for grades 2-6. In CIRC Reading [Slav91], students are taught in reading groups and then return to mixed ability teams to work on a series of cooperative activities, including partner reading, making predictions, identification of characters, settings, problems and problem solutions, summarization, vocabulary, spelling, reading comprehension exercises, and story-related writing.

CIRC Reading materials have been developed to supplement most widely used basal series and novels. These materials replace workbooks and other supplementary materials.

CIRC Writing/Language Arts is a comprehensive approach to writing and language arts based on a writing process model, with the same teams used in CIRC Reading serving as peer response groups. Students work together to plan, draft, revise, edit, and ultimately "publish" compositions. Teachers present mini-lessons on style, content, and mechanics of writing, which are integrated with student writing. CIRC Writing/Language Arts provides a structure to help teachers and students succeed in helping all students become effective authors. CIRC Reading and CIRC Writing/Language Arts are usually used together, but can be used as separate reading and writing/language arts programs.

2. Jigsaw Teaching (JT)

Elliot Aronson and his students at the University of Texas and the University of California first developed the jigsaw technique in the early 1970s. The jigsaw classroom is a specific cooperative learning technique with a three-decade track record of success. Just as in a jigsaw puzzle, each piece--each student's part--is essential for the completion and full understanding of the final product. If each student's part is essential, then each student is essential; and that is precisely what makes this strategy so effective.

- Divide students into 5- or 6-person jigsaw groups. The groups should be diverse in terms of gender, ethnicity, race, and ability.
- Appoint one student from each group as the leader. Initially, this person should be the maturest student in the group.
- Divide the day's lesson into 5-6 segments. For example, if you want history students to learn about Eleanor Roosevelt, you might divide a short biography of her into stand-alone segments on: (1) Her childhood, (2) Her family life with Franklin and their children, (3) Her life after Franklin contracted polio, (4) Her work in the White House as First Lady, and (5) Her life and work after Franklin's death.
• Assign each student to learn one segment, making sure students have direct access only to their own segment.

• Give students time to read over their segment at least twice and become familiar with it. There is no need for them to memorize it.

• Form temporary "expert groups" by having one student from each jigsaw group join other students assigned to the same segment. Give students in these expert groups time to discuss the main points of their segment and to rehearse the presentations they will make to their jigsaw group.

• Bring the students back into their jigsaw groups.

• Ask each student to present her or his segment to the group. Encourage others in the group to ask questions for clarification.

• Float from group to group, observing the process. If any group is having trouble (e.g., a member is dominating or disruptive), make an appropriate intervention. Eventually, it's best for the group leader to handle this task. Leaders can be trained by whispering an instruction on how to intervene, until the leader gets the hang of it.

• At the end of the session, give a quiz on the material so that students quickly come to realize that these sessions are not just fun and games but really count.

Jigsaw II, is a modification of the jigsaw method that includes two important changes. First, all team members read the entire lesson to be learned rather than only one part. Second, individual improvement scores combine to contribute to an overall team score. The rest is the same [Aron78].

3. Group Investigation (GI)

Shlomo Sharan developed a method known as group investigation, which combines independent, pair and group work and offers a group reward for individual achievement [Shar94]. The teacher sets the problem for the class, but students choose what they want to study in order to explore an issue. The work is divided among the members of the group, who work individually, but the integration, summary and presentation of findings are a group decision. It is a kind of advanced cooperative learning with the teacher’s role being that of facilitating investigation and helping to maintain cooperative norms in the classroom. Group members cooperate to set learning goals, and they cooperate in planning how to find the means of reaching those goals. Finally, they collaborate with the teacher to evaluate their effort. Sharam points out that this is the way problems are solved in communities in the real world.
4. Structural Approach

Kagan developed a set of simple ways that help teachers to structure the interaction of students [Kaga90]. Kagan’s structures not only led to greater cooperativeness, but led also to greater academic achievement, improved ethnic relations, enhanced self-esteem, harmonious classroom climate, and a range of social skills. Next there is a brief description of the most important ones:

4.1 RoundRobin: Students share their individual art projects, working in-groups of four. One at a time, moving around the group in a clockwise direction, each student stands, shows the art project to the group, and explains its significance in relation to the book he or she has read. The person to the speaker’s right asks a question or makes a comment.

4.2 Corners: Teacher announces a topic and gives students a choice of four alternatives. Students then form groups in the Four Corners of the room and share reasons for their choice with a partner in their corner. Students realize they can be accepted while making choices that are different from their classmates.

4.3 Match Mine: Students attempt to match the arrangement of objects on a grid of another student using oral communication only.

4.4 Numbered Heads Together: The teacher has students number off within groups (1,2,3 and 4). The teacher asks a high consensus question. The students put their heads together to make sure everyone on the team knows the answer. The teacher calls on a number (1,2,3 or 4) and only the student with the number can raise his/her hand to respond.

4.5 Pairs Check: The class divides into groups of four, and each group then subdivides into pairs. One member of each pair develops and writes down solutions for the first problem on the list, thinking aloud as he or she does it (1). The other member of the pair listen and watches, and then provides feedback on the other person’ solutions and the explanations behind them (2). The observer praises the writer for good ideas, and the thinking behind them (3). Next, the two members of each pair reverse roles for the second problem. When both pairs have completed the first two problems, they check their answers with each other (4). If they agree that each pair has developed sensible solutions with valid explanations (there may not be one correct answer), they give each other their special group handshake and then go back on (3) and (4) in the same manner. If one pair finishes early, they can practice the collaborative skills of waiting patiently, while the other pair practice the skill of trying not to keep others waiting.

4.6 Three-Step Interview: Person A interviews Person B; Person C interviews Person D. When finished, they switch roles: Person B interviews Person A; Person D interviews Person C. Time limit: 8 minutes.
4.7 Think-Pair-Share: In this didactic technique, people first work individually thinking alone without writing. Next they discuss their ideas with the other member of their pair. Finally, students share their ideas with the rest of the class.

4.8 RoundTable: Each person takes a sheet of paper and writes the title of the task at the top. Each person writes one idea for the question and passes their paper to the person on the right. The paper circulates around the entire group at least once. Each time a person receives the paper, they should write a different task. Whole class discussion should follow.

4.9 Inside-Ouside Circle: Half the pairs form the inside circle facing outward. The other pairs form the outside circle facing the first circle facing in toward the people in the inside circle. Each person in the outside circle should be facing one person in the inside circle. They can be standing up or sitting down. People in the outside circle exchange ideas with the person facing them in the inside circle. Then, those in the outside circle rotate to face a different person in the inside circle.

4.10 Cooperative Controversy: People change positions during cooperative controversy. They start the debate assigned to one position (pro or con) and later are assigned to the other position. In other words, if they were initially assigned to the pro position, they will later be assigned to speak in favor of the con position. At the end of the debate, they speak in favor of their own opinion: pro, con a combination of two, or a completely different view. Participants in cooperative controversy try to reach a consensus at the end of the debate. It is not a requirement of the procedure that they actually do reach a consensus in their group, just that they try.

4.11 Folded Value Lines: Each person draws a line on a piece of paper and puts the two options at each end. Then, they put a mark at the point along the line where they feel their own opinion on cooperative learning lies. They should consider a particular context when doing this. In other words, they might have one view if they were teaching a particular group of students or were at a particular school, but another approach if they were teaching a different group of students or were at a different school. Course members stand up and form a Value Line like the one it drew and each stands in the place along the line according to her/his opinion. The do Split Value Lines, the line is divided in half. The people in the left half stay in the order in which they are standing and walk in a straight line until they each are facing one person in the right half. The two people facing each other discuss for their opinion on the issue.

5. Informal Cooperative Learning Groups

This technique can be used to accompany lectures, videos, demonstrations, or any other time when students need to listen to information being presented. By having students interact with one another before, during, and after the presentation, the technique may help foster understanding, interest and retention. Before the presentation begins, students
discuss, in pairs, a question related to the topic of presentation. This serves as an advance organizer, helping students to bring out their knowledge, opinions, experiences, and/or questions related to the topic. Whole class discussion can follow, with students called on randomly to share the discussion that took place in their pair.

The first part of the presentation is given, normally this should not be longer than 10 or 15 minutes. The same pairs discuss their understanding of, opinions about, experiences related to, and/or questions on what have just been presented. Alternatively, the teacher can ask a question or provide a brief task for the pairs to work on. To foster equal participation, each member of the pair can have a minute to think alone before discussing with their partner. When the presentation has concluded, pairs can work together to create a summary, perform a task, raise questions, and discuss actions they can take based on their reaction to the presentation, or to highlight key points they have learned.

Cooperative learning provides many benefits. Over the past few years, as new methods and strategies have been developed, cooperative group work has become a regular tool for learning in classrooms everywhere. In addition to improved social skills, other benefits include language development and critical thinking. Also, cooperative learning, allows systematic equal status interaction among students of varied linguistic and cultural background. All of those benefits are important in today’s crowded multicultural classroom.
APPENDIX 2: LEARNING THEORIES

1. Operant Conditioning

This theory is based upon the idea that learning is a function of change in overt behavior [Skni53]. Changes in behavior are the result of an individual's response to events (stimuli) that occur in the environment. A response produces a consequence such as defining a word, hitting a ball, or solving a math problem. When a particular Stimulus-Response (S-R) pattern is reinforced (rewarded), the individual is conditioned to respond. The distinctive characteristic of operant conditioning relative to previous forms of behaviorism is that the organism can emit responses instead of only eliciting response due to an external stimulus.

Reinforcement is the key element in Skinner's S-R theory. A reinforce is anything that strengthens the desired response. It could be verbal praise, a good grade or a feeling of increased accomplishment or satisfaction. The theory also covers negative reinforces -- any stimulus that results in the increased frequency of a response when it is withdrawn (different from adverse stimuli -- punishment -- which result in reduced responses). A great deal of attention was given to schedules of reinforcement (e.g. interval versus ratio) and their effects on establishing and maintaining behavior.

One of the distinctive aspects of Skinner's theory is that it attempted to provide behavioral explanations for a broad range of cognitive phenomena. For example, Skinner explained drive (motivation) in terms of deprivation and reinforcement schedules. Skinner tried to account for verbal learning and language within the operant conditioning paradigm, although this effort was strongly rejected by linguists and psycholinguists [Skin57]. Skinner deals with the issue of free will and social control [Skin71].

Operant conditioning has been widely applied in clinical settings (i.e., behavior modification) as well as teaching (i.e., classroom management) and instructional development (e.g., programmed instruction). Parenthetically, it should be noted that Skinner rejected the idea of theories of learning. By way of example, consider the implications of reinforcement theory as applied to the development of programmed instruction [Mark69].

1. Practice should take the form of question (stimulus) - answer (response) frames, which expose the student to the subject in gradual steps.

2. Require that the learner make a response for every frame and receive immediate feedback.

3. Try to arrange the difficulty of the questions so the response is always correct and hence a positive reinforcement.
4. Ensure that good performance in the lesson is paired with secondary reinforcers such as verbal praise, prizes and good grades.

The principles of this theory can be summarized as:

1. Behavior that is positively reinforced will reoccur; intermittent reinforcement is particularly effective
2. Information should be presented in small amounts so that responses can be reinforced ("shaping")
3. Reinforcements will generalize across similar stimuli ("stimulus generalization") producing secondary conditioning

2. Constructivism

Constructivism has roots in philosophy, psychology, sociology, and education. But while it is important for educators to understand constructivism, it is equally important to understand the implications this view of learning has for teaching and teacher professional development.

Constructivism's central idea is that human learning is constructed, that learners build new knowledge upon the foundation of previous learning. This view of learning sharply contrasts with one in which learning is the passive transmission of information from one individual to another, a view in which reception, not construction, is key.

Two important notions orbit around the simple idea of constructed knowledge. The first is that learners construct new understandings using what they already know. There is no tabula rasa on which new knowledge is etched. Rather, learners come to learning situations with knowledge gained from previous experience and those prior knowledge influences what new or modified knowledge they will construct from new learning experiences.

The second notion is that learning is active rather than passive. Learners confront their understanding in light of what they encounter in the new learning situation. If what learners encounter is inconsistent with their current understanding their understanding can change to accommodate new experience. Learners remain active throughout this process: they apply current understandings, note relevant elements in new learning experiences, judge the consistency of prior and emerging knowledge, and based on that judgment, they can modify knowledge.

Constructivism has important implications for teaching. First, teaching cannot be viewed as the transmission of knowledge from enlightened to unenlightened; constructivist teachers do not take the role of the "sage on the stage." Rather, teachers act as "guides on
the side" who provide students with opportunities to test the adequacy of their current understandings.

Second, if learning is based on prior knowledge, then teachers must note that knowledge and provide learning environments that exploit inconsistencies between learners' current understandings and the new experiences before them. This challenges teachers, for they cannot assume that all children understand something in the same way. Further, children may need different experiences to advance to different levels of understanding.

Third, if students must apply their current understandings in new situations in order to build new knowledge, then teachers must engage students in learning, bringing students' current understandings to the forefront. Teachers can ensure that learning experiences incorporate problems that are important to students, not those that are primarily important to teachers and the educational system. Teachers can also encourage group interaction, where the interplay among participants helps individual students become explicit about their own understanding by comparing it to that of their peers.

Fourth, if new knowledge is actively built, then time is needed to build it. Ample time facilitates student reflection about new experiences, how those experiences line up against current understandings, and how a different understanding might provide students with an improved (not "correct") view of the world.

If learning is a constructive process, and instruction must be designed to provide opportunities for such construction, then what professional development practices can bring teachers to teach in student-centered ways?

First recognize that construction in learning is not just the domain of children but of learners, all learners. Constructivist professional development give teachers time to make explicit their understandings of learning (e.g., is it a constructive process?), of teaching (e.g., is a teacher an orator or a facilitator, and what is the teacher's understanding of content?), and of professional development (e.g., is a teacher's own learning best approached through a constructivist orientation?). Furthermore, such professional development provides opportunities for teachers to test their understandings and build new ones. Training that affects student-centered teaching cannot come in one-day workshops. Systematic, long-term development that allows practice - and reflection on that practice - is required.

It is also useful to remember the educator’s maxim, Teachers teach as they are taught, not as they are told to teach. Thus, trainers in constructivist professional development sessions model learning activities that teachers can apply in their own classrooms. It is not enough for trainers to describe new ways of teaching and expect teachers to translate from talk to action; it is more effective to engage teachers in activities that will lead to new actions in classrooms.
Constructivism represents one of the big ideas in education. Its implications for how teachers teach and learn to teach are enormous. If our efforts in reforming education for all students are to succeed, then we must focus on students. To date, a focus on student-centered learning may well be the most important contribution of constructivism.

There are, however, two major strands of the constructivist perspective. These two strands, cognitive constructivism and social constructivism, are different in emphasis, but they also share many common perspectives about teaching and learning. Before looking at the differences between cognitive and social constructivists, it might be worthwhile to look at what they have in common. Jonassen's (1994) description of the general characteristics of constructivist learning environments is a succinct summary of the constructivist perspective.

Jonassen proposed that there are eight characteristics that differentiate constructivist learning environments [Jona94]:

1. Constructivist learning environments provide multiple representations of reality.
2. Multiple representations avoid oversimplification and represent the complexity of the real world.
3. Constructivist learning environments emphasize knowledge construction instead of knowledge reproduction.
5. Constructivist learning environments provide learning environments such as real-world settings or case-based learning instead of predetermined sequences of instruction.
7. Constructivist learning environments "enable context- and content- dependent knowledge construction."
8. Constructivist learning environments support "collaborative construction of knowledge through social negotiation, not competition among learners for recognition."

Jonassen's eight characteristics would be supported by both social and cognitive constructivists. There is, however, a difference in the emphasis these two strands on constructivism place on each of those characteristics.

2.1 Cognitive Constructivism

Cognitive constructivism is based on the work of Swiss developmental psychologist Jean Piaget [Piag26]. Piaget’s theory has two major parts: an "ages and stages"
component that predicts what children can and cannot understand at different ages, and a theory of development that describes how children develop cognitive abilities. It is the theory of development that will be the focus here because it is the major foundation for cognitive constructivist approaches to teaching and learning.

Piaget’s theory of cognitive development proposes that humans cannot be "given" information, which they immediately understand and use. Instead, humans must "construct" their own knowledge. They build their knowledge through experience. Experiences enable them to create schemas mental models in their heads. These schemas are changed, enlarged, and made more sophisticated through two complimentary processes: assimilation and accommodation. There are thousands of books, articles, and papers on the theories of Piaget and the implications of those theories for teaching and learning. One important generalization of Piagetian theory is role of the teacher. In a Piagetian classroom an important teacher role is to provide a rich environment for the spontaneous exploration of the child. A classroom filled with interesting things to explore encourages students to become active constructors of their own knowledge (their own schemas) through experiences that encourage assimilation and accommodation.

There are two key Piagetian principles for teaching and learning:

- **Learning is an active process**: Direct experience, making errors, and looking for solutions are vital for the assimilation and accommodation of information. How information is presented is important. When information is introduced as an aid to problem solving, it functions as a tool rather than an isolated arbitrary fact.

- **Learning should be whole, authentic, and "real"**: Piaget helps us to understand that meaning is constructed as children interact in meaningful ways with the world around them. Thus, that means less emphasis on isolated "skill" exercises that try to teach something like long division or end of sentence punctuation. Students still learn these things in Piagetian classrooms, but they are more likely to learn them if they are engaged in meaningful activities (such as operating a class "store" or "bank" or writing and editing a class newspaper).

Whole activities, as opposed to isolated skill exercises, authentic activities which are inherently interesting and meaningful to the student, and real activities that result in something other than a grade on a test or a "Great, you did well" from the computer lesson software, are emphasized in Piagetian classrooms. Within the field of educational computing, the best-known cognitive constructivist theoretician is Papert [Pape93], who characterizes behavioral approaches as "clean" teaching whereas Constructivist approaches are "dirty" teaching. The contrast emphasizes the differences between approaches that isolate and break down knowledge to be learned (clean) versus approaches that are holistic and authentic (dirty).

In a Piagetian classroom, students must be given opportunities to construct knowledge through their own experiences. They cannot be "told" by the teacher. There is less
emphasis on directly teaching specific skills and more emphasis on learning in a meaningful context. Technology, particularly multimedia, offers a vast array of such opportunities. With technology support such as videodisks and CD-ROMs, teachers can provide a learning environment that helps expand the conceptual and experiential background of the reader. Although much of the educational software created in the 1970s and 1980s was based on behavioral principles, much of the new multimedia educational software is based on constructivist theories. Technology provides essential tools with which to accomplish the goals of a constructivist classroom.

2.2 Social Constructivism

Another cognitive psychologist, Lev Vygotsky [Vigo78] shared many Piaget’s assumptions about how children learn, but he placed more emphasis on the social context of learning. Piaget’s cognitive theories have been used as the foundation for discovery learning models in which the teacher plays a limited role. In Vygotsky’s theories both teachers and older or more experienced children play very important roles in learning.

There is a great deal of overlap between cognitive constructivism and Vygotsky's social constructivist theory. However, Vygotsky’s constructivist theory, which is often called social constructivism, has much more room for an active, involved teacher. For Vygotsky the culture gives the child the cognitive tools needed for development. The type and quality of those tools determines, to a much greater extent than they do in Piaget's theory, the pattern and rate of development. Adults such as parents and teachers are conduits for the tools of the culture, including language. The tools the culture provides a child include cultural history, social context, and language. Today they also include electronic forms of information access.

Although Vygotsky died at the age of 38 in 1934, most of his publications did not appear in English until after 1960. There are, however, a growing number of applications of social constructivism in the area of educational technology.

It is called Vygotsky's brand of constructivism social constructivism because he emphasized the critical importance of culture and the importance of the social context for cognitive development. Vygotsky's the zone of proximal development is probably his best-known concept. It argues that students can, with help from adults or children who are more advanced, master concepts and ideas that they cannot understand on their own.
There are thousands of books, articles, and papers on the theories of Vygotsky and the implications of those theories for teaching and learning. If Vygotsky is correct and children develop in social or group settings, the use of technology to connect rather than separate students from one another would be very appropriate use.

A constructivist teacher creates a context for learning in which students can become engaged in interesting activities that encourages and facilitates learning. The teacher does not simply stand by, however, and watch children explore and discover. Instead, the teacher may often guide students as they approach problems, may encourage them to work in groups to think about issues and questions, and support them with encouragement and advice as they tackle problems, adventures, and challenges that are rooted in real life situations that are both interesting to the students and satisfying in terms of the result of their work. Teachers thus facilitate cognitive growth and learning as do peers and other members of the child's community.

All classrooms in which instructional strategies compatible with Vygotsky's social constructivist approach are used do not necessarily look alike. The activities and the format can vary considerably. However, four principles are applied in any Vygotskian classroom.

1. Learning and development is a social, collaborative activity.
2. The Zone of Proximal Development can serve as a guide for curricular and lesson planning.
3. School learning should occur in a meaningful context and not be separated from learning and knowledge children develop in the "real world".
4. Out-of-school experiences should be related to the child's school experience.

Technology provides essential tools with which to accomplish the goals of a social constructivist classroom. Below are a few examples of the way information technology can support social constructivist teaching and learning:

- Telecommunications tools such as e-mail and the Internet provide a means for dialogue, discussion, and debate -- interactivity that leads to the social construction of meaning. Students can talk with other students, teachers, and professionals in communities far from their classroom. Telecommunications tools can also provide students access to many different types of information resources that help them understand both their culture and the culture of others.

- Networked writing programs provides a unique platform for collaborative writing. Students can write for real audiences who respond instantly and who participate in a collective writing activity.

- Simulations can make learning meaningful by situating something to be learned in the context of a "real world" activity such as running a nuclear power plant, writing...
up "breaking" stories for a newspaper, or dealing with the pollution problems of local waterways.

3. Situated Learning

Lave argues that learning as it normally occurs is a function of the activity, context and culture in which it occurs (i.e. it is situated) [Lave90]. This contrasts with traditional classroom learning activities, which involve knowledge, which is often presented in an abstract form and out of context. Social interaction is a critical component of situated learning--learners become involved in a "community of practice" which embodies certain beliefs and behaviors to be acquired. As the beginner or newcomer moves from the periphery of this community to its center, they become more active and engaged within the culture and hence assume the role of expert or "old-timer".

Furthermore, situated learning is usually unintentional (incidental) rather than deliberates. These ideas are what Lave et al. [Lave90] call the process of "legitimate peripheral participation". Other researchers have further developed the theory of situated learning. Brown et al. [Brown89] emphasize the idea of cognitive apprenticeship: cognitive apprenticeship supports learning in a domain by enabling students to acquire, develop and use cognitive tools in authentic domain activity. Learning, both outside and inside school, advances through collaborative social interaction and the social construction of knowledge.

Brown et al., also emphasize the need for a new epistemology for learning --one that emphasizes active perception over concepts and representations. Situated learning has antecedents in the work of Vygotsky (social learning). Some theorists strongly advocate the design of learning environments in schools that are centered on the concept of cognitive apprenticeship.

Situated learning is a general theory of knowledge acquisition. It has been applied in the context of technology-based learning activities that focus on problem-solving skills. The principles can be summarized as:

- Knowledge needs to be presented and learned in an authentic context, i.e. settings and applications that would normally involve that knowledge.
- Learning requires social interaction and collaboration.

4. Information Processing Theory
George A. Miller has provided two theoretical ideas that are fundamental to the information processing framework and cognitive psychology more generally. The first concept is 'chunking' and the capacity of short term (working) memory. Miller [Mill56] presented the idea that short-term memory could only hold 5-9 chunks of information (seven plus or minus two) where a chunk is any meaningful unit. A chunk could refer to digits, words, chess positions, or people's faces. The concept of chunking and the limited capacity of short-term memory became a basic element of all subsequent theories of memory.

The second concept, that of information processing, uses the computer as a model for human learning. Like the computer, the human mind takes in information, performs operations on it to change its form and content, stores and locates it and generates responses to it. Thus, processing involves gathering and representing information, or encoding; holding information or retention; and getting at the information when needed, or retrieval. Information processing theorists approach learning primarily through a study of memory.

Information processing theory has become a general theory of human cognition; the phenomenon of chunking has been generally verified for all levels of cognitive processing. Of late, cognitive psychologists have begun to consider how the limitations of working memory are not usually taken into account in designing computer assisted instruction, and they have begun to design cognitively robust instructional software that enhances the learning process using Computer Assisted Learning materials. The classic example of chunks is the ability to remember long sequences of binary numbers because they can be encoded into decimal form. For example, the sequence 10100 01001 11001 101 1010 could easily be remembered as 20 9 25 5 10. Of course, this would only work for someone who can convert binary to decimal numbers (i.e. the chunks are 'meaningful').

5. Experiential Learning

Rogers [Roge69] distinguished two types of learning: cognitive (meaningless) and experiential (significant). The former corresponds to academic knowledge such as learning vocabulary or multiplication tables and the latter refers to applied knowledge such as learning about engines in order to repair a car. The key to the distinction is that experiential learning addresses the needs and wants of the learner. Rogers lists these qualities of experiential learning:

- personal involvement;
- learner-initiated;
- evaluated by learner; and,
- pervasive effects on learner.
To Rogers, experiential learning is equivalent to personal change and growth. Rogers feels that all human beings have a natural propensity to learn; the role of the teacher is to facilitate such learning. This includes

- setting a positive climate for learning;
- clarifying the purposes of the learner(s);
- organizing and making available learning resources;
- balancing intellectual and emotional components of learning; and,
- sharing feelings and thoughts with learners but not dominating.

According to Rogers, learning is facilitated when:

- the student participates completely in the learning process and has control over its nature and direction
- it is primarily based upon direct confrontation with practical, social, personal or research problems; and
- self-evaluation is the principal method of assessing progress or success

Rogers also emphasizes the importance of learning to learn and an openness to change.

6. Multiple Intelligence Theories

Multiple Intelligences theory is a pluralist way of understanding the intellect. Recent advances in cognitive science, developmental psychology and neuroscience suggest that each person's level of intelligence, as it has been traditionally considered, is actually made up of autonomous faculties that can work individually or in concert with other faculties. Howard Gardner [Gard93] has identified seven such faculties, which he labels as “intelligences”:

- Musical Intelligence
- Bodily-Kinesthetic Intelligence
- Logical-Mathematical Intelligence
- Linguistic Intelligence
- Spatial Intelligence
- Interpersonal Intelligence
• Intrapersonal Intelligence

Verbal/Linguistic--deals with abilities in the complex acquisition, formation and processing of language. Thinking symbolically and reasoning abstractly fall under this category, as does the ability to create conceptual verbal patterns. Reading, writing, the development of symbolic writing and language skills--anagrams, palindromes, metaphors, similes, puns, and analogies come under this heading. Children who talk early, those who enjoy making sounds and rhyming patterns; children who are prolific readers and have good memories for poetry, lyrics, tongue twisters, and verse may have a propensity in this area. These individuals love words, both spoken and written, and often think in words. They learn by verbalization, by seeing and hearing words and usually enjoy word games.

Logical/mathematical--deals with the ability to think logically; inductively, and to some degree deductively; categorically; to recognize patterns, both geometric and numerical; as well as the ability to see and work with abstract concepts. Children who possess this form of developed intelligence may be constant questioners; they may easily grasp games that involve sophisticated strategies--like chess; or they may devise experimental formats to test their ideas. Also, they may be fascinated with computers or with puzzles that involving logic and reasoning abilities.

Spatial Intelligence--deals with the ability to perceive images. These children think in images and are usually the ones able to find missing objects due to their tremendous powers of visual recall. They may be the first to notice things that have been changed or rearranged. Many are earlier drawers--delighted with shapes, lines and colors. These folks are attracted to jigsaw puzzles, mazes, and find the hidden picture puzzles and they love to construct things with blocks. They have an early sense of proportion and perspective. They are also good at reading and constructing maps and discerning objects as they might appear in three-dimensional space. They are often referred to as daydreamers--starring off into space.

Musical--obviously deals with the ability to create or interpret music. These children may need music while they study, and they are continually humming, singing, tapping out tunes rhythmically, or whistling. They have keen ears for distinguishing sounds and subtle nuances in music and in the sounds in their environments. These children can also be excellent mimics and can easily discern differences in speech patterns or accents.

Bodily/Kinesthetic--deals with the gift of physical movement, that of both the fine and/or the large muscle systems. These children are the movers of the universe, and frequently they squirm, rock, and even fall off their chairs when required to sit still for extended periods of time. These children are adept at creating and interpreting gestures and are often attuned at communicating in, or reading others body language. They may even have a need to enter the personal space of others or to touch them while communicating. This group of students needs to learn by acting and moving, to learn by haptic experiences.
Interpersonal--deals with the ability to understand and communicate with others and to facilitate relationships and group processes. The phrase "they can work the room " aptly describes their uncanny abilities to read people. Often these children are highly empathetic, and they can arbitrate differences between people or groups. They can easily pick up on the vibrations, the feelings of others. These children enjoy cooperative learning experiences and learn best in cooperative settings.

Intrapersonal--deals with the ability to be somewhat insulated from ones peers; to have a strong sense of self; to have leadership abilities in reference to making decisions that may not be popular with others. This strong sense of self creates a certain amount of immunity from peer pressure. These children may be what are described as "loners". They may have gifts out the ordinary realm of human understanding--strong intuitive feelings, a sense of inner wisdom, or precognition. These children need learning experiences where they can focus on their inner being and activities that allow them to work by themselves on material and projects of their own choosing.

This view stands in stark contrast to the traditional view of intelligence, which is often discussed in terms of a person's ability to solve problems, utilize logic, and think critically. A person's intelligence, traditionally speaking, is contained in his or her general intellect--in other words, how each and every one of us comprehend, examine, and respond to outside stimuli, whether it be to solve a math problem correctly or to anticipate an opponent's next move in a game of tennis.

Howard Gardner’s work adds new depth to understanding the multifaceted and varied dimensions of human intelligence. Under the umbrella of Gardner’s definitions, American schools seemingly have few problems meeting the needs of students who have verbal/linguistic or logical/mathematical intelligences. Even in special programs that are designed for "gifted" students, many of Gardner’s intelligences are not recognized or acknowledged as important or valued gifts. As a result of this ancient, and very Western, cultural mindset, some children are elevated while others are must go wanting. And although physical giftedness appeared in the initial definitions concerning federal mandates governing gifted education, during the 70's that form of giftedness was removed from successive definitions. This was done reportedly because schools meet the need of physically gifted children through expensive sports programs. While that is undoubtedly true for those students displaying physical traits compatible with the narrow needs of established sports, it is not true that all kinesthetically/bodily gifted students are served by schools' athletic programs. Students having kinesthetic gifts in areas such as dance, mime, gymnastics, small muscle kinesthetic proficiencies, performance arts, table tennis and so forth, are virtually ignored by school programs.
APPENDIX 3: LOG FILES

Message Log Files
05/02/2003 07:23:30 De Daniel a Luna. Mensaje:

05/02/2003 07:23:58 De Isenhart a todos los jugadores. Mensaje: Luna ha solicitado tiempo fuera... El tiempo se detendrá por 3 minutos.

05/02/2003 07:24:08 De Isenhart a todos los jugadores. Mensaje: Daniel ha solicitado tiempo fuera... El tiempo se detendrá por 3 minutos.

05/02/2003 07:24:22 De Pooh a Luna. Mensaje: Auxilio!

05/02/2003 07:24:29 De Pooh a Luna. Mensaje: Auxilio!

05/02/2003 07:24:34 De Pooh a Luna. Mensaje: Socorro!

05/02/2003 07:24:40 De Pooh a Luna. Mensaje:

05/02/2003 07:25:03 De Isenhart a todos los jugadores. Mensaje: Pooh ha solicitado tiempo fuera... El tiempo se detendrá por 3 minutos.

05/02/2003 07:25:13 De Pooh a Daniel. Mensaje: Auxilio!

05/02/2003 07:25:14 De Luna a Pooh. Mensaje: No te preocupes, pronto rescataremos a la princesa.

05/02/2003 07:25:24 De Pooh a toti. Mensaje: Saquenme de aqui!

05/02/2003 07:25:50 De Isenhart a todos los jugadores. Mensaje: toti ha solicitado tiempo fuera... El tiempo se detendrá por 3 minutos.

05/02/2003 07:26:12 De Daniel a toti. Mensaje: para que se solicita tiempo fuera

05/02/2003 07:26:16 De Pooh a toti. Mensaje: Definitivamente esto no funciona!!

05/02/2003 07:26:23 De Pooh a toti. Mensaje: Que alguien haga algo!!

05/02/2003 07:26:30 De Pooh a toti. Mensaje: Volvamonos un equipo!

05/02/2003 07:26:46 De Luna a Daniel. Mensaje: Auxilio....

05/02/2003 07:26:58 De Daniel a toti. Mensaje:
05/02/2003 07:27:02 De toti a Pooh. Mensaje: Que has descubierto!!

05/02/2003 07:27:12 De Luna a Daniel. Mensaje: Ya te apareció la brujula?

05/02/2003 07:27:19 De Pooh a toti. Mensaje: Nada aun!

05/02/2003 07:27:27 De toti a Pooh. Mensaje: Yo no me puedo mover!!

05/02/2003 07:27:40 De Daniel a Pooh. Mensaje:

05/02/2003 07:27:45 De Luna a toti. Mensaje: Ya te apareció la brujula?

05/02/2003 07:27:51 De Luna a Pooh. Mensaje: Ya te apareció la brujula?

05/02/2003 07:27:57 De Luna a Daniel. Mensaje: Ya te apareció la brujula?

05/02/2003 07:28:11 De Daniel a Pooh. Mensaje: no y a ti?

05/02/2003 07:28:13 De toti a Luna. Mensaje: si aparece, pero no me puedo mover

05/02/2003 07:28:30 De Daniel a toti. Mensaje: tu has hecho algo diferente a enviar mensajes

05/02/2003 07:28:49 De toti a Daniel. Mensaje: no, no me puedo mover en el mapa

05/02/2003 07:28:50 De Daniel a Pooh. Mensaje: tu entiendes este juego

05/02/2003 07:28:54 De Daniel a Luna. Mensaje: tu entiendes este juego

05/02/2003 07:28:57 De Daniel a toti. Mensaje: tu entiendes este juego

05/02/2003 07:29:02 De 21 a todos los jugadores. Mensaje: toti ha chocado con un cactus

05/02/2003 07:29:03 De 21 a todos los jugadores. Mensaje: toti ha chocado con un cactus

05/02/2003 07:29:03 De 21 a todos los jugadores. Mensaje: toti ha chocado con un cactus

05/02/2003 07:29:07 De 21 a todos los jugadores. Mensaje: toti ha chocado con un cactus

05/02/2003 07:29:14 De 21 a todos los jugadores. Mensaje: toti ha chocado con un cactus
05/02/2003 07:29:15 De 21 a todos los jugadores. Mensaje: toti ha chocado con un cactus

05/02/2003 07:29:15 De 21 a todos los jugadores. Mensaje: toti ha chocado con un cactus

05/02/2003 07:29:30 De Luna a toti. Mensaje: Como lograste moverte?

05/02/2003 07:29:45 De Daniel a toti. Mensaje: c¿omo te chocaste con un cactus?

05/02/2003 07:29:53 De Pooh a toti. Mensaje: Que estás haciendo?

05/02/2003 07:29:59 De toti a Luna. Mensaje: No se pero empece a moverme!

05/02/2003 07:30:07 De Isenhart a todos los jugadores. Mensaje: muy bien mis valientes!!!!

05/02/2003 07:30:12 De Pooh a toti. Mensaje: Yo no se ni donde estoy, ni tengo brújula!

05/02/2003 07:30:35 De toti a Pooh. Mensaje: no ves la brujula?

05/02/2003 07:30:51 De Pooh a toti. Mensaje: No, no tengo brújula!

05/02/2003 07:30:57 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:00 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:02 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:05 De Isenhart a todos los jugadores. Mensaje: felicitaciones!!! han pasado el primer nivel

05/02/2003 07:31:18 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:18 De Daniel a toti. Mensaje: qué es RP?, que significa?

05/02/2003 07:31:19 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:19 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus
05/02/2003 07:31:20 De toti a Pooh. Mensaje: Se me fue la brujula

05/02/2003 07:31:22 De Daniel a Pooh. Mensaje: qué es RP?, que significa?

05/02/2003 07:31:22 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:22 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:26 De Daniel a Luna. Mensaje: qué es RP?, que significa?

05/02/2003 07:31:44 De toti a Pooh. Mensaje: Parece que nos rotamos la brujula

05/02/2003 07:31:52 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:52 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:54 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:57 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:58 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:31:59 De Daniel a toti. Mensaje: por que nadie me responde?

05/02/2003 07:32:00 De toti a Daniel. Mensaje: parece que nos rotamos la brujula

05/02/2003 07:32:02 De Daniel a Pooh. Mensaje: por que nadie me responde?

05/02/2003 07:32:03 De 21 a todos los jugadores. Mensaje: Pooh ha chocado con un cactus

05/02/2003 07:32:05 De Pooh a toti. Mensaje: Ummm Pues yo la tengo, ahora que hago?

05/02/2003 07:32:05 De Daniel a Luna. Mensaje: por que nadie me responde?

05/02/2003 07:32:09 De 21 a todos los jugadores. Mensaje: Pooh La misión ha fracasado
05/02/2003 07:32:09 De Pooh a todos los jugadores. Mensaje: juego terminado

05/02/2003 07:32:25 De toti a Daniel. Mensaje: camina e investiga

05/02/2003 07:32:41 De Daniel a Luna. Mensaje: cómo así que nos rotamos la brujula?

05/02/2003 07:32:52 De toti a Daniel. Mensaje: perdón eso no era para ti, le decía a Pooh que caminara

05/02/2003 07:32:53 De Pooh a Daniel. Mensaje: Alguien diga algo!

05/02/2003 07:33:00 De Luna a Daniel. Mensaje: No se que es RP, Si tu estas moviendo el angelito, debes ir a rescatar a la princesa en el borde inferior izquierdo de la pantalla.

05/02/2003 07:33:14 De toti a Pooh. Mensaje: camina e investiga

05/02/2003 07:33:26 De Daniel a Pooh. Mensaje:

05/02/2003 07:33:33 De Pooh a Daniel. Mensaje: pero como me muevo?

05/02/2003 07:33:41 De Luna a toti. Mensaje: Tu estas moviendo el angelito?

05/02/2003 07:33:46 De Luna a Pooh. Mensaje: Tu estas moviendo el angelito?

05/02/2003 07:33:48 De toti a Pooh. Mensaje: sigues con la brujula??

05/02/2003 07:33:50 De Luna a Daniel. Mensaje: Tu estas moviendo el angelito?

05/02/2003 07:33:57 De toti a Daniel. Mensaje: No es Pooh

05/02/2003 07:34:09 De Daniel a Luna. Mensaje: no, yo no se cómo moverme

05/02/2003 07:34:10 De Isenhart a todos los jugadores. Mensaje: colaboracion!!!

05/02/2003 07:34:29 De toti a Luna. Mensaje: Tu tienes la brujula??

05/02/2003 07:34:33 De Pooh a Daniel. Mensaje: Sí, pero no puedo hacer nada!

05/02/2003 07:34:41 De Pooh a Daniel. Mensaje: Alguien se está moviendo?

05/02/2003 07:34:44 De toti a Pooh. Mensaje: tu tienes la brujula??

05/02/2003 07:34:45 De Isenhart a todos los jugadores. Mensaje: paciencia mis valientes!!!
05/02/2003 07:34:56 De Daniel a Pooh. Mensaje: nooooooooooooooooooooooo

05/02/2003 07:35:00 De Luna a toti. Mensaje: No, yo no la tengo. El que la tenga debe ser el líder...Bueno, eso creo...

05/02/2003 07:35:02 De Pooh a Daniel. Mensaje: SI, yo la tengo! Pero no me puedo mover!

05/02/2003 07:35:15 De Pooh a Daniel. Mensaje: Pooh tiene la brújula!

05/02/2003 07:35:24 De Luna a Pooh. Mensaje: Tu tienes la bruja? Dime por favor...

05/02/2003 07:35:27 De toti a Luna. Mensaje: creo que sí, intenta moverte

05/02/2003 07:36:16 De toti a Luna. Mensaje: Sigues con la bruja

05/02/2003 07:36:38 De Daniel a toti. Mensaje: dónde está mi sol?

05/02/2003 07:36:40 De Luna a toti. Mensaje: Lo siento, no veo la bruja.

05/02/2003 07:36:54 De Daniel a Luna. Mensaje: dónde está mi sol?

05/02/2003 07:37:03 De Luna a toti. Mensaje: El angelito se mueve sin mi permiso.

05/02/2003 07:37:06 De toti a Luna. Mensaje: tu preguntabas por rp??

05/02/2003 07:37:44 De toti a Pooh. Mensaje: que haces??

05/02/2003 07:37:44 De Pooh a toti. Mensaje: Brújula!

05/02/2003 07:37:44 De Luna a toti. Mensaje: No, por la brújula pero también quisiera saber que es RP, por favor.

05/02/2003 07:37:51 De Pooh a toti. Mensaje: Nada!

05/02/2003 07:38:07 De Luna a Daniel. Mensaje: Donde esta mi floresita

05/02/2003 07:38:09 De Pooh a toti. Mensaje: Tengo la maldita brújula y no se que hacer con ella!

05/02/2003 07:38:24 De toti a Pooh. Mensaje: creo que tiene que ver con la vida del muñequito

05/02/2003 07:38:29 De Daniel a Luna. Mensaje: aquí

05/02/2003 07:38:39 De Pooh a toti. Mensaje: Explícame!
05/02/2003 07:39:03 De Luna a Daniel. Mensaje: Pequeña, tu sabes que hacer?

05/02/2003 07:39:05 De toti a Pooh. Mensaje: Ten cuidado de no estrellarte, los indicadores de vida que son los azules se están acabando

05/02/2003 07:39:12 De Daniel a Luna. Mensaje: no amor

05/02/2003 07:39:22 De Daniel a Luna. Mensaje: teno hambre

05/02/2003 07:39:35 De Luna a Daniel. Mensaje: yo también...

05/02/2003 07:39:35 De Daniel a Luna. Mensaje: tu entiendes un poquito el juego?

05/02/2003 07:39:38 De Pooh a toti. Mensaje: Me estrellé muchas veces, pero ya no me puedo mover.

05/02/2003 07:39:48 De Pooh a toti. Mensaje: Por ende ya no me puedo estrellar

05/02/2003 07:39:57 De toti a Pooh. Mensaje: creo que estas muerto o algo así

05/02/2003 07:40:24 De Luna a Daniel. Mensaje: Claro, hay que rescatar a la princesa que está en el borde inferior izquierdo, pero creo que solo uno de nosotros tiene la brújula y puede moverse.

05/02/2003 07:40:27 De Pooh a toti. Mensaje: Sí, debo estar muerto.

05/02/2003 07:40:42 De Luna a Pooh. Mensaje: Tu estas moviendo el muñequito?

05/02/2003 07:40:47 De toti a Pooh. Mensaje: y entons??

05/02/2003 07:41:02 De toti a Daniel. Mensaje: creo que pooh se murio

05/02/2003 07:41:17 De Pooh a toti. Mensaje: Estoy muerto!

05/02/2003 07:41:18 De toti a Luna. Mensaje: pooh creo que esta muerto

05/02/2003 07:41:24 De Daniel a toti. Mensaje: y por que crees eso?

05/02/2003 07:41:24 De Pooh a toti. Mensaje: Y ustedes no...

05/02/2003 07:41:29 De toti a Pooh. Mensaje: sip!!

05/02/2003 07:41:39 De Pooh a Daniel. Mensaje: Estoy muerto y Uds no!

05/02/2003 07:41:44 De Pooh a Daniel. Mensaje: Soy libre!
05/02/2003 07:41:54 De Pooh a Daniel. Mensaje: Ja ja ja ja!
05/02/2003 07:41:59 De Daniel a Pooh. Mensaje: no pues, que envidia
05/02/2003 07:42:03 De Luna a Daniel. Mensaje: Auxilio, puedes explicarme un poco?. No entiendo que hacer.
05/02/2003 07:42:07 De Pooh a Daniel. Mensaje: Saquenme de aqui!
05/02/2003 07:42:14 De Daniel a Pooh. Mensaje: yo tambiên pero del hambre
05/02/2003 07:42:15 De toti a Daniel. Mensaje: ves los controles que estan al lado de los muñecos se le acabó el rojo
05/02/2003 07:42:28 De Daniel a Luna. Mensaje: tranquilo, yo tampoco
05/02/2003 07:42:42 De toti a Daniel. Mensaje: y lo peor es que el tenia la brujula
05/02/2003 07:42:57 De Daniel a toti. Mensaje: y entonces ya perdimos?
05/02/2003 07:43:02 De Luna a Daniel. Mensaje: Bueno, tu tienes la brujula?
05/02/2003 07:43:04 De toti a Daniel. Mensaje: no se
05/02/2003 07:43:17 De Pooh a Daniel. Mensaje: Todo es culpa de Ulises
05/02/2003 07:48:06 De Isenhart a todos los jugadores. Mensaje: mejor suerte mis valientes!!!!
05/02/2003 07:54:31 De Isenhart a todos los jugadores. Mensaje: uno para todos, y todos para uno!!!
05/02/2003 08:00:34 De Isenhart a todos los jugadores. Mensaje: gracias por su tiempo
05/02/2003 08:00:51 De Isenhart a todos los jugadores. Mensaje: lo quieren volver a intentar?

Movements Log File

05/02/2003 08:12:04 Leon se ha movido al este desde (0,0) hasta (0,1).
05/02/2003 08:13:15 Leon se ha movido al este desde (0,1) hasta (0,2).
05/02/2003 08:14:19 Leon se ha movido al sur desde (0,2) hasta (1,2).
05/02/2003 08:14:48 Leon se ha movido al sur desde (1,2) hasta (2,2).

05/02/2003 08:16:18 Leon no logra moverse al sur porque hay un obstáculo en el camino.

05/02/2003 08:16:22 Leon ha chocado con un cactus Su vida y resistencia cambia de HP: 100/100 y RP: 20/20 a HP: 90/100 y RP: 20/20.

05/02/2003 08:16:22 Leon no logra moverse al sur porque hay un obstáculo en el camino.

05/02/2003 08:16:25 Leon ha chocado con un cactus Su vida y resistencia cambia de HP: 100/100 y RP: 20/20 a HP: 90/100 y RP: 20/20.

05/02/2003 08:16:26 Leon no logra moverse al sur porque hay un obstáculo en el camino.

05/02/2003 08:16:26 Leon ha chocado con un cactus Su vida y resistencia cambia de HP: 90/100 y RP: 20/20 a HP: 80/100 y RP: 20/20.

05/02/2003 08:16:27 Leon no logra moverse al sur porque hay un obstáculo en el camino.

05/02/2003 08:16:27 Leon ha chocado con un cactus Su vida y resistencia cambia de HP: 90/100 y RP: 20/20 a HP: 80/100 y RP: 20/20.

05/02/2003 08:16:54 Leon no logra moverse al este porque hay un obstáculo en el camino.

05/02/2003 08:16:57 Leon ha chocado con un cactus Su vida y resistencia cambia de HP: 60/100 y RP: 20/20 a HP: 50/100 y RP: 20/20.

05/02/2003 08:16:58 Leon no logra moverse al este porque hay un obstáculo en el camino.

05/02/2003 08:17:01 Leon ha chocado con un cactus Su vida y resistencia cambia de HP: 50/100 y RP: 20/20 a HP: 40/100 y RP: 20/20.

05/02/2003 08:18:23 Leon se ha movido al oeste desde (2,2) hasta (2,1).

05/02/2003 08:18:24 Leon se ha movido al oeste desde (2,1) hasta (2,0).

05/02/2003 08:19:35 Leon se ha movido al sur desde (2,0) hasta (3,0).

05/02/2003 08:19:39 Leon se ha movido al sur desde (3,0) hasta (4,0).
05/02/2003 08:19:39 Leon se ha movido al sur desde (4,0) hasta (5,0).
05/02/2003 08:20:09 Leon se ha movido al sur desde (5,0) hasta (6,0).
05/02/2003 08:20:09 Leon no logra moverse al sur porque hay un obstáculo en el camino.
05/02/2003 08:20:10 Leon no logra moverse al sur porque hay un obstáculo en el camino.
05/02/2003 08:21:57 Leon se ha movido al este desde (6,0) hasta (6,1).
05/02/2003 08:21:57 Leon se ha movido al este desde (6,1) hasta (6,2).
05/02/2003 08:21:58 Leon se ha movido al este desde (6,2) hasta (6,3).
05/02/2003 08:22:47 Leon se ha movido al este desde (6,3) hasta (6,4).
05/02/2003 08:22:48 Leon se ha movido al este desde (6,4) hasta (6,5).
05/02/2003 08:22:48 Leon se ha movido al este desde (6,5) hasta (6,6).
05/02/2003 08:22:49 Leon no logra moverse al este porque hay un obstáculo en el camino.
05/02/2003 08:23:24 Leon se ha movido al norte desde (6,6) hasta (5,6).
05/02/2003 08:23:25 Leon se ha movido al norte desde (5,6) hasta (4,6).
05/02/2003 08:23:25 Leon se ha movido al norte desde (4,6) hasta (3,6).
05/02/2003 08:23:25 Leon ha entrado a un pasadizo desde zona 0 hasta zona 1.
05/02/2003 08:23:28 rosa ha salido por un pazadiso en 3, 9.
05/02/2003 08:23:28 rosa se ha movido al norte desde (3,9) hasta (2,9).
05/02/2003 08:24:21 rosa se ha movido al norte desde (2,9) hasta (1,9).
05/02/2003 08:26:18 rosa se ha movido al norte desde (1,9) hasta (0,9).
05/02/2003 08:26:18 rosa no logra moverse al norte por estar en el límite norte.
05/02/2003 08:26:23 rosa se ha movido al este desde (0,9) hasta (0,10).
05/02/2003 08:26:24 rosa se ha movido al este desde (0,10) hasta (0,11).
05/02/2003 08:27:05 rosa se ha movido al sur desde (0,11) hasta (1,11).
05/02/2003 08:27:06 rosa se ha movido al sur desde (1,11) hasta (2,11).
05/02/2003 08:27:14 rosa se ha movido al sur desde (2,11) hasta (3,11).
05/02/2003 08:27:14 rosa se ha movido al sur desde (3,11) hasta (4,11).
05/02/2003 08:27:21 rosa se ha movido al sur desde (4,11) hasta (5,11).
05/02/2003 08:27:24 rosa se ha movido al sur desde (5,11) hasta (6,11).
05/02/2003 08:27:27 rosa se ha movido al este desde (6,11) hasta (6,12).
05/02/2003 08:27:27 rosa se ha movido al este desde (6,12) hasta (6,13).
05/02/2003 08:27:29 rosa se ha movido al este desde (6,13) hasta (6,14).
05/02/2003 08:27:29 rosa se ha movido al este desde (6,14) hasta (6,15).
05/02/2003 08:27:29 rosa ha entrado a un pasadizo desde zona 1 hasta zona 3.
05/02/2003 08:27:30 pipino ha salido por un pasadizo en 9, 15.
05/02/2003 08:30:03 pipino no logra moverse al sur porque hay un obstáculo en el camino.
05/02/2003 08:30:04 pipino ha chocado con un cactus Su vida y resistencia cambia de HP: 100/100 y RP: 20/20 a HP: 90/100 y RP: 20/20.
05/02/2003 08:30:04 pipino no logra moverse al sur porque hay un obstáculo en el camino.
05/02/2003 08:32:09 pipino se ha movido al oeste desde (9,15) hasta (9,14).
05/02/2003 08:32:09 pipino se ha movido al oeste desde (9,14) hasta (9,13).
05/02/2003 08:34:21 pipino no logra moverse al oeste porque hay un obstáculo en el camino.
05/02/2003 08:34:21 pipino ha chocado con un cactus Su vida y resistencia cambia de HP: 80/100 y RP: 20/20 a HP: 70/100 y RP: 20/20.
05/02/2003 08:34:22 pipino no logra moverse al oeste porque hay un obstáculo en el camino.

05/02/2003 08:34:22 pipino ha chocado con un cactus Su vida y resistencia cambia de HP: 80/100 y RP: 20/20 a HP: 70/100 y RP: 20/20.

05/02/2003 08:34:22 pipino no logra moverse al oeste porque hay un obstáculo en el camino.

05/02/2003 08:34:22 pipino ha chocado con un cactus Su vida y resistencia cambia de HP: 80/100 y RP: 20/20 a HP: 70/100 y RP: 20/20.

05/02/2003 08:35:10 pipino se ha movido al sur desde (9,13) hasta (10,13).

05/02/2003 08:35:11 pipino se ha movido al sur desde (10,13) hasta (11,13).

05/02/2003 08:35:11 pipino no logra moverse al sur porque hay un obstáculo en el camino.

05/02/2003 08:35:11 pipino ha chocado con un cactus Su vida y resistencia cambia de HP: 50/100 y RP: 20/20 a HP: 40/100 y RP: 20/20.

05/02/2003 08:38:16 pipino se ha movido al este desde (11,13) hasta (11,14).

05/02/2003 08:38:16 pipino se ha movido al este desde (11,14) hasta (11,15).

05/02/2003 08:38:17 pipino no logra moverse al este por estar en el límite este.

05/02/2003 08:38:17 pipino no logra moverse al este por estar en el límite este.

05/02/2003 08:39:20 pipino se ha movido al sur desde (11,15) hasta (12,15).

05/02/2003 08:39:20 pipino se ha movido al sur desde (12,15) hasta (13,15).

05/02/2003 08:39:21 pipino se ha movido al sur desde (13,15) hasta (14,15).

05/02/2003 08:39:21 pipino se ha movido al sur desde (14,15) hasta (15,15).

05/02/2003 08:39:31 pipino se ha movido al norte desde (15,15) hasta (14,15).

05/02/2003 08:39:31 pipino se ha movido al norte desde (14,15) hasta (13,15).

05/02/2003 08:39:32 pipino se ha movido al norte desde (13,15) hasta (12,15).

05/02/2003 08:39:35 pipino se ha movido al norte desde (12,15) hasta (11,15).
05/02/2003 08:39:39 pipino se ha movido al sur desde (11,15) hasta (12,15).
05/02/2003 08:39:39 pipino se ha movido al sur desde (12,15) hasta (13,15).
05/02/2003 08:39:40 pipino se ha movido al sur desde (13,15) hasta (14,15).
05/02/2003 08:39:40 pipino se ha movido al sur desde (14,15) hasta (15,15).
05/02/2003 08:40:50 pipino se ha movido al oeste desde (15,15) hasta (15,14).
05/02/2003 08:40:50 pipino se ha movido al oeste desde (15,14) hasta (15,13).
05/02/2003 08:40:51 pipino se ha movido al oeste desde (15,13) hasta (15,12).
05/02/2003 08:40:51 pipino se ha movido al oeste desde (15,12) hasta (15,11).
05/02/2003 08:40:52 pipino se ha movido al oeste desde (15,11) hasta (15,10).
05/02/2003 08:42:17 pipino no logra moverse al oeste porque hay un obstáculo en el camino.
05/02/2003 08:42:18 pipino no logra moverse al oeste porque hay un obstáculo en el camino.
05/02/2003 08:42:18 pipino no logra moverse al oeste porque hay un obstáculo en el camino.
05/02/2003 08:42:19 pipino no logra moverse al oeste porque hay un obstáculo en el camino.
05/02/2003 08:42:22 flora ha salido por un pasadizo en 12, 6.
05/02/2003 08:42:22 flora se ha movido al norte desde (12,6) hasta (11,6).
05/02/2003 08:42:23 flora se ha movido al norte desde (11,6) hasta (10,6).
05/02/2003 08:42:24 pipino se ha movido al norte desde (15,9) hasta (14,9).
05/02/2003 08:42:25 pipino se ha movido al norte desde (14,9) hasta (13,9).
05/02/2003 08:42:25 pipino se ha movido al norte desde (13,9) hasta (12,9).
05/02/2003 08:42:25 pipino ha entrado a un pasadizo desde zona 3 hasta zona 2.
05/02/2003 08:45:00 flora se ha movido al oeste desde (10,6) hasta (10,5).
05/02/2003 08:45:00 flora se ha movido al oeste desde (10,5) hasta (10,4).
05/02/2003 08:47:18 flora se ha movido al sur desde (10,4) hasta (11,4).
05/02/2003 08:47:19 flora se ha movido al sur desde (11,4) hasta (12,4).
05/02/2003 08:47:19 flora se ha movido al sur desde (12,4) hasta (13,4).
05/02/2003 08:48:01 flora se ha movido al sur desde (13,4) hasta (14,4).
05/02/2003 08:48:02 flora se ha movido al sur desde (14,4) hasta (15,4).
05/02/2003 08:48:05 flora no logra moverse al sur por estar en el límite sur.
05/02/2003 08:50:03 flora se ha movido al norte desde (15,4) hasta (14,4).
05/02/2003 08:50:03 flora se ha movido al norte desde (14,4) hasta (13,4).
05/02/2003 08:50:04 flora se ha movido al norte desde (13,4) hasta (12,4).
05/02/2003 08:51:35 flora se ha movido al sur desde (12,4) hasta (13,4).
05/02/2003 08:51:38 flora se ha movido al sur desde (13,4) hasta (14,4).
05/02/2003 08:51:39 flora se ha movido al sur desde (14,4) hasta (15,4).
05/02/2003 08:51:39 flora no logra moverse al sur por estar en el límite sur.
05/02/2003 08:54:01 flora se ha movido al norte desde (15,4) hasta (14,4).
05/02/2003 08:54:02 flora se ha movido al norte desde (14,4) hasta (13,4).
05/02/2003 08:54:02 flora se ha movido al norte desde (13,4) hasta (12,4).
05/02/2003 08:54:03 flora se ha movido al norte desde (12,4) hasta (11,4).
05/02/2003 08:57:27 flora se ha movido al oeste desde (11,4) hasta (11,3).
05/02/2003 08:57:31 flora se ha movido al oeste desde (11,3) hasta (11,2).
05/02/2003 08:57:31 flora se ha movido al oeste desde (11,2) hasta (11,1).
05/02/2003 08:57:32 flora se ha movido al oeste desde (11,1) hasta (11,0).
05/02/2003 08:57:32 flora no logra moverse al oeste por estar en el límite oeste.
05/02/2003 08:57:36 flora no logra moverse al oeste por estar en el límite oeste.

05/02/2003 08:57:36 flora no logra moverse al oeste por estar en el límite oeste.

05/02/2003 08:57:37 flora no logra moverse al oeste por estar en el límite oeste.

05/02/2003 08:57:37 flora no logra moverse al oeste por estar en el límite oeste.

05/02/2003 08:57:38 flora no logra moverse al oeste por estar en el límite oeste.

05/02/2003 08:58:18 flora se ha movido al sur desde (11,0) hasta (12,0).

05/02/2003 08:58:19 flora se ha movido al sur desde (12,0) hasta (13,0).

05/02/2003 08:58:20 flora no logra moverse al sur porque hay un obstáculo en el camino.

05/02/2003 08:58:20 flora ha chocado con un cactus Su vida y resistencia cambia de HP: 100/100 y RP: 18/20 a HP: 90/100 y RP: 18/20.

05/02/2003 08:58:22 flora no logra moverse al sur porque hay un obstáculo en el camino.

05/02/2003 08:58:22 flora ha chocado con un cactus Su vida y resistencia cambia de HP: 90/100 y RP: 13/20 a HP: 80/100 y RP: 13/20.

05/02/2003 08:58:26 flora no logra moverse al sur porque hay un obstáculo en el camino.

05/02/2003 08:58:26 flora ha chocado con un cactus Su vida y resistencia cambia de HP: 90/100 y RP: 13/20 a HP: 80/100 y RP: 13/20.

05/02/2003 08:59:47 flora se ha movido al este desde (13,0) hasta (13,1).

05/02/2003 08:59:47 flora se ha movido al este desde (13,1) hasta (13,2).

05/02/2003 08:59:48 flora no logra moverse al este porque hay un obstáculo en el camino.

05/02/2003 08:59:48 flora ha chocado con un cactus Su vida y resistencia cambia de HP: 70/100 y RP: 20/20 a HP: 60/100 y RP: 20/20.

05/02/2003 08:59:48 flora no logra moverse al este porque hay un obstáculo en el camino.
05/02/2003 08:59:48 flora ha chocado con un cactus Su vida y resistencia cambia de HP: 70/100 y RP: 20/20 a HP: 60/100 y RP: 20/20.

05/02/2003 08:59:49 flora no logra moverse al este porque hay un obstáculo en el camino.

05/02/2003 08:59:49 flora ha chocado con un cactus Su vida y resistencia cambia de HP: 70/100 y RP: 20/20 a HP: 60/100 y RP: 20/20.

05/02/2003 08:59:49 flora no logra moverse al este porque hay un obstáculo en el camino.

05/02/2003 08:59:49 flora ha chocado con un cactus Su vida y resistencia cambia de HP: 70/100 y RP: 20/20 a HP: 60/100 y RP: 20/20.

05/02/2003 09:00:34 flora se ha movido al sur desde (13,2) hasta (14,2).

05/02/2003 09:00:35 flora no logra moverse al sur por estar en el límite sur.

05/02/2003 09:00:36 flora no logra moverse al sur por estar en el límite sur.

05/02/2003 09:00:54 flora se ha movido al oeste desde (15,2) hasta (15,1).

05/02/2003 09:00:54 La princesa ha sido rescatada

05/02/2003 09:00:55 flora no logra moverse al oeste por estar en el límite oeste.

05/02/2003 09:00:56 flora no logra moverse al oeste por estar en el límite oeste.
APPENDIX 4: INTERVIEWS

Metacognitive Questionnaire:

When you have some task, and you do not know anything about the subject, what you make frequently to know more on the subject?

When you are studying for a test, how you really know that you are understanding the subject?

Do you think that is useful to interchange information with your classmates? How frequently do you interchange information?

(1 a 5: 1 Completely Agree...5 Completely Disagree)

I respect the group decisions.

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
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</tbody>
</table>

I act like an independent person of the other members of the group

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
<tbody>
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</table>

I would not support a decision of the group if I knew that it is mistaken.

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
<tbody>
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<td></td>
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</tbody>
</table>

I would continue in the groups if they need to me, although does not feel me satisfied with the group

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

Is important for me to act like an independent person in the group

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
<tbody>
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</table>

I Respect the wishes of the group.
<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I express my opinions when I feel that I am not agree with the group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely Agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Partially Disagree</td>
<td>Completely Disagree</td>
</tr>
<tr>
<td>Accept the claims of the group member, although they imply to be against of myself</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Completely Agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Partially Disagree</td>
<td>Completely Disagree</td>
</tr>
<tr>
<td>In any work group, my personal identity is very important</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Completely Agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Partially Disagree</td>
<td>Completely Disagree</td>
</tr>
<tr>
<td>Product Evaluation.</td>
<td></td>
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<tr>
<td>(1 a 5: 1 Completely Agree...5 Completely Disagree)</td>
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<tr>
<td>I was so satisfied with the group performance</td>
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<td></td>
</tr>
<tr>
<td>Completely Agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Partially Disagree</td>
<td>Completely Disagree</td>
</tr>
<tr>
<td>I think that our performance in this activity was satisfactory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely Agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Partially Disagree</td>
<td>Completely Disagree</td>
</tr>
<tr>
<td>We did our work in a equitable way</td>
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<td></td>
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</tr>
<tr>
<td>Completely Agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Partially Disagree</td>
<td>Completely Disagree</td>
</tr>
<tr>
<td>The way we work in group was satisfactory</td>
<td></td>
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</tr>
<tr>
<td>Completely Agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Partially Disagree</td>
<td>Completely Disagree</td>
</tr>
</tbody>
</table>
All the group members are prepared to solve the problematic situation.

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
</table>

There were some members that they tried to be prepared when really they were not it.

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
</table>

Some members of the group worked very smoothly.

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
</table>

My personal level of satisfaction within the group was high.

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
</table>

I felt very important within the group.

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
</table>

I would like to work again with this group.

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Partially Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
</table>

Some comments of the last experience:

Both the subject and the methodology were interesting.

Work group is reinforced with this kind of activities.

This kind of work allows a greater analysis of the subjects and is less singsong than the classes.

The best thing of the raised methodology is that it was possible to spoke and express with greater freedom.
All the subjects do not have to work this way.

Difficulty to obtain understanding with some group members.

Low participation of some group members, so the work group was not as good as we would like it.

There were difficult concepts in the text.

Positive Aspects of the activity

The activity was funny and interesting.

The activity got a union within the group.

We learnt to see what the others saw.

We learnt that in many opportunities we do not take the best decisions to solve a problematic situation.

It seemed to me that the activity emphasized the importance of the communication for the work in-group, since this is to which we are going away to face like professionals.

We learnt the importance of communication.

Negative Aspects of the activity

Poor communication among group members.

Some members of the group did not like to work in the group.

We learnt we do not know how to work in a collaborative way.
APPENDIX 5: Pre-Test High-School Students

Date: Feb. 14th 2003

Main Topic: Human Sexuality

Topics:

- Sexual orientation
- Definitions.
- Myths and taboos.
- Sexual aberrations.

Organization:

Group 11
- Juan Velasco
- Eruin Delgado
- Alejandro Sarasty
- **Cristian Dorado**

Group 12
- Leonardo Sánchez
- **John Moreno**
- Yudy Alegría
- Mario Cajiao

Group 13
- Orlando Ortiz
- Yenny Ordóñez
- Edison Alvarez
- **Oscar Rubio**

Group 14
Javier Arcos  
Paola Tulande  
José Múñoz  
**Diego Tapia**

Group 15  
Eduard Ruiz  
Wison Diago  
Jorge Mora  
**Jorge Castillo**

Note: Persons in bold face were chosen for the test.

Questions of the Test

- How do you define sexual orientation?  
- Describe 2 venereal diseases?  
- Describe 2 taboos of the sexual activity.  
- Describe some sexual aberrations.

Scores of the Test

The range is 1.0 to 5. The final score is the average of the questions.

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>Question 1</th>
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<th>Question 3</th>
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System Engineering Students

Date: May 7th 2003

Main Topic: Multimedia - Part 1

Topics:
- History and state of the art.
- General Concepts
- Roles
- Importance in Education.

Organization:

Group 16
- Jennifer Valencia
- Juan Gabriel Vernaza
- Gabriel Álvarez
- Nelson Rengifo

Group 17
- Diego Adarmes
- Daniel Rosero
- Pablo Zúñiga
- Judy Molano

Group 18
- German Ruiz
- Deiro Zúñiga
- Maritza Paredes
- Andrés Pisso

Group 19
- Jacqueline Pomeo
- Cristian Andrés Chávez
• Marino Hernán Tobar
• Marsoly Quinayas
Group 20
• Andrés Felipe Manzano
• David Manzano
• Isabel Burbano
• Jhon Alexander Gutiérrez

Note: Persons in bold face were chosen for the test.

Test Questions

• How the computer concept has changed taking into account the multimedia concept?
• Define multimedia
• What kind of roles are necessary for multimedia production?
• What is the impact of multimedia technology in education?

Scores of the Test

The range is 1.0 to 5. The final score is the average of the questions.

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<tr>
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APPENDIX 6: POST-TEST- HIGH SCHOOL STUDENTS

Date: Feb. 16th 2003

Main Topic: Collaborative Learning

Topics:
- Definition
- Mechanism that operate in a collaborative situation
- Roles of teachers and students in collaborative learning
- Applications and techniques within a classroom

Organization:

Group 11
- Juan Velasco
- Eruin Delgado
- Alejandro Sarasty
- Cristian Dorado

Group 12
- Leonardo Sánchez
- John Moreno
- Yudy Alegría
- Mario Cajiao

Group 13
- Orlando Ortiz
- Yenny Ordóñez
- Edison Alvarez
- Oscar Rubio

Group 14
• Javier Arcos
• Paola Tulande
• José Muñoz
• Diego Tapia

Group 15
• Eduard Ruiz
• Wison Diago
• Jorge Mora
• Jorge Castillo

Note: Persons in bold face were chosen for the test.

Test Questions
• What is Collaborative Learning?
• Describe 2 aspects that are necessary for a collaborative activity.
• What are the new roles of teachers in a collaborative activity?
• How do you apply Collaborative Learning in your classroom?

Scores of the Test
The range is 1.0 to 5. The final score is the average of the questions.

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System Engineering Students

**Date:** May 9th-2003

**Main Topic:** Multimedia - Part 2

**Topics:**

- Audio formats
- Graphics formats.
- Video formats.
- Devices (Memory, input/output, communication)

**Organization:**

Group 16

- Jennifer Valencia
- Juan Gabriel Vernaza
- Gabriel Álvarez
- **Nelson Rengifo**

Group 17

- Diego Adarmes
- **Daniel Rosero**
- Pablo Zúñiga
- Judy Molano

Group 18

- German Ruiz
- Deiro Zúñiga
- Maritza Paredes
- **Andrés Pisso**

Group 19

- Jacqueline Pomeo
- Cristian Andrés Chávez
• Marino Hernán Tobar
• Marsoly Quinayas
Group 20
• Andrés Felipe Manzano
• David Manzano
• Isabel Burbano
• Jhon Alexander Gutiérrez

Note: Persons in bold face were chosen for the test.

Test Questions

• Which are the main categories of the audio formats?
• Which are the main categories of the graphics formats?
• Which are the main categories of the video formats?
• What kind of devices we can use in multimedia applications?

Scores of the Test

The range is 1.0 to 5. The final score is the average of the questions.

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