# Design Patterns for Collaborative Games Supporting Evaluating Collaborative Learning Processes

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**Abstract.** Several researchers in the area of collaborative work take the quality of the group outcome as a success criterion. Nevertheless, recent findings are giving more importance to the quality of the collaboration process itself. This paper presents a set of patterns the main objective of which is to evaluate and monitor the collaborative learning process. Also we describe a software tool we have implemented based on these set of patterns and how the patterns proposed have helped us to evaluate and monitor the collaborative learning processes.

## 1 Introduction

If the collaboration process is improved, the quality and quantity of topics learned by the group could be increased. As Ewing mentions, it is necessary to know more in detail the process that occur when a group of people is trying to solve a problematic situation in a collaborative way [1]. It is necessary to provide a support for the design of educative activities, and to have a set of appropriate elements for the development of educative frameworks, especially those environments that support monitoring and evaluation of collaboration processes. This paper presents a set of patterns that provide guidelines to design the necessary evaluation mechanisms for supporting the collaborative learning processes. Next section briefly describes the model we propose, describing some of the analysis patterns we have proposed. Then a software tools based on games we have implemented. Finally we present some conclusion and further work.

## 2 Our Proposal

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 diverse groups of apprentices can be contrasted. Based on this premise, next sections present a system of patterns which includes aspects of the design of collabora-

tive activities, as well as of the evaluating and monitoring process. These patterns characterize the most common situations when collaborative learning activities are used. Thirteen patterns compose the analysis pattern's system: activities, group of apprentices, facilitator, apprentice, positive interdependence, nature of the task, shared objects, coordination, integration, conflicts and making decisions, evaluation, process outcome, and feedback.

## 2.1 Activities Pattern

Defining the CSCL activities, it is necessary to specify the group of people, the required conditions of collaboration, the nature of the activity, the type, and the mechanisms that provide positive interdependences and coordination.

**Name of the Pattern:** Activities.

**Problem:** Not all the activities executed by the group are CSCL activities.

**Context:** In collaborative environments, diverse activities are proposed so students can achieve the desired results, that is, acquire knowledge through the development of a collaborative task.

**Description:** The designed activities specify the work 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. [2].

**Solution:** Plan the activities in order for the students to change from an individual perspective to a group one. That is, move the group of students 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 imply elements that will guarantee positive interdependence and good collaboration schemes. It is necessary to specify and clearly define the activity, describing its nature, type, people in charge, and desirable conditions of collaboration.

## 2.2 Group of Apprentices Pattern

The roles inside the collaborative learning groups must be carefully defined.

**Name of the Pattern:** Group of apprentices.

**Problem:** Being a member of a group is not sufficient to promote good learning interactions.

**Context:** In CSCL activities, groups of people are associated to the functions undertaken to execute a particular activity.

**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 Apprentices. 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 resides in that

different users possess different levels of knowledge, as well as access to different information sources.

**Solution:** For the collaborative activity to be successful, it is essential to clearly define the tasks to be undertaken by each one 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. In a Collaborative scenario, although the phrase team cognition suggests something that happens inside people's heads, teams are very much situated in the real world, and there are a number of activities that have to happen out in that world for teams to be able to think and work together. This is not just spoken communication. Depending on the circumstances, effective team cognition includes activities such as using environmental cues to establish a common ground of understanding, seeing who is around and what they are doing, monitoring the state of artifacts in a shared work setting, noticing other people's gestures and what they are referring to, and so on [4].

### 2.3 Facilitator Pattern

The facilitator plays a key role in the collaborative learning activity. The whole learning activity depends on this person.

**Name of the Pattern:** facilitator.

**Problem:** In a collaborative learning context, someone is responsible for the success of the activities.

**Context:** The facilitator plays a key role in the design and execution of collaborative learning activities. He/she must structure the activities and must be able to monitor the group process.

**Description:** The facilitator is the person in charge of: defining the initial work conditions, planning the activity and their objectives, defining the conditions of success, among others. In general, the facilitator is the one who creates interesting learning environments and activities that link the new information to the previous knowledge providing opportunities for the collaborative work and offering the apprentices a variety of real tasks. The facilitator must have the ability to determine when and how to intervene.

**Solution:** For an effective decision making process inside the groups, it is essential to define coordination policies. Making effective the collaborative learning process requires following certain guidelines and defining certain roles inside the group. However the sole definition of these guidelines and roles do 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 facilitator is responsible to define the groups and the roles.

### 2.4 Apprentice Pattern

The apprentice is the most important element in the collaborative learning activity.

The whole learning activity is centered on a group of apprentices.

**Name of the Pattern:** apprentice.

**Problem:** In a collaborative learning context, someone must obtain certain knowledge or some kind of skill.

**Context:** The apprentice is the person who must be subject to interact with other students in order to acquire the knowledge the collaborative activity proposes.

**Description:** The apprentice has a key role in the development of the collaborative activity. He/she is responsible for the completion of the activities that will achieve the goals and for the solving of the problems define by the Facilitator. His/her main objective is the cooperative gathering of knowledge about a problematic situation.

**Solution:** The different roles of the apprentices 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 apprentices must be rotated while the activity is ongoing because the exchange of roles is very positive in collaborative learning activities [8].

### 2.5 Positive Interdependence Pattern

Positive interdependence is the heart of collaborative activities. These interdependences define the collaboration process and transform group work into teamwork.

**Name of the Pattern:** positive interdependence.

**Problem:** In a collaborative learning activity just putting people around the activity does not imply a collaboration activity among people; it is necessary to structure the activity incorporating elements like positive interdependence.

**Context:** Positive interdependences are a fundamental aspect in the Collaborative Learning scenarios, unfortunately there is a lack of support in order to determine the best way to include them in those kinds of scenarios.

**Description:** As Johnson et al. [9] 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 exist positive interdependence among all the group members. It is a key feature that has been emphasized by scholars concerned primarily with promoting students' academic achievement and cognitive development [10].

**Solution:** Design activities that permit to foster different kinds of positive interdependencies among members of the group [11]. 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 there are negative consequences when failing to do one's own part. Johnson et al., have defined 9 types of positives interdependencies (goal, role, outside enemy, resource, identity, reward, fantasy, task, environmental)[9], therefore, specify the task including the larger part of the positive interdependencies.

### 2.6 Nature of the Task Pattern

The characteristics of the task in some way define the degree of interaction that can exist among the group members**.**

**Name of the Pattern:** Nature of the task.

**Problem:** In a collaborative learning activity the lack of information about the objectives, the rules and the collaboration environment can result in that a given task not be properly undertaken.

**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.

**Description:** 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 collective development of an activity requires the integration of all participants, and therefore, it is necessary that the apprentices be very aware of the steps that are needed to be followed to achieve the objectives and of their role within this process.

**Solution:** When defining the nature of the task, the following aspects must be taken into consideration: (a) Period of collaboration. (b) Setting of collaboration (c) Type of activity (d) Rules. (e) Nature of Collaborators (f) Goals. (g) Conditions of collaboration.

### 2.7 Shared Objects Pattern

Shared objects represent the space where the participants exchange information and represent any important element in CSCL scenarios.

**Name of the Pattern:** Shared objects.

**Problem:** In a collaborative learning activity it is very important to understand the activities the other members of the group are performing. This aspect in many cases is considered as the group awareness.

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

**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 problematic situation. Awareness is a concept related to the mechanisms that guarantee that people can understand or be aware of the process itself and of the interaction among all the participants of a given activity.

**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 of the group can have the following information:

    o Where are the other members of the group?

    o What are the other members doing to complete the task?

o What have the other members done?

o What will the other members do to solve the task?

## 2.8 Coordination Pattern

In a collaborative setting it is important to define mechanisms to organize the work that must be performed among the group members.

**Name of the Pattern:** Coordination.

**Problem:** 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.

**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.

**Description:** 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 [12].

**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 in the construction of some type of knowledge. According to Johnson et al., another aspect of the coordination has to do with in the ways of maintaining the group stimulated, such mechanisms that incentive participation and communication [13]. Guidelines must be provided that serve as help mechanisms and which 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.

## 2.9 Integration Pattern

In a collaborative setting it is important to define mechanisms to provide cohesiveness aspects to the work performed among group members.

**Name of the Pattern:** Integration.

**Problem:** In collaborative learning environments non integrated groups do not fully reach their objectives.

**Context:** The means used by the individuals to integrate into a group will characterize their relationship. In integrated groups, people tend to act in a coordinated way.

**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.

**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.

### 2.10 Conflicts and Making-decisions Pattern

Conflicts are very important in CSCL scenarios in order to assimilate the shared knowledge within a group.

**Name of the pattern:** Conflicts and making-decisions.

**Problem:** In the context of collaborative learning environments, a negotiation is an auxiliary mechanism related to the Coordination that forces apprentices to make decisions about the execution of some tasks, which in turn forces them to elaborate a solution for a proposed problem, thus promoting learning.

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

**Description:** 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. [14]. 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 apprentices, 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 promote learning [8].

**Solution:** Stahl says that collaboration requires divergence (stating of ideas) and convergence (negotiation, synthesis, and consensus) [15]. 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. *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 at least must be the same.

### 2.11 Evaluation Pattern

The evaluation must function as an instrument that gives possibility to the teacher to analyze in a critical way the collaborative activity. Also, must provide the possibility

to detect the main weakness of a certain group, in order to define some mechanisms to support them.

**Name of the Pattern:** Evaluation.

**Problem:** There are a growing number of experiences in qualitative evaluation in CSCL environments [18]. 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 who 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.

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

**Description:** Evaluation in collaborative learning involves a number of actions organized with the purpose of obtaining information about the knowledge acquired by the apprentices.

**Solution:** In a collaborative learning environment, it is necessary to record all of the activities that occur within the group when solving a problematic situation. All the mechanisms that allow the recording of all the activities should be provide, 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.

### 2.12 Process Outcome Pattern

A collaborative learning process is typically composed of several tasks that must be developed by the cognitive mediator or facilitator

**Name of the Pattern:** Process Outcome.

**Problem:** In a collaborative activity a series of steps occur in order to reach the final goal.

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

**Description:** A collaborative 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. 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 [19]. 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 accompli-shed 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 in the evalua-

tion of this stage. In order to specify this division, we present the structure of a cooperative learning activity identified by Johnson & Johnson in [9].

**Solution:** A group of indicators have been defined that allow the evaluation, to some degree, of the collaborative process [20]. These indicators are the following: (a) *Applying Strategies* (b) *Intra-group Cooperation*; (c) *Success criteria review*; (d) *Monitoring*; (e) *Performance*.

### 2.13 Feedback Pattern

All the collaborative activities require receive information about the work performed.

**Name of the Pattern:** Feedback.

**Problem:** In a collaborative activity it is necessary to define mechanism that permit to understand the activities performed.

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

**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.

**Solution:** In a collaborative learning environment all the necessary means should be provided so that the people evaluating 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.

In the following section we present a developed software tool, taking into account the Patterns previously described.

## 3 Example: Memonet

This game is based on the classic "Memorize Game", which goal is to find the equal pair within several covered cards (Figure 1). This is repeated successively until there are no covered cards remaining.

*Activities:* The goal of the game is that four people try to find four equal cards from an initial set of ten different cards.

*Group of Apprentices:* This game is played by four persons selected in a random way.

*Facilitator:* There is a person who is in charge of the activity design and will be the responsible of the monitoring and evaluation of the activity.

*Apprentice:* 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

problematic situation.

*Positive Interdependences:* There is a Positive Resource Interdependence, because every member of the group has only 25% of the total information to solve the problematic situation.
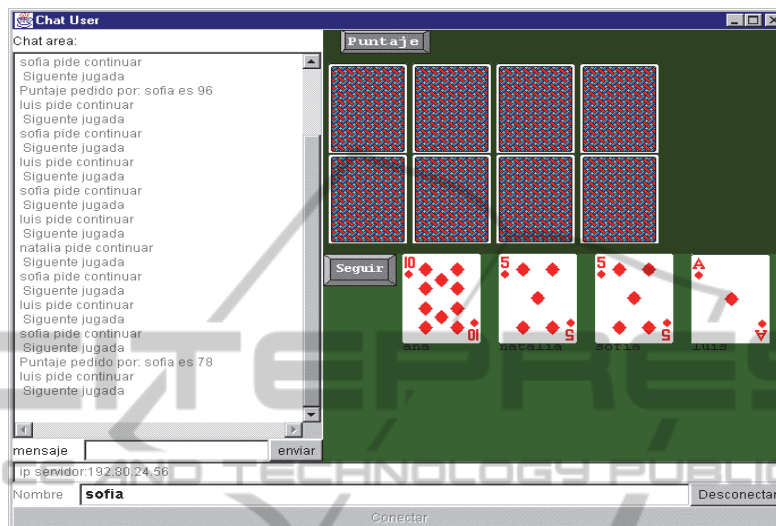


**Fig. 1.** MemoNet user interface (in Spanish).

- *Nature of the Task:* (1) Period of collaboration: it is expected the activity will be performed in a session of 2 or 3 hours. (2) Settings: The game is played in a distributed fashion, with communication allowed through a chat tool. (3) Type of activity: Problem-solving. (4) Rules: Players are given very few details about the game. Participants while playing must discover the rest of the rules. They also have to develop shared strategies to succeed. (5) Nature of collaborators: peer-to-peer interaction. (6) Goals: the software presents a strict goal positive interdependence because team members need each other to succeed. The only way to reach the goal is through the team collaboration where the participants can define, communicate and negotiate different strategies in order to solve the problematic situation. (7) Conditions of collaboration: Computer-mediated collaboration.

- *Shared Objects:* There is a space where the player places his name to be able to connect himself to the server. It provides a virtual shared environment in which the participants can solve the problematic situation in a collaborative way.

- *Coordination:* 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 problematic situation. The card is removed when the four players have found it. The game continues until all cards are uncovered.

- *Integration:* When a user clicks on a card, this one turns and appears as it is depicted in figure 2. If it is un-selected two events could occur: if no success, all the cards will be given back: if success, the cards will disappear from the screen.

- *Conflict and Making-decision:* Because each participant has a partial view of the game, the player must interact with his/her peers in order to solve the problematic situation. In this way participants need to collaborate.
  *Evaluation:* The application records every message sent by any member of the group. Along with the message, it registers the time of occurrence and sender. The tool also registers the start and finish game time.
  *Outcomes:* Use of strategies, intra-group cooperation, checking the success criteria, monitoring and the ability of providing help.
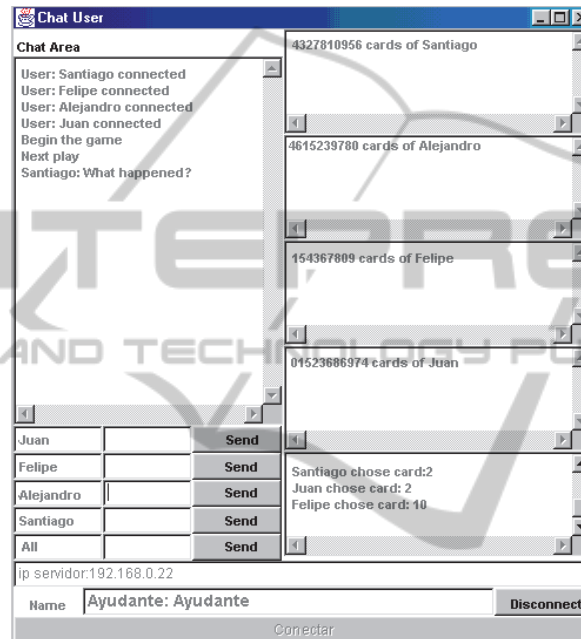


**Fig. 2.** Teacher's user interface of MemoNet.

*Feedback:* Figure 2 illustrates the teacher interface. In the chat area it is also clearly possible to watch all the messages sent by the players. Players can send a message to any of her peers or to all of them. Also we can observe in the data area the letter selected by each player in the last play. Messages sent by the teacher to the players are written on an independent window. They appear to the receiver as mechanical alerts of the program to a particular fact.

## 4 Conclusions and Further Work

Understanding the collaborative process of learning in groups is an interesting research field. In the case of collaborative activities, performing a task well implies not only having the skills to execute the task, but also collaborating well with teammates to do it. This complexity offers opportunities to develop tools and techniques for

improving collaboration. One way to evaluate the effectiveness of a group is through monitoring and observing the interaction between their members while working. In order to achieve predefined collaborative learning objectives it is necessary to design a group process that allows to monitor it and to evaluate it. It is also necessary to understand how the apprentices work and they learn. If the group work process is improved, the quality and quantity of the group learning will be increased. In this paper we try to describe mechanisms for supporting the design of collaborative learning activities, and to show a set of appropriate elements for the development of educative frameworks, especially environments that support monitoring and evaluation of collaboration processes.

Several conditions regarding group work have been investigated, such as the composition of the group, individual pre-requisites, characteristics of the task at hand, and the context of collaboration. Thus, it is important not only to consider the design of the structure of the collaborative environment and 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 through modeling it. On the other hand, one of the most important aspects in evaluating a collaborative learning process is defining clear criteria for evaluating such process. An improvement in the collaboration process should provide higher quality about the learned knowledge. Based on this premise, this paper presents a set of patterns that include aspects related to designing collaborative learning activities, as well as for evaluating and monitoring such processes.

## References

1. Ewing, J., & Miller, D., A framework for evaluating computer supported collaborative learning. EducationalTechnology and Society, Vol. 5, No.1, pp.112-18, 2002
2. Gallardo, T., Guerrero, L., Collazos, C., Pino, J., & Ochoa, S., Supporting JIGSAW-type Collaborative Learning. Proc. Published by IEEE Computer Society Press, Los Alamitos, CA, USA. Hawaii, January, 2003.
3. Dillenbourg, P., What do you mean by collaborative learning? In P. Dillenbourg(Ed) Collaborative-Learning: Cognitive and Computational Approaches, pp.1-19, Oxford: Elsevier, 1999.
4. Hutchins, E. (1996) Cognition in the wild. Cambridge, MA: MIT Press.
5. Gutwin, C., and Greenberg, S. (2004) The Importance of Awareness for Team Cognition in Distributed Collaboration. In E. Salas and S. M. Fiore (Editors). Team Cognition: Understanding the Factors that Drive Process and Performance, pp. 177-201, Washington:APA Press
6. Kagan, S., Cooperative Learning. San Juan Capistrano, CA: Kagan Cooperative Learning, 1992.
7. Collazos, C., Guerrero, L., Llaña, M., & Oetzel, J., Gender: an influential factor in the collaborative work process. ICNEE, pp.7-11, Lugano, Switzerland, 1992.
8. Dillenbourg, P., Baker, M., Blake, A. & O'malley, C., The evolution of research on collaborative learning. In Spada, H. and Reimann, P. (Eds.), Learning in Humans and Machines: Towards an interdisciplinary learning science. pp-189-211. Oxford: Elsevier, 1995.
9. Johnson, P. M., & Tjahjono, D., Improving software quality through computer supported collaborative review. Proceedings of ECSCW'93, pp.61-76, 1993.
10. Slavin, R., Madden, N. & Stevens, R., Cooperative learning models for the 3 R's. Educa

tional Leadership. Vol. 47, No.4, pp.22-28, 1990

11. Collazos, C., Guerrero, L., Pino, J., A Computational Model to Support the Monitoring of the Collaborative Learning Process. Advanced Technology for Learning 1(3), pp. 174-180, 2004.

12. Farnham, S., Chesley, H., Mcghee, D., & Kawal, R., Structured Online Interactions: Improving the Decision-Making of Small Discussion Groups. In: Proceedings of Computer-Supported Cooperative Work-CSCW´00, pp. 299-308, Philadelphia, USA, 2000.

13. Johnson, D., Johnson, E., & Smith, K., Increasing College Faculty Instructional Productivity, ASHE-ERIC Higher Education Report No.4, School of Education and Human Development, George Washington University, 1991.

14. BARROS, L., Support to Distributed Environments for Cooperative Learning (In Portuguese). PhD. Thesis, COPPE/UFRJ, Rio de Janeiro, Brazil, 1994.

15. Stahl, G., Reflections on WebGuide: Seven Issues for the Next Generation of Collaborative Knowledge Building Environments. Proceedings of Computer Supported for Collaborative Learning, Stanford, USA, pp. 600-610, 1999.

16. Delvin, K., & Rosemberg, D., Language at work: analyzing communication breakdown to inform system design. CSLI Lecture Notes, No.66, 1996.

17. STAHL, G., Supporting knowledge negotiation in virtual classrooms. Technical Report, College of Information Science & Technology. Drexel University. 2002.

18. Wassin, B., Guribye, F., & Morch, A., Project DoCTA: Design and use of collaborative tele-learning artifacts. Bergen: Pedagogisk Informasjonsvitenskap, Univesitetet i Bergen, 2000.

19. Collazos, C., Guerrero, L., Pino, J., & Ochoa, S., Evaluating collaborative learning processes. Lecture Notes in Computer Science 2440, Heidelberg, Springer Verlag, pp. 203-221, 2002.

20. Johnson, D. W., & Johnson, R. T., Dennis Adams, Mary Hamm, II Edition, The Handbook of Research for Educational Communications and Technology. David Jonassen Editors, pp. 1017-1045, 1996