A Model and a Game for Investigating and Designing Collaborative Learning Environments

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Abstract. Collaborative learning environments require carefully crafted designs – both technical and social. This paper presents a model describing how to design socio-technical environments that will promote collaboration in group activities. A game was developed based on this model. This tool was used to conduct experiments for studying the collaborative learning process. Testing with this system revealed some strengths and weaknesses, which are being addressed in on-going research.

1. Introduction

Quantitative research in CSCL is complicated to conduct. There are many reasons that difficult the measuring of the collaboration process. The most relevant reasons are the following ones:

- Effective collaborative learning depends on subtle social factors and pedagogical structuring, not just simple tasks and technologies [Dill99].
- Collaborative learning technologies must go beyond generic groupware applications, and even the basic technology is not yet well developed [Stah02].
- Settings of collaboration in classrooms and other groups are “messy” compared to classic laboratory research settings, full of intervening factors that cannot be controlled for [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 cooperative interactions tend to lose collaborative content.

The advantages of collaborative learning are well documented [John86]. However, it is not clear how to design and analyze collaborative processes, and how to promote collaboration. In order to answer these questions, we developed a game requiring four players. These players must collaborate with each other in order to pass through a labyrinth as fast as possible. In designing the software tool controlling the interactions among subjects, we developed a model that specifies initial conditions and the design of the structure of the shared workspace which structures the collaboration process. This paper presents a model for designing environments that explicitly promote collaboration (section 2). Section 3 presents a software tool developed on this model. Section 4 briefly presents a discussion, and section 5 presents conclusions.

2. The Proposed Model

Instead of designing systems that compensate for metacognitive deficiencies by becoming increasingly directive, we should develop systems supporting the learner's metacognitive activities (or even better, that develop their metacognitive skills) [Dill92]. 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 for increasing the probability that they will happen. One of these ways is by designing well-specified collaborative scenarios. Thus, we need to design the learning task and the learning environment. The design of the learning task needs to draw on the best we know about how people learn, on knowledge of academic subject matter and/or vocational competencies, and on knowledge of the learners. A task needs to be sufficiently well-specified 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].

2.1. Set-up initial conditions

A first way to increase the probability that some types of interactions 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. Based on the elements proposed by Bannon [Bann89], our model defines a set of elements to consider for specifying the initial characteristics of the groups.

2.1.1. 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. It could, e.g., include tasks such as: puzzle solving, editing a newspaper, writing a letter, etc.

2.1.2. Nature of collaborators: Specify the types of interaction that occur. It could include three types of interaction: (a) peer to peer interaction, (b) teacher-student interaction, and (c) student-computer interaction.

2.1.3. Group heterogeneity: This covers several independent variables such as: size of the group, gender and differences within the group. Typically, the smaller the group, the more each member talks and the less chance there is someone will be left out. Also, smaller groups require less group management skill and they can usually decide faster [Kaga92]. Gender specifies the male/female group composition.

2.1.4. Positive interdependence: This is one of the key elements in successful groups. Based on many studies, psychologists working in education identified positive interdependence as a feature of good learning groups [Slav90]. Collazos et al. have developed various ways of structuring positive interdependences in software tools based on the interface design to ensure students think “we” instead of “me” [Coll03a].

2.1.5. Setting of collaboration: This corresponds to the place where the collaborative activity will be held. It could correspond to the classroom, workplace or home.

2.1.6. Conditions of collaboration: This specifies the kind of mediation. It could be, physically co-present or computer-mediated.

2.1.7. Period of collaboration: This specifies the interval time in which the collaborative activity will occur. It could be specified in minutes, hours, days, weeks, months or years.

2.2. Structuring collaboration

The teacher cannot simply ask students to start projects and encourage peers to learn together, but he/she should specify a scenario. That scenario should include several phases. At each phase, the team has to produce something and the team members have some role to play. The scenario we propose 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 [Jerm01]. Our model looks at the following aspects of a scenario:

2.2.1. Activities: Specify the tasks that must be performed by the group members during the collaborative activity. This includes the goals and rules of the tasks.

2.2.1.1. Goals: There are activities performed by the group associated to the main goal, and activities done by every member of the group related to the partial goals. An objection to having students work in groups is that some group members end up doing all the work and all the learning. This can occur because some students do not work or because others want to do everything [Kaga92].

2.2.1.2. Rules: Specify the rules of the group activity. These rules 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 the review of boundaries and guidelines of the group activity.

2.2.2. People: Specify the roles of the group members. Each group member has a role which he is to perform, e.g., a reading passage can be divided into sections. Members of a pair read the first section silently. These roles must rotate [John98].

2.2.3. Objects: Define the tools through people who can perform the collaborative activities. They must include aspects related with communication and participation.

2.2.3.1. Communication. Define mechanisms supporting communication among members of the group, such as chat boxes. Communication is important in individual knowledge and cooperative practices such as sign language with hands in face-to-face communication [Delv96]. The participants of group work must communicate in order to accomplish tasks that are independent, that are not completely described or that require negotiation [Fuss98].

2.2.3.2. Participation. The idea is to define scenarios where members of the group have the same chances to participate to solve the problematic situation. The complexity of the activities must be designed in a way that every member of the group can perform the same work [Kaga94].

2.3. Maintaining the collaboration

The last aspect we consider in our model is to design scenarios where it could be possible to maintain the collaboration among members of the group. That activity could be performed by the cognitive mediator or by the same members of the group.

Even if the efforts to structure collaboration increase the probability productive interactions would occur, there is no guarantee that the interactions do actually occur. Hence, some external regulation is needed 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 mediator will not be to intervene at the task level, but to guarantee all the group members participate, and to frequently ask questions such as: What happened? What does it mean? The role of the cognitive mediator is to maintain the focus of the discussion, guiding students through the knowledge construction process. As the collaboration goes on, the state of interaction is evaluated and remedial actions may be proposed to reduce discrepancies between these states.

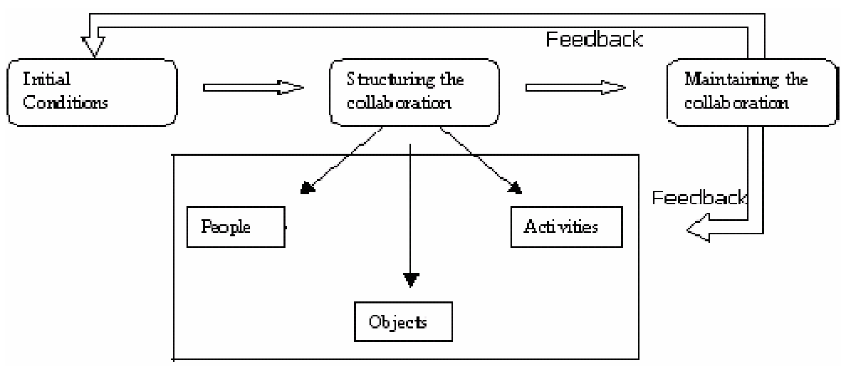

Figure 1. Proposed Model

Fig. 1 depicts the proposed model. It attempts to assist collaboration in two ways: 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). Next we explain a game implementing this model.

3. The Gaming Tool

Our game – called Chase the Cheese – is played by four persons, each with a computer. The computers are physically distant and the only communication allowed is computer-mediated. All activities made by participants are recorded for analysis and players are made aware of that. Players are given very few details about the game. The rest of the game rules must be discovered by the participants while playing. They also have to develop joint strategies to succeed. Therefore, people can only play the game once.

Figure 2 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 persons can only help the coordinator sending 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 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 obstacle locations to the coordinator. 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 must interact with his peers to solve the problem. In order to communicate with them, each player has a dialogue box (8) from which he can send messages to each of them through a set of buttons associated to the color of the destination (9). Since each player has a color associated, his quadrant shows the corresponding color (5). When starting to move the mouse, the coordinator has an individual score (11) of 100 points.

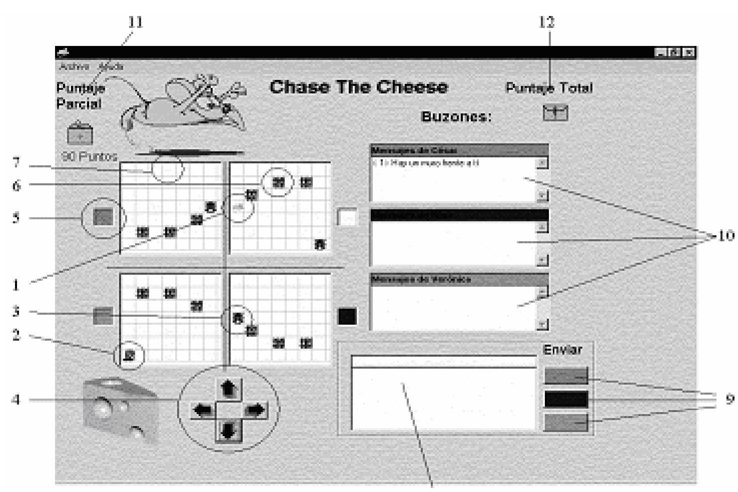

Figure 2. Game Interface

Whenever the mouse hits an obstacle, the score is decreased 10 points. The coordinator has to lead the mouse to the cheese (in the case of the last quadrant) or to a traffic light (3). When the mouse passes to another quadrant the coordinator role is switched. When the coordinator passes the mouse to the next quadrant his individual score is added to the total score of the group (12). If any individual score reaches a value below or equal to 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.

Let us see how we design the software interface according to the model proposed in the previous section. Table 1 presents the initial conditions in the software tool we have developed (Chase the Cheese). Table 2, presents the way we structured the collaboration among members of the group in the software tool we have developed.

Table 1: Initial Conditions

Elements	**Chase the Cheese**
Type of activity	Solve a labyrinth
Nature of Collaborators	Peer to peer interaction
Group heterogeneity	The game is played by four person, randomly selected.
Positive Interdependence	Goal interdependence, because, there is a common goal, in that case, lead the mouse to its cheese
	Role interdependence: There are two predefined roles, coordinator and collaborators.
	Resource interdependence: Every member of the group has information that the other ones need. They have a partial view of the labyrinth, because they have information about their own colorful obstacles.
	Reward interdependence: Group members not only must lead the mouse to its cheese but arrive with the highest score.
Setting of Collaboration	Classroom
Conditions of Collaboration	Computer-mediated
Period of Collaboration	45 minutes

Table 2: Structuring collaboration

Elements	**Chase the Cheese**
Activities	Global: Lead the mouse to its cheese
	Partial: Pass through every traffic light icon
	Rules: The coordinator is the only person able to move the mouse. When the score arrives to 0, the game is over.
People (roles)	Coordinator: one per quadrant
	Collaborators: the three remaining

Objects (Communication)	The system provides some dialogue boxes, where every participant can send messages to every member or the group. Also, includes mailbox messages, where each player can see the messages he/she has received from the other players.
Objects (Participation)	In order to guarantee equal participation of all members of the group, the labyrinth was designed with a similar complexity in every quadrant. Every quadrant was designed in a way that had the same number of obstacles (general and colorful), and their distribution was similar in all the quadrants.

The third part of the model, maintaining the collaboration, includes participation of the cognitive mediator. Our first experiments did not include it in an explicit way. We only presented the information at the end of the activity. Through semantic analysis of the messages, we re-built the collaboration processes, and so, we determined the degree of collaboration measured by some indicators of collaboration have been proposed in previous work [Coll02]. In future versions, we will show some visualization of the interactions to the subjects. Then, the participation of the cognitive mediator could be important. The cognitive mediator and/or participants could interpret the visualization and decide what actions (if any) to take, in order to improve the collaboration [Coll03b]. It could be possible that students, who view and analyze our proposed indicators values [Coll02], may learn to understand and improve their own interaction. Next, we present some initial experiments we have done.

4.7. Discussion

Despite the fact our application includes many of the elements proposed in our model; the results obtained were not the best. What matters is not just the design of a game or program, nor even the design of a single task or curricular unit. Rather, the cultivation of minds, which itself requires engagement in a social process of meaning appropriation, requires the whole environment, not just the computer program, be designed as a well orchestrated whole. This includes curriculum, teacher’s behavior, collaborative tasks, mode of collaboration and interaction, tasks, learning goals, etc. Kozma has found, analyzing student interaction, the amount and nature of collaboration between partners had less to do with the availability of computer software and more to do with the way the instructor designed and structured the task [Kozm91].

5. Conclusions and Future Work

The design of well-specified scenarios could induce collaborative activities within a group. So, it is important to carefully define every activity, in order to promote collaborative activities. We have proposed a model that includes a set of elements to be performed to specify scenarios that promote collaborative activities.

Based on our results, we believe 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. The model we present attempts to support collaboration in two ways: 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). In future versions, we will build tools that monitor the state of the interaction, model the state of the interaction and provide collaborators with visualizations that can be used to self-diagnose the interaction.

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