

Collaborative Scenarios to Promote Positive Interdependence among Group Members

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Abstract. Positive interdependence is the heart of collaborative activities that define collaboration and transform group work into teamwork. To achieve positive interdependence among students, just putting them in group and telling them to work together may not be sufficient. Previously, several types of positive interdependencies have been identified for unsupported group activities. These kinds of interdependencies are now instantiated for the case of computer-supported group learning. The examples we show in this paper are taken from computer games and other tools we have developed to set students in a scenario in which they must collaborate in order to succeed. This paper also presents diverse forms of structuring positive interdependence in software tools based on the interface design to ensure that students think *we* instead of *me*.

1 Introduction

The success of one person is bound by with the success of others in collaborative learning activities. This is referred to as positive interdependence. Interdependence is meant to foster cooperation within the groups. Students need to have a reason for working together. Group tasks are collaborative when they structure positive interdependence among group members: a sink or swim together feeling and commitment to the group goal. Such a disposition is vital for successful teams, whether in sports, drama, business, hospital operating rooms or in academic pursuits. Positive interdependence is considered the key attribute of classroom cooperation [8]. It can take many forms. Successful democracies are by definition cooperative since the conflicts are resolved under the assumption that we are all working towards the good of the society as a whole even if we disagree, sometimes strongly, on the means to promote such good.

Johnson & Johnson have posted the statistical results of over 575 experimental and 100 correlational studies that were conducted by many researchers over various decades with different age subjects, in several subject areas, and in different settings [12]. These studies clearly demonstrate the positive effect that cooperative learning has on student academic achievement and social development. One of the issues addressed by this research is the type of interaction patterns found in cooperative, competitive,

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and individualistic situations [12]. Positive interdependence creates promotive interaction. Promotive interaction occurs as individuals encourage and facilitate each other's efforts to reach the group goals (such as maximizing each member's learning). Negative interdependence typically results in oppositional interaction. Oppositional interaction occurs as individuals discourage and obstruct each other's efforts to achieve something. Individuals focus both on increasing their own success and on preventing anyone else from being more successful than they are. No interaction exists when individuals work independently without any communication with each other. Individuals focus only on increasing their own success and consider the efforts of others as irrelevant. Each of these interaction patterns creates different outcomes.

Positive interdependence is the heart of collaborative activities that define collaboration and transform group work into teamwork. It is a key feature that has been emphasized by scholars concerned primarily with promoting students' academic achievement and cognitive development [18,12], as well as research concerned with students' holistic development. Chickering [7] argues that, in its highest form, the development of autonomy does not simply involve the development of freedom to choose and act independently of outside influences, but it also involves the development of freedom that recognizes one's dependence and obligations to others.

As Johnson *et al.* [13] 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. In a cooperatively learning group, this means learners realize that they are connected to each other in a way where one cannot succeed unless everyone succeeds. Each one is dependent on the contribution of all the others within the group.

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 [5, 20]. Doing so creates a commitment to the success of group members as well as one's own and is the heart of cooperative learning. If there is no positive interdependence, there is no cooperation [13].

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. The examples of software interfaces we developed are structured in a way intended to promote collaborative activities through several types of positive interdependences.

This paper shows some collaborative scenarios we have designed and implemented in various software tools in order to promote this kind of interdependence. We point out the basic principles of positive interdependence, discussed through four simple game examples, where participants have to collaborate to reach a goal. In Section 2, we present some related works. Section 3 presents a set of software tools we have developed to support positive interdependences. Section 4 includes some examples on how to structure positive interdependences. Discussion about our work is done on Section 5, and finally we present some conclusions in Section 6.

2 Related Work

There are many examples of techniques that promote positive interdependence such as: using 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.

Cuseo defines some single-step strategies that may be used to promote positive interdependence among students working in groups [6]. They are: (1) Redirect instructor-directed questions posed by individual students back to the students' team; (2) have teams seek help from other teams before asking it to the instructor; (3) let the last team receiving help provide it to the next team requesting support, (4) 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 (5) let students consistently use team language in the classroom ("we" and "our" vs. "I" "me" or "mine"), among others.

Al-Saleh *et al.* have defined some cooperative learning/teaching strategies, taking into account group interdependence activities [1]: Prior to the initiation of the first class meeting, the room environment is structured to enhance cooperative learning activities. Tables are arranged to seat groups of three to four students. Walking space is provided between tables. The instructor has easy access to all students and is not pinned down to one location at the front of the class.

Johnson *et al.* believe that group grades can be used fairly and appropriately. They say that making goals, resources, roles or rewards interdependent can create positive interdependence, the heart of cooperative learning. Because grades are the most common reward given in a classroom, they "are one of many ways in which students may be given the message, 'We sink or swim together.'" While the Johnsons never state that the use of group grades is essential to cooperative learning, they do offer a number of strategies for making grades interdependent, including: averaging members' individual scores, dual academic and non-academic rewards, totaling members individual scores, individual score plus group bonus, group score on a single product, all members receive lowest member's score, bonus points based on lowest score, individual score plus group average, average of academic and collaborative performance score, randomly selecting one member's paper or exam to score [11].

Silberman proposes a structure designed to promote positive interdependence among group members called Card Sort [17]. This structure serves a class-building function because students circulate around the room and interact with other students in class. First, each student is given an index card that contains an illustration or example that fits within a general category (e.g., category of living things, food types, or media modalities). Students then move around the room and try to find other students whose cards contain examples relating to the same category as their own. When students think they have found all other classmates carrying cards with examples from the same category, they present themselves to the class as a team. (If the categories are relevant to the contents of the course, then this structure may also double as a learning exercise, in which case the instructor assesses the accuracy of students' classifications and provides explanations or additional information if needed.

Kagan proposes a structure that requires each team member to correctly paraphrase or restate the idea of the teammate who previously spoke before being allowed to

contribute his own idea [15]. This structure explicitly encourages interdependence by encouraging the individual to actively listen to and process the ideas of his teammates. It can also be slightly modified to create a different structure called "Affirmation Passport," whereby team members are expected to affirm something about the comment of the previous student (e.g., its clarity, creativity, or most powerful point) before contributing their own idea.

3 Software Tools

In this section we are presenting some software tools we have developed in order to address the issue of promoting positive interdependence using explicit mechanisms. The subjects may be high school or college students.

3.1 Chase the Cheese

This game is played by four persons, each one with a computer. The computers are physically distant and the only communication allowed is computer-mediated.

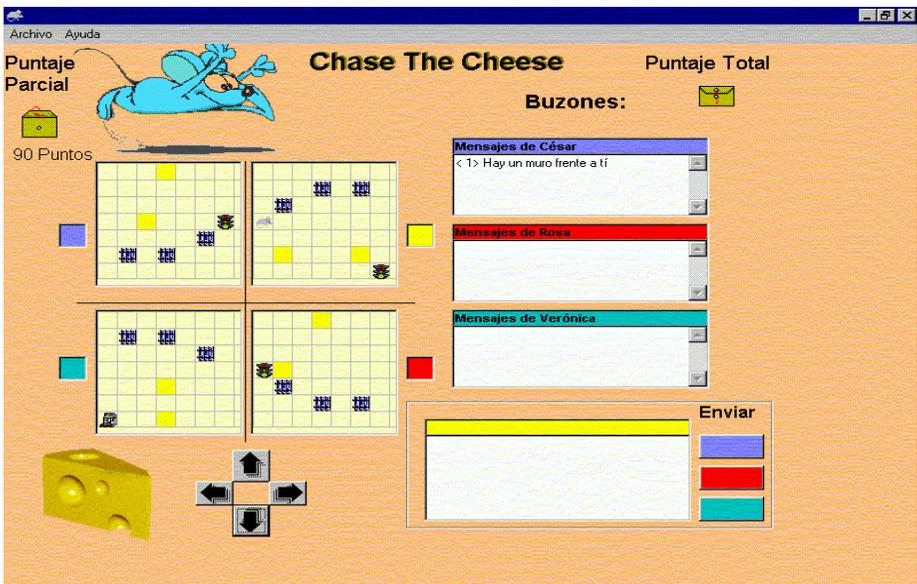


Fig. 1. Chase the Cheese user interface (in Spanish)

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.

The goal of the game is to move a mouse through a labyrinth to its cheese. The labyrinth is divided in four quadrants, and each quadrant has a *coordinator* -one of the players. The other participants can only help the coordinator sending their messages,

(see Figure 1). Each player has two predefined roles: *coordinator* (only one per quadrant and randomly assigned) or *collaborator* (the three remaining). These roles are switched during the collaborative activity. Most of the obstacles are invisible to the quadrant coordinator, but visible to one of the other players [2].

3.2 MemoNet

This game is loosely based on the classic “Memorize Game”, which goal is to find the equal pair within several covered cards. This is repeated successively until there are no covered cards remaining. 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.

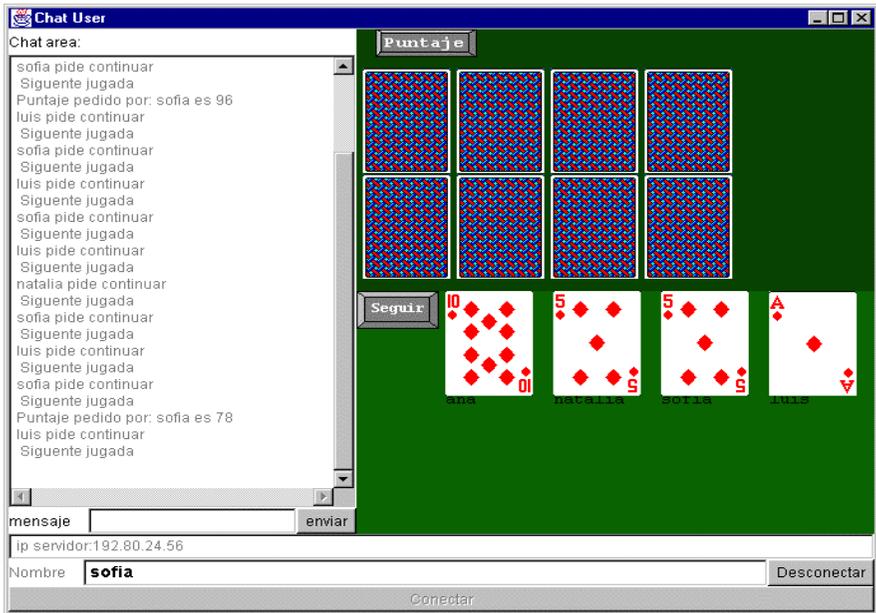


Fig. 2. MemoNet user interface (in Spanish)

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. The game is played in a distributed fashion, with communication allowed through a chat tool [3]. Also it provides a space where the player places his name to be able to connect himself to the server (see Figure 2).

3.3 ColorWay

This game has a 6 x 4 board of colored squares with obstacles (see Figure 3). Each player can see her own obstacles (with her color). Each player has a token with her

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 grey squares, which are not currently used by another token. Another restriction to do 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 similar way to MemoNet, this game provides communication through chat. The problem is there is only one way to arrange the tokens, therefore they need to communicate in order to win the game [3].

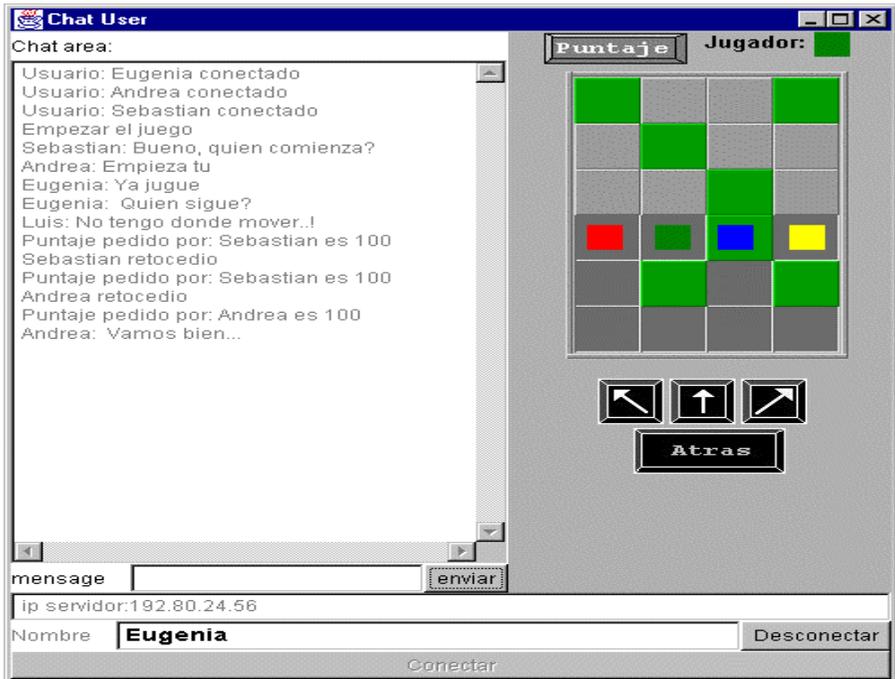


Fig. 3. ColorWay user interface (in Spanish)

3.4 CCCuento

This tool helps a group to collaboratively write stories. Four participants work four stories at the same time. Each story has four phases: introduction, body A, body B and conclusion. Each member must write a different section of every story. In a first stage every participant writes introduction of one of the stories. In a second stage every participant writes the first part of the development of a different story (body A) whom wrote the introduction. Then, they continue working until they finish all stories. The group members may edit the parts they were responsible at any time during project development (see Figure 4).

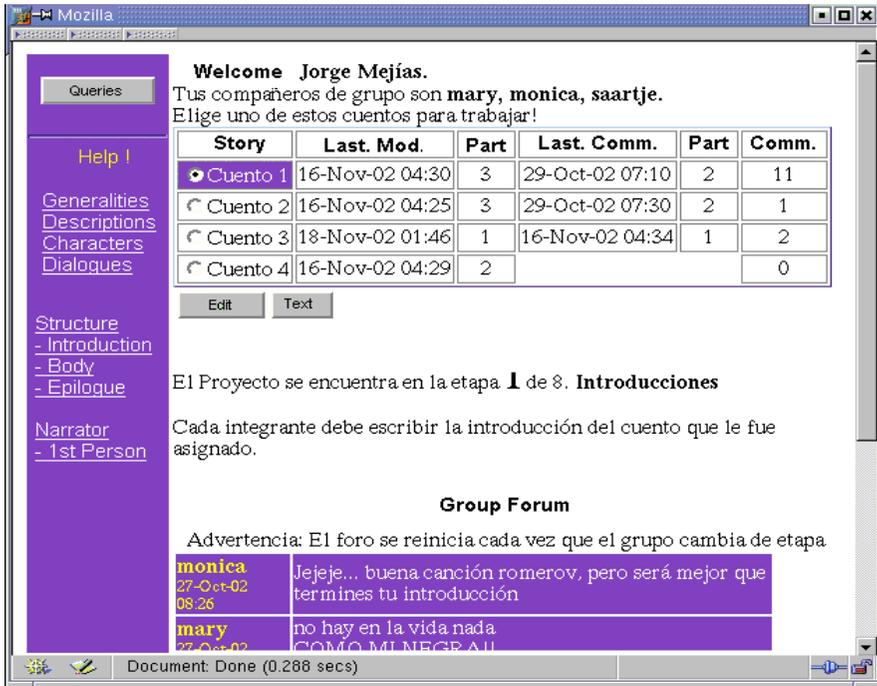


Fig. 4. CCCuento user interface (in Spanish)

3.5 TeamQuest

This game is another labyrinth with obstacles [4]. The players of a team must reach a goal by satisfying subgoals in each of the game stages. Each player is identified with a role image and name. The screen has three well-defined areas: game, communication and information (see Figure 5). The game area has four quadrants (each one assigned to a player who has the “doer” role; the other players are collaborators for that quadrant). In a quadrant, the doer must move an avatar from the initial position to the “cave” that allows entering the next quadrant. In the way, the doer must circumvent all obstacles and traps in the map (which are not visible to all players). Moreover, the doer must pick an item 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, etc. (see Figure 5).

4 Kinds of Positive Interdependences

Johnson, et al. describe three levels in establishing positive interdependence [11]. The teacher first has to assign the group a clear, measurable task, then structure positive goal interdependence, and finally blend positive goal interdependence with other

types of positive interdependence. They mention positive interdependence as what distinguishes a cooperative learning group from a casually connected group. This aspect is intentionally planned so that all members must participate in order for the task to be completed. It is the "glue" that holds the members together. There are several different types of positive interdependence [11] which are described in the next sections.

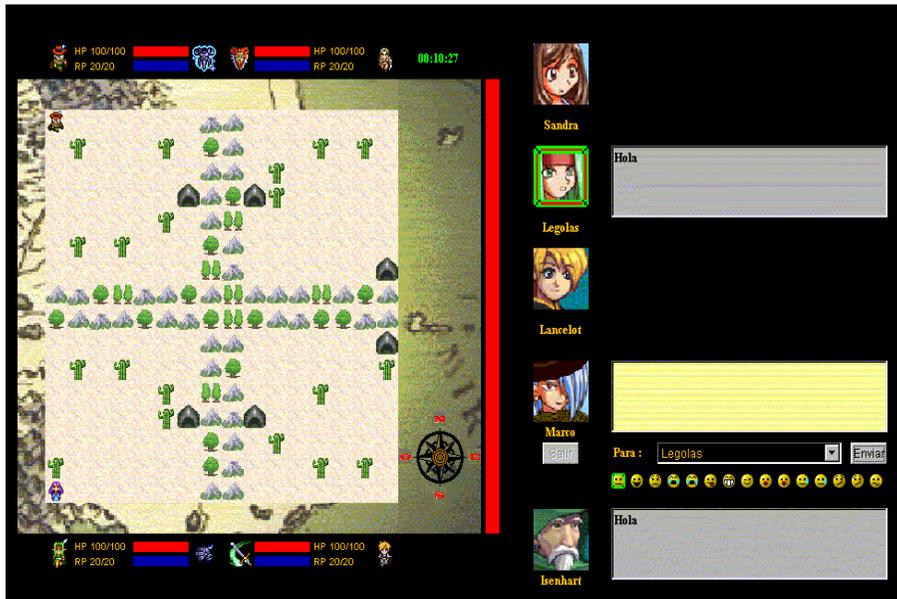


Fig. 5. TeamQuest user interface

4.1 Positive Goal Interdependence

Students must perceive they can achieve their learning if and only if the other members in the group achieve their goals. The group is motivated to achieve a common goal so they must be concerned with how much each other learns, they must understand that they must sink or swim together. The teacher therefore has to structure a clear group goal such as having students learn the assigned material and ensuring that.

Examples: In Chase the Cheese, MemoNet, ColorWay and TeamQuest, 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. In CCCuento, the goal of the activity is to generate the stories. Of course, all participants are co-authors of all the stories. This goal cannot be reached unless all group members do their part. If there is failure, the blame is also shared.

4.2 Positive Celebration/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. Regular celebrations of group efforts and successes stimulate cooperation.

Examples: In Chase the Cheese when starting to move the mouse, the coordinator has an individual score of 100 points. Whenever the mouse hits an obstacle, this score is decreased 10 points. When the mouse passes to another quadrant the individual score is added to the total score of the group. If any of the individual scores 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 (the highest score is obviously 400 points).

4.3 Positive Resource Interdependence

Each member has only a portion 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. Unless the members combine their resources the group will not achieve its goals. The teacher may want to give students limited resources and emphasize the importance of sharing and cooperating in order for the group to succeed.

Examples: In TeamQuest, as each member has only a portion of the information about traps- which is necessary for the task to be completed- the members' information need to be shared in order for the group to achieve its goal. In Chase the Cheese, since each participant has a partial view of the labyrinth, she must interact with her peers to solve the problem. In MemoNet, each participant has a partial view of the game; therefore, the player must interact with her peers to solve the problem. Color-Way uses the same idea.

4.4 Positive Role Interdependence

Each member is assigned roles that are inter-connected and which give specific responsibilities that the group needs in order to complete the joint task. The teacher needs to assign complementary roles such as reader, recorder, checker of understanding, encourager of participation, and elaborator of knowledge. These assigned roles ensure high-quality learning.

An example of the usefulness of these roles is the checker of understanding. The teacher cannot verify the understanding of every student at all times. However, a student can do this work for her by periodically asking each group member to explain what is being learned.

Examples: In TeamQuest there are two predefined roles: Doer and Collaborators. Roles are switched during the collaborative activity. In Chase the cheese, the roles are *coordinator* (only one per quadrant and randomly assigned) or *collaborator* (the three remaining). The roles are also interchanged during the game.

4.5 Positive 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.

Example: In TeamQuest, before playing it, a player creates a new game instance, according to her personal preference. Each player wishing to enter this new game must choose an avatar according to the type of game. In that way, group members define an identity within the game. In CCCuento this is achieved by choosing the group name and the story title, trying to find consensus.

4.6 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. Although there is not a common physical environment where members of the group can play, there is a virtual shared environment in which they can solve the problematic situation in a collaborative way.

Examples: This interdependence applies to all software tools we have developed. The computers are distributed and the only communication allowed is computer-mediated.

4.7 Positive 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. A typical example of this is a game including an imaginary environment, where the group members assume various kinds of imaginary roles.

Examples: Chase the Cheese and TeamQuest include this feature. In TeamQuest group members can choose several environments. For example, they can pretend to be in the Middle Age, and according to that, different kinds of characters appear, as Paladin, Elfo, Bardo. They then need to use language to accomplish goals in their imaginary situations.

4.8 Positive Task Interdependence

Work has to be organized sequentially. Students have to divide the work and 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.

Examples: In Chase the Cheese and TeamQuest, the fact that only one player has the control of the game, and that control is switched every time that a player passes through every cave or quadrant, provides sequentiality. For most tasks, one group member must complete her work before another person gets her turn.

4.9 Positive 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 [11]. This interdependence does not apply to collaborative learning in our examples.

There are nine kinds of positive interdependences, and it could be difficult to try to define which is the most important one. However, the greater positive interdependence is structured within a cooperative group, the more group members will feel personally responsible for contributing their efforts to accomplish the group goals and the more they will realize that negative sanctions appear for failing to do one's part.

Table 1 presents a summary of the kinds of positive interdependences offering some tips on how to design and implement them in a software tool. Also, shows some examples of our software tools.

These eight types of positive interdependence (we do not include Positive Outside Enemy Interdependence) are not mutually exclusive. Indeed, our software tools described in this paper involve several types of positive interdependence.

5 Discussion

Rather than simply allowing students to interact in small groups and then hoping they will do so in a cooperative manner, our software tools incorporate specific procedures designed to create a feeling of group identity among students and collective responsibility for one another's learning. It is important to notice that we are drawing insights from studies done at unsupported face-to-face settings. Our study, instead, includes computer-mediated communication. The computer support introduces several aspects into the collaborative situation by modifying the interdependences, as discussed below. The following procedures are used to increase the likelihood that this sense of positive interdependence develops within groups:

Group Production of a Common Product at the End of the Cooperative Learning Experience. In contrast to the usual discussion, or buzz group which gets together for informal discussion of some course related issue, each group is expected to generate a formal product which represents a concrete manifestation of the group collective effort (it solve the problematic situation). The objective of working towards a clearly defined common goal is essential for keeping individual students on task and focused on a group goal.

Assignment of Interdependent Roles for Each Group Member. A sense of individual responsibility to the group may be increased if each group member has a specific and essential role to play in achieving the group's final goal or product. Roles can also be assigned on the basis of different perspectives that group members are expected to contribute to the final product e.g., historical, ethical, economic, or global, etc. Such role specialization assures that each individual has an explicit and well differentiated responsibility to the group throughout the learning process. A further advantage of role specialization is that the quality of each member's contribution can be more readily identified and assessed by the instructor, thus allowing for individual grading and individual accountability which is a critical feature of Collaborative Learning [11].

This monitoring feature distinguishes our approach from the unsupported previous face-to-face experiments.

Table 1. Kinds of positive interdependences

Interdependence	Guidelines	Examples
Goal	One way to promote that kind of positive interdependence could be including some break points, where group members have to check success criteria, such as guidelines, roles and boundaries.	In CCCuento, before passing to another phase it is necessary to solve a consensual activity. E.g., the first synchronization instant (before passing to “body A” part), has a break in which the students must assign a name to their group. After finishing the last phase, they must give a name to the story.
Reward	It can be built into the group by having some form of shared grades. E.g., besides their individual scores on an activity, the tool gives a certain number of points if all group members score at or above a certain score.	In Chase the cheese there are partial and total scores. In CCCuento, we have used the software tool as part of a writing course. At the end, the teacher gives a grade according to the quality of stories presented.
Resource	Students do not have to complete the task by themselves. The tool must “force” to interact hiding part of the information to some participants.	In Chase the Cheese, TeamQuest, MemoNet and ColorWay every member of the group has only 25% of the total information to solve the problematic situation.
Role	The participants of the session using the software tool must have specific roles assigning specific responsibilities to each person. These roles must be interchanged.	In Chase the Cheese, MemoNet, ColorWay and TeamQuest there are two kinds of roles: Coordinator and collaborators. These roles are exchanged during the collaborative activity.
Identity	It provides a mechanism through which people can choose an avatar, name of the group, and level of difficulty.	TeamQuest includes an option to choose an avatar according to the type of game.
Environment	It provides a virtual shared environment in which they can solve the problematic situation in a collaborative way.	In Chase the Cheese there is a collaborative shared virtual environment, where players must lead the mouse to its cheese.
Fantasy	Design the interface using imaginary situations where those participants find enjoyable and captivating.	In TeamQuest group members pretend to be in another time (revival, medieval, etc), or to be different people.
Task	Design the activity in a sequential way. To complete certain part it is necessary to have completed a previous part. One group member must first complete her task before the next task can be completed.	In Chase the Cheese and TeamQuest group members must fulfill a partial goal that is accomplished when every one of them “solves” her own quadrant before passing to the other quadrant.

Team-Building Activities Designed to Produce a Sense of Group Identity and Social Cohesiveness. For example, in CCCuento, before passing to another phase it is necessary to solve a consensual activity. Such activities would include ice breakers or warm-up activities when groups are first formed; creating team names; providing explicit suggestions and concrete recommendations for promoting cooperation and teamwork. The underlying rationale for these team-building activities is to create a social and emotional climate conducive to the development of an *esprit de corps* and a sense of intimacy among the group's members. This will enable them to feel comfortable in future tasks that will ask them to express their personal viewpoints, disagree with others and reach consensus in an open, non-defensive fashion. The key assumption here is that the potential cognitive benefits of small-group learning are more likely to be realized in a social context characterized by group cohesiveness, mutual trust, and emotional security. Furthermore, such explicit attention to the social and emotional aspects of small-group dynamics may be instrumental in fostering social support and emotional ties among peers which are factors known to have a significant impact on student retention [19].

6 Conclusions

Positive interdependence provides the context within which promotive interaction takes place, group membership and interpersonal interaction among students do not produce high achievement unless positive interdependence is clearly structured. For that reason, 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. Positive resource, role, and task interdependence result in individuals realizing that the performance of group members is mutually caused. No student is on her own. As a result of mutual causation, cooperative efforts are characterized by positive inducibility, i.e., that group members are open to being influenced by each other. If one member of the group has taken the action there is no need for other members to do so [14].

Just putting students in groups and telling them to work together may not be sufficient to achieve positive interdependence among them [10]. For this reason, it is necessary to structure collaborative activities in order to promote positive interdependence among members of the group. 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.

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 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, complete tasks and produce in order to reach the group's goals).

The collaborative scenarios we propose are based on an interpretation given by Dillenbourg on how to link learning situations, interactions, cognitive mechanisms and cognitive effects when groups engage in solving problems [9]. We include positive interdependence as an element to help promote that kind of collaborative situation.

Through careful planning, positive interdependence can be established by having students achieve: (a) mutual goals, such as reaching a consensus on specific solutions to problems or arriving at team-generated solutions; (b) mutual rewards, such as individually assigned points counting towards a criterion-referenced final grade, points which only help, but never handicap; (c) structured tasks, such as a report or complex problem with sections mutually developed by all team members; and (d) interdependent roles, such as group members serving alternately as discussion leaders, organizers, recorders, and spokespersons [16].

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