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Study and analysis of workspace awareness in CDebate: a groupware application for collaborative debates

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Abstract

In this paper, we study the workspace awareness in a groupware application allowing the development of an information task through collaborative debates. The application, called CDebate, is based on the APRI (Action–Perception–Reflection–Intention) model, which establishes a cognitive and motor states organization that occurs when humans are interacting with one another in a constructivist and collaborative learning situation. In CDebate, the interactions among students occur through a graphical language that reflects the mental operations appropriate for a debate. As an evaluation method, a conceptual framework, which provides a set of elements that give information about the up-to-the-moment knowledge about participants' location and actions, is used. The results of this study allow us to confirm that group awareness information, supported through a graphical language and a window showing the participants' presence (informal awareness), were sufficient for success in the collaborative learning situation. This experience could be useful for interface designers of groupware applications, in particular for collaborative debate interfaces.

Keywords: CSCL; Group awareness; Workspace awareness; Groupware interface; Collaborative debate; APRI

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1. Introduction

Research work on Computer Supported Collaborative Work has revealed the importance of groupware applications that have the ability to integrate efficient mechanisms in order to achieve group awareness. Group awareness can be understood as “a mental state of the users generated by their mutual interactions and their interactions with the shared workspace. Thanks to this mental state, a user is able to collect a common knowledge, which enables him to make decisions about his own actions with the purpose of reaching the group goal” (Mendoza Chapa et al., 2000, p. 113). The shared workspace refers to a physical space where the participants can carry out any joint activity.

Gutwin and Greenberg (1996, 1999, 2002) consider that group awareness should provide up-to-the-moment information on the workspace, location of participants and their actions within the workspace. Based on diverse research on group awareness for groupware applications, the authors identified four types of awareness:

- *Informal awareness.* The general knowledge of who is around and who is present (casual interaction; social interaction).
- *Social awareness.* The knowledge a person maintains about his peers in a social or conversational context (emotional state; level of interest).
- *Group-structure awareness.* The knowledge about the roles and responsibilities of people, as well as their positions on any element (group decision making; representation of arguments).
- *Workspace awareness.* The up-to-the-moment knowledge used by a person in order to capture the interactions of other people within the workspace (presence; activity and location of participants).

It is possible to estimate the value of *knowledge* as a key element for group awareness within a collaborative environment, since this constitutes a crucial aspect of the success of the interaction among the members in a group. Collaboration in a workgroup is characterized, in first instance, by the fact that participants have a common objective. Besides, they should also develop actions toward the successful execution of the objective. To this effect, it is necessary to know the individual behaviour of the members as a way to find out if they are carrying out collaborative actions or if their personal objectives are being interposed. On the other hand, the will to participate plays an essential role in group work, due to the possibility of visualizing the result of a reflection, by means of the actions developed, at the time a member is interacting with the group.

With the aim of assessing students’ participation in a collaborative learning activity, a groupware application called CDebate has been developed, which allows the construction of an information task through collaborative debates. Such application is based on the APRI (Action–Perception–Reflection–Intention) model (Osuna-Gomez et al., 2003), which establishes an organization of the cognitive (Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation) and motor (physical skills, corporal movement thinking, etc.) states that occur in human beings while interacting with others during a constructivist collaborative learning situation.

The aim of this work is to study and analyze the workspace awareness in CDebate in order to know if the information of group awareness, handled through a graphical language (essential feature of CDebate as an instantiation of the APRI model), is sufficient for a collaborative learning situation. In order to accomplish this goal, the framework proposed by Gutwin and Greenberg (1996, 1999, 2002) is used as an evaluation method providing a set of elements to get information about the up-to-date knowledge of participants' locations and actions. The scope of this study is limited to focus only on workspace awareness.

The rest of the paper is organized as follows. In Sections 2 and 3, the APRI model is described and an overview of the evaluation method is presented as being a conceptual framework for the CDebate implementation. In Section 4, the CDebate application is described. The case study and analysis of the results are given in Section 5. Finally, in Section 6 conclusions and the future work are discussed.

2. The APRI model

Different models of cognition have been developed and studied both in cognitive and computer sciences (Stanback, 1992; Jonassen and Land, 2002; Newell, 1990). Usually, human cognition is seen as a fused, cyclical, interrelationship among the *cognitive components*: the senses, intellect, emotion, will, behaviour, and stored knowledge. All the components of cognition are interrelated or interdependent. They function or operate upon consciousness; thus to be conscious is to learn or to be actively involved in the educational process in some manner, i.e. by being aware of oneself and about what is happening in the learning environment.

Recently, more emphasis has been placed upon the aspects of cognition and learning in collaborative contexts. This change of focus implies the necessity to consider the notions of joint mental attitudes and actions. In these cases, we can speak about *interacting mental attitudes* constituting a state of a workspace and *interacting actions* as well. Different aspects of this type of behaviour are studied in dialogue theories as communicative interactions and in planning approaches as concurrent interacting actions (Traum, 1997, 1999; Cavedon et al., 1997; Alvarado et al., 2002).

In this sense, we have developed the APRI model, which is derived from the field of the human–human interaction as an organization of the mental states resulting from teamwork. The proposed model is constituted by four well-identified phases: action, perception, reflection and intention and follows the ideas of Jonassen (Jonassen and Land, 2002) who models these phases as conscious states. The APRI model is an organization of perceptive, cognitive will and action phases that occur inside the participants while interacting with one another. It explicitly covers the collaborative context in constructive and collaborative learning situations. In the HCI field, there exists a key model derived from the Norman's work. It is named Norman's seven level model (Norman, 1986) and it suggests that the interaction between a person and a computer requires both mental and physical activities. Although this model covers the human–computer interaction, we noted a clear relation with the collaborative learning process. In these environments, a key perspective is to promote the interaction in order to collaborate and learn. Thus, the evaluation and interpretation steps were included together in a reflection process because students, in a learning process, do not evaluate immediately. Evaluation can be presented—or not—in a collaborative learning environment. On the other hand, action and execution—steps of the Norman Model—are considered in the APRI in the 'action' level because of the duality of the collaborative learning activities. This duality is derived from the human–computer and the human–human interactions, which are presented in the real classroom where students combine them in order to learn together.

The phases of the APRI model are represented in a linear way starting from the individual human action and they are derived from the collaborative global goal (in particular the collaborative learning goal). The phases are: *action, perception, reflection and intention*. Fig. 1 describes the model phases in an individual (a) and collaborative (b) situations. Communication among participants is made through *interaction*.

In the individual situation (see Fig. 1(a)), we can observe the phases flow. The first phase is action (1), where a participant executes an operation or task in order to change the environment. An action is the activity performed by a participant in order to communicate his/her goal, knowledge, sense and environment evaluation (Driscoll, 1999). Thus, it is the connection between the participant and the environment and frequently it has motor characteristics because the participant has to use one (or a combination) of physical and external senses (with the exception of silence, which is

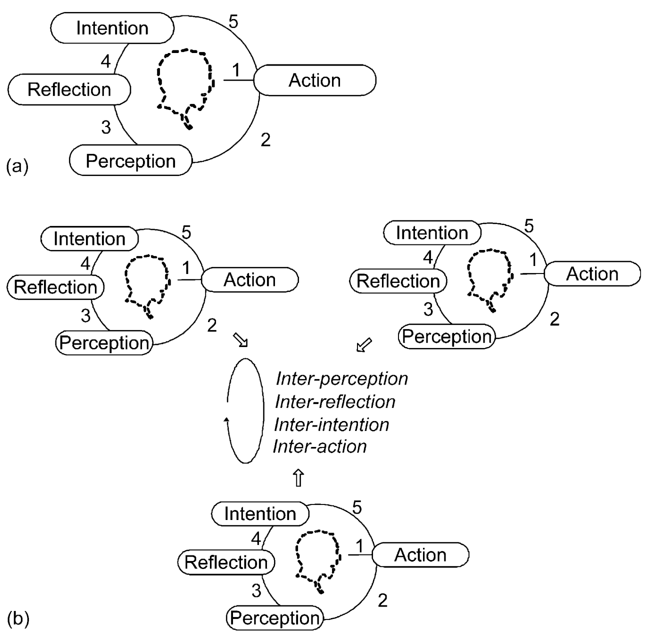

Fig. 1. The APRI Model. (a) Individual model. (b) Collaborative model.

considered as a physical state without motion). Also, action is a tangible event, which can be observed by others, and it has been used in order to evaluate the individual cognitive situation in the debate about learning. In a collaborative learning situation the relation among actions is known as *interaction* and it has been widely used in order to measure and evaluate the participant contributions, group organization, and distribution, and cognitive individual development (Martinez, 2003; Stone, 2002). However, as we see below, APRI suggests extending this perception.

Action changes (step 2 in Fig. 1) are taken by the participants in the perception phase, which is understood as the meaning assigned, in an individual way, to the information received from the environment. This individual assignment begins with the participant's previous knowledge, experience and values, related to the environment information (Wilson, 1997). With respect to learning, perception has a direct impact on the teaching–learning process configuration since both teacher or instructor can compose learning activities highly related with the previous students' schemes. Consideration of learning is a process of previously experienced reorganization (Ausubel, 1963).

Perception is considered in the reflection phase (step 3 in Fig. 1), which is an individual way to justify the perception change. This means that reflection facilitates the internal debate, where a participant proposes arguments (for or against) with the idea of changing or not the perception related with the action. Reflection is a cognitive and affective process, where a participant processes his/her decisions and relates the last contribution with a new participation in the environment.

After a reflective process, a participant adds an intention to it (step 4 in Fig. 1). Intention is understood as the determination to achieve a goal. If the intention is known, then it is possible to know the existence—or not—of the collaboration desire. In APRI, intention is studied in two motivation perspectives: (i) as the information added in order to represent the individual reflection in the environment; and (ii) as the individual necessity to increase a participant knowledge environment. Finally, in this phase the participant produces a new action (step 5 in Fig. 1) in order to change the environment.

A collaborative situation is shown in Fig. 1(b), where participants are working together in order to achieve a common goal. In a traditional way, the collaboration process has been mainly studied under the interaction perspective. In this sense, APRI suggests that the collaborative process has to be focused not only on the interaction studies, but also on a set of properties emerging from this process and the common goal. These properties are: *inter-perception*, *inter-reflection* and *inter-intention*, which can facilitate information about the relation among participant internal processes and can open a new way to classify the best collaborative practices.

Inter-perception is the relation established among the participant's perceptions. In APRI, a perception is related with learning styles. In a collaborative learning situation, we can observe multiple kinds of learning styles. For example: extravert, introvert, judge, passive, sensitive, intuitive. A complete list can be found in (Blank et al., 2002). Thus, inter-perception is derived from the involvement of two or more perception styles in the student relation. An inter-perception has an implication on the collaborative situation because the collaborative goal has multiple meanings depending on the individual style perception.

The second emerging property proposed in APRI is inter-reflection, caused by the different cognitive levels of participants. In the model, the cognitive levels are derived from Bloom's taxonomy (Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation) (Bloom, 1956). Then, in a collaborative situation an inter-reflection is among cognitive levels and it also has an important implication for the collaborative process. In fact, while one participant can reflect on a simple comprehension, another one can reflect on evaluation. Inter-reflection means not only to put the levels together, but also to understand the implication of one level for the other. Currently, we are studying how to add affective levels to the reflection process.

The last emerging property suggested in APRI is inter-intention, which establishes the relation among the intention components. In order to know and measure the participant intention, APRI proposes to work with both the Grice Principle (Grice, 1975) and the Language Functions (Jakobson, 1984).

The cooperative Principle of Grice is based on four maxims. The MAXIM OF RELEVANCE, suggests that the sender's contribution must adjust to the system of expectations and selective restrictions, which are ordered in relation to the collaborative goal of the group. This maxim looks for whether the information, given by the group members, is significant or not to the group goal. The MAXIM OF MANNER recommends that the participation in the conversation must be brief, ordered, clear and concise without ambiguity. It is important that the correct construction of each intervention be in agreement with the grammar laws and the rhetoric. The MAXIM OF QUANTITY proposes that the members must offer a contribution, which is not more informative than necessary. The MAXIM OF QUALITY suggests that the sender should not give his opinion on that for which s/he has no evidence, what s/he considers false or what has not been verified. On the other hand, the Language functions are Phatic, Emotive, Conative, Poetic, Referential and Metalinguistic.

The inter-intention is derived from both the relation among Grice's Maxims and the relation among language functions. In this sense, we can observe that while a student shows cooperation scoring high in the Maxim of Quality, another can score low. At the same time, while one student can communicate his thought emotively, another one can use a referential expression. Thus, inter-intentions can give information about the intention difference among students in a collaborative learning activity.

Currently, APRI is being studied in different collaborative learning situations, in order to find new parameters and to finish a framework. APRI has been tested with intentions and inter-intentions as shown below.

3. Conceptual framework for the workspace awareness study

Gutwin and Greenberg (1996, 1999, 2002) proposed a conceptual framework that establishes the necessity for a vocabulary and a starting point for the structural development of group awareness. This framework considers, on one hand, a functional set of *elements* that plays a role in the workspace awareness of group participants. On the other hand, it considers the *mechanisms* that these participants use in order to gather the necessary information to maintain the workspace awareness. Note that the workspace awareness mainly contains information about who is working on what.

It is important to understand that the interactions among participants in the workspace allow: (a) event interpretation; (b) the appropriate anticipation of the necessities; and (c) the appropriate interaction of shared objects. In this way, a continuous cycle is established where each participant: (i) collects the information related to the workspace; (ii) integrates this information with his/her existent knowledge; and (iii) uses new knowledge in order to manage his/her actions, which is highly related with APRI perspective. Table 1 shows the elements of awareness related to the workspace of this framework. The participants take into account these elements when a collaborative learning situation is presented. In this way, questions asked by each participant—during the collaborative activity—can also be found in Table 1.

At this point, it is important to mention that this framework is only related to the property of *interaction* within the APRI model. Therefore, our analysis in this work is focused only on *workspace awareness*, which is our starting point for studying the three properties of the APRI model (inter-perceptions, inter-reflections and inter-intentions); these are important in order to understand the global process of collaboration. The interactions in CDebate—represented through a graphical language—provide information about the workspace awareness such as presence and current action of each participant in the debate scenario. Table 2 shows a subset of our graphic language and corresponding learning activities.

The first question—concerning presence in the workspace—indicates the identity of all the people working in the workspace. The other questions could be grouped in different categories. The first category of questions reveals *which* information is taking place in the workspace, while the second class of questions indicates *where* this is happening. The elements that contain the word *what* reveal knowledge about: amount of activity, nature

Table 1
Workspace awareness elements (adopted from Gutwin and Greenberg, 1996)

Elements	Relevant questions
Identity	Who is participating in the activity?
Location	Where are they?
Activity Level	Are they active in the workspace?
	How fast are they working?
Actions	What are they doing?
	What are their current activities and tasks?
Intentions	What are they going to do?
	Where are they going to be?
Changes	What changes are they making?
	Where are changes being made?
Objects	What objects are they using?
Extents	What can they see?
Abilities	What can they do?
Expectations	What do they need me to do next?
Sphere of Influence	Where can they have effects?

Table 2
Some elements of the CDebate graphical language

Learning Activity	Icons of the CDebate Graphical Language				
CONCEPTUALIZATION	Main Subject	Partial Subject	Function	Factors	Relation
RELATION	¿Qué? ¿What?	¿Para que? What for?	¿Cuándo? ¿When?	¿Por qué? Why?	¿Quien? Who?
DISCUSSION	Argument for	Argument against	Explanation	Position	Picture
WRITING	Knowledge	Comprehension	Analysis	Application	Evaluation

and content, changes that take place in the shared objects, the participants' skills to carry out actions, as well as their expectations for other's actions. Those elements that contain the word *where* reveal knowledge about: the attention center of each participant, the changes being carried out, as well as the objects they are manipulating.

Having a complete knowledge about what is going on within the workspace allows the participants to carry out a fluent interaction and to work together in order to create new opportunities of collaboration. The workspace must be an assistant to coordinate tasks and resources with the purpose of supporting participants' tasks and their actions.

Through this conceptual framework, we propose to study the workspace awareness of CDebate. Within the shared workspace, we studied and analyzed which information about the students' interactions is gathered and how it is presented to the others.

4. The CDebate application

CDebate is a groupware application for collaborative learning in which the collaboration analysis is based on the APRI model and learning activities are designed based on the DELFOS framework (Osuna-Gomez, 1999). DELFOS allows the development of collaborative learning situations whose objective is to motivate students to develop and to describe information tasks (Kuhlthau, 1993). The application emerges as a result of an activity derived from the exploration and recovery of information. CDebate allows the exploration task to be carried out by collaborative learning groups. Our application objectives are similar to those of CIR (Collaboration Information Retrieval) application (Raya et al., 1999) where the exploration, selection, classification and presentation of information processes are carried out collaboratively.

4.1. Learning situation with CDebate

In DELFOS framework vocabulary, CDebate is a learning situation configured in five learning activities: CONCEPTUALIZATION, RELATION, ANSWER, DISCUSSION and WRITING.

The framework of CDebate is organized as a synchronous shared whiteboard, with neither floor control nor hierarchy. The professor takes a spectator role and does not participate in the students' interactions. However, at the beginning, the professor indicates a topic and gives instructions to the students in order to elaborate an information task related to it.

The first activity, CONCEPTUALIZATION, suggests that the students set up goals, topics, attributes and factors related to the topic indicated by the professor. These elements help to configure a conceptual map related to the topic they are exploring. This activity allows knowing the topic's structure and its components by which the student determines the information to be explored. Also, this activity has the constructivist objective of *exploration of previous knowledge*, where the students expose their previous knowledge scheme related to the topic to be discussed (Ausubel, 1963). There is a mouse pointer for each student in the shared whiteboard. These pointers are identified by different colors. When a student decides to perform an action in the shared whiteboard, first he must identify his pointer, because the mouse pointers of all the students are visualized in the same workspace. After that, he selects an icon related to a debate concept from the menu bar. The selected icon appears in the mouse pointer position. Finally, a student writes a note in order to justify his action (see Fig. 2).

Fig. 2 shows the CONCEPTUALIZATION activity in which a whiteboard is used to generate a collaborative conceptual map. Participants use the icons available in the toolbar. It is possible to see that each participant owns a mouse pointer. All participants can manipulate the structure of the conceptual map or they can move pictograms, add new ones, modify the existing ones or erase them from the conceptual map. The application has a central server which controls concurrent access to shared objects.

The second activity, RELATION, proposes to establish relations among concepts as in a conceptual map. This activity promotes *n-to-n* relationship among attributes, functions and factors. This task has the constructivist objective of identification and justification of relationships. The students discover hypothetical relations among the elements that constitute the topic (see Fig. 3).

Fig. 3 shows the RELATION activity in which the participants justify the available relations or they can generate new hypotheses or relations. In order to justify the relations, participants use a Chat-like tool, by which each participant expresses his point of view. The window at the right shows the list of all the active participants (presence awareness).

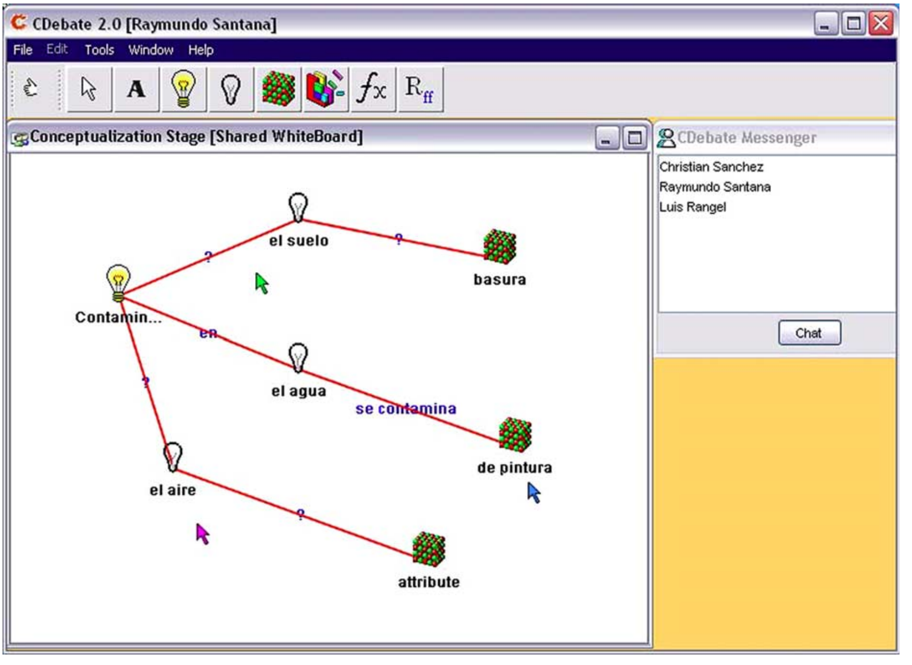

Fig. 2. The CONCEPTUALIZATION learning activity.

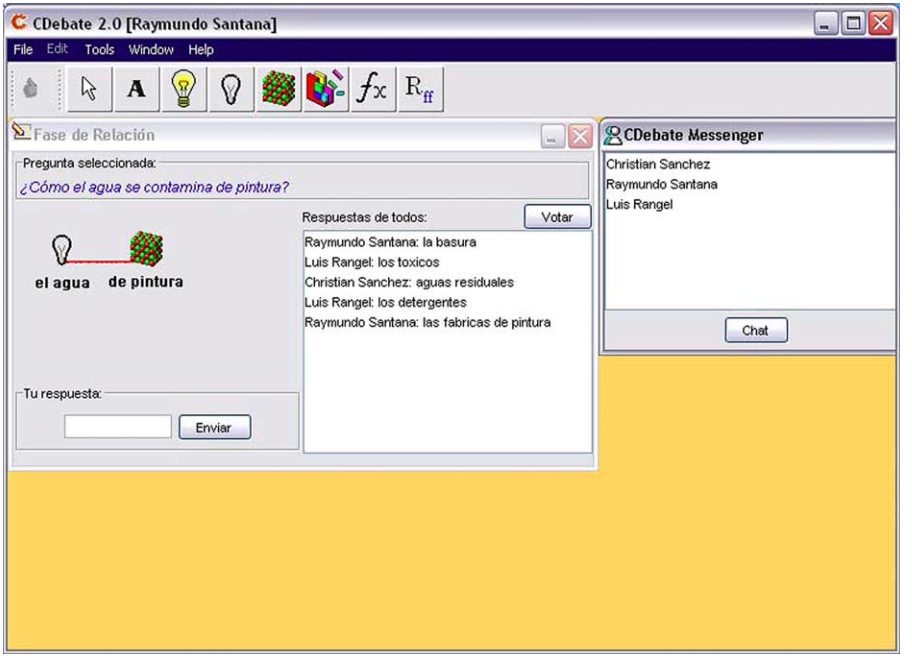

Fig. 3. The RELATION learning activity.

The third activity, ANSWER, allows students to justify relationships through hypotheses. The students propose their ideas with the purpose of understanding the relationships among attributes, factors and functions of the topic. This activity has the constructivist objective of *searching for alternative solutions*. In this activity, the students neither discuss, nor debate the validity of the hypotheses, but they describe many possible answers. They work doing collaborative brainstorming, in which each member just writes without evaluating the ideas. This activity facilitates a constructivist scaffolding that helps students to detect answers. This scaffolding is composed of common research questions, such as: What? Who? How? Where? Why? What is his/her purpose? What is being used? These questions motivate the students to investigate the hypothetical explanations and organize ideas. The relationship between these questions is based on critical thinking and the students have to use the most significant questions for them (see Fig. 4).

Fig. 4 shows the ANSWER activity in which all participants expose different ideas/answers about one question. Once the set of ideas is presented, all participants can carry out a voting to choose the idea that the group is going to follow. A central server collects all voting and computes the final result.

The fourth activity, DISCUSSION, requires the selection of the hypotheses mentioned above and suggests the beginning of a debate among the members of the group. The students have to devise and support ‘for and against’ arguments and they must present

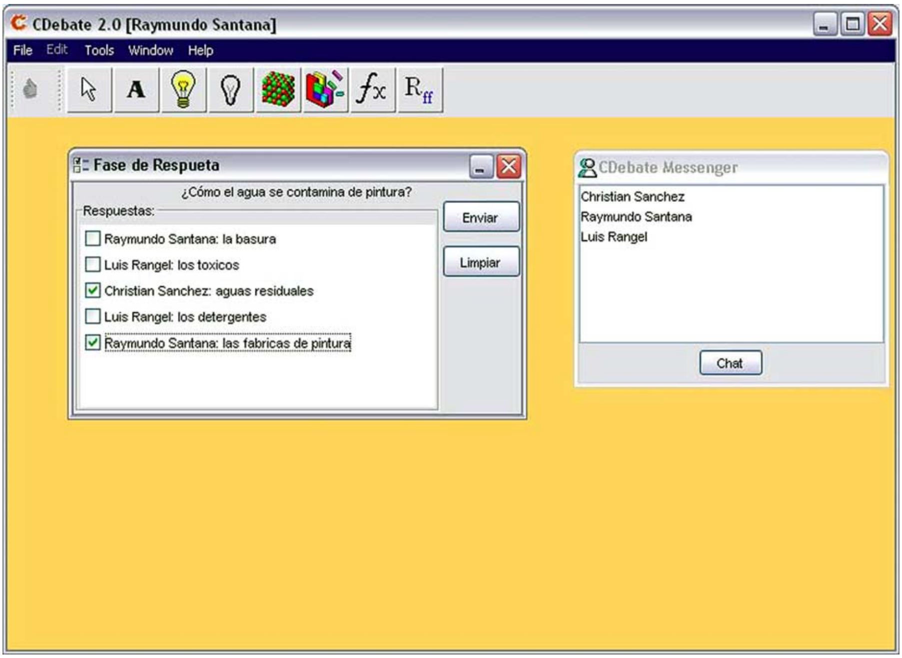

Fig. 4. The ANSWER learning activity.

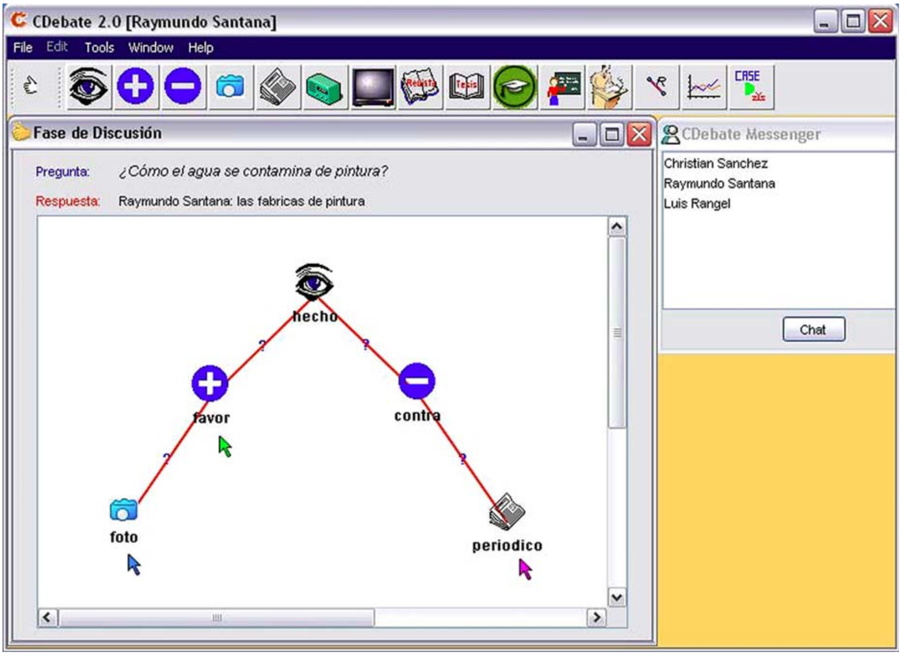

Fig. 5. The DISCUSSION learning activity.

evidence and discussion threads. The debate is carried out by the selection of which icons from the menu bar are related with mental debate operations (see Fig. 5).

Fig. 5 shows the DISCUSSION activity in which we can see the question and the answer selected by a majority vote. We can see that the participants are giving arguments for and against that are related to the answer and are in accordance with their personal interest, always justifying them with evidence. Note that the interface is similar to the CONCEPTUALIZATION activity's whiteboard. The only difference is the toolbar provided which is specialized to generate debates. The evidence is usually represented by icons, but these icons can also be linked to external media (audio, video, text files, images, Web pages, etc.) or to written notes.

The proposed language for CDebate may be extended to all learning situations, in contrast to the one proposed by Horn (Horn, 2000), which includes a limited graphic language to establish the discussion threads.

Finally, the WRITING activity allows collaborative writing. It includes the formal definition of an exploration task, based on the debate learning results. The activity offers a workspace for collaborative writing where the students write the sentence of the information task. This workspace has been proposed in (Sheremetov and Romero-Salcedo, 2003). It includes a group of verbs indicating a cognitive action. Therefore, the students select a verb with the purpose of defining the cognitive goal of the information task. Verbs are taken from the six categories of Bloom's taxonomy levels mentioned above.

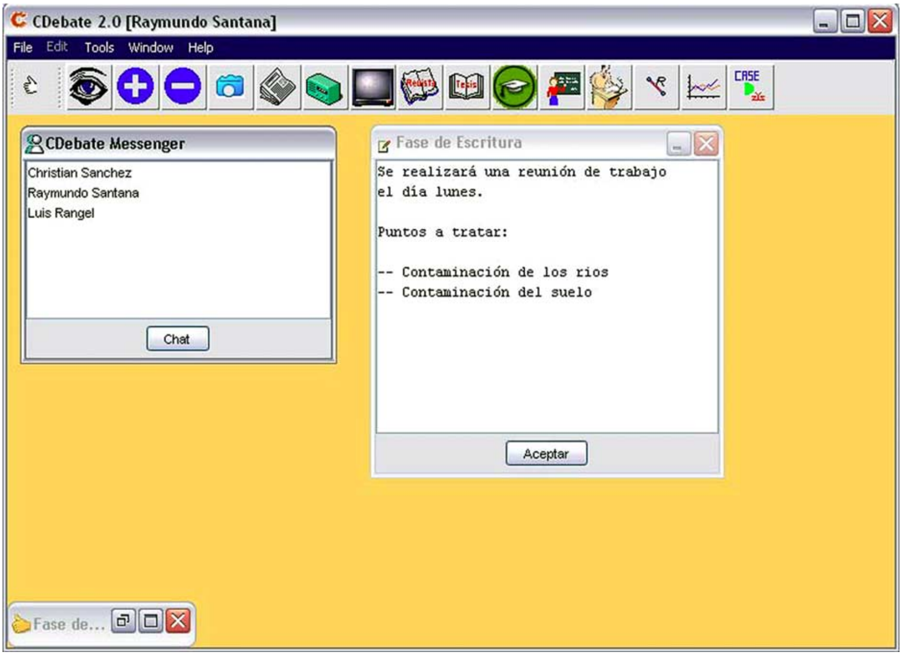

Fig. 6. The WRITING learning activity.

The activity has the constructivist objective of promoting *meaningful construction* (see Fig. 6). Furthermore, it is possible to add evidence from the argument through a multimedia tool in CDebate.

Fig. 6 shows the WRITING activity in which a simple group editing tool is used by all participants. In this text editor participants can jointly write their information task.

5. Case study: the workspace awareness in CDebate

5.1. Methodology

In order to carry out the study and analysis of the workspace awareness in CDebate, we carried out an evaluation study of the usability within the conceptual framework of Gutwin and Greenberg (1996, 1999, 2002). Students from the Engineering Faculty of the Guadalajara Autonomous University and from the IMP (Mexican Petroleum Institute) participated in the study constituting two different groups. Students' group organization was in co-located configuration. At the beginning, the teacher explained to the students the use of the CDebate application and presented the topic at hand in order to elaborate the information task. Each student used a personal computer connected to the Internet in which the application was running. Immediately, the students began the development of the information task, associated with the topic, through the collaborative debate.

With the aims of: (i) identifying, describing and comparing the captured information about the interactions between the students, and (ii) using collaborative CDebate whiteboard and presentation of this information to the others, the following activities were completed:

1. Recording a video of the collaborative debate with the purpose of reconstructing the history of the learning situation.
2. Presenting questionnaires to the students and the teacher with the purpose of obtaining their opinions and comments.
3. Analyzing the video, focusing on the arguments written by the students and the use of the icons of the graphical language.
4. Interviewing the students and the professor during the debate with the aim of knowing other aspects not considered in the questionnaire.
5. Writing a document with the description of the history, as well as the results about the quality and amount of the contributions, relations between the concepts, actions and interactions (group awareness) between the students while fulfilling the objective.

The evaluation was done at the beginning, during and at the end of the CDebate session. We analyzed mainly the interaction among the students, through the graphical language, with the shared workspace and the objects inside it. Students' interactions were supported by a window showing the presence of all the participants (informal awareness). Observing how these actions were completed by using the graphical language available, we obtained information about their interactions. The study of the interactions allowed us to establish an interface with more operations in the debate threads.

Based on a combination of the analysis of the questionnaires and the video, as well as the interviews (questions 2, 3 and 4), we found that each one of the students took a reflection time which depended on the other's actions. Through the interview made to the students during the debate session, the questions were asked before executing an action. Most of the answers were that they reflected, thought, imagined and observed the actions of the others with the purpose of knowing what to do immediately.

We corroborated as well that the pointers of each mouse were a suitable source to know what each student was doing, as well as how and where s/he was working. Through the analysis of the video, we observed that the mouse pointers implicitly gave the idea to each student about the amount of the activity and the content of actions, as well as the changes occurred.

Some of the questions included in the questionnaire were: Did you know the graphical language? Is there any relation between the previous idea about the debate and the CDebate graphical language? How do you perceive the idea of a debate as a set of arguments? Did the students use and share enough evidence in their arguments? Do you think this activity helps the debate process? Was there a constructivist objective? And so on.

Usability evaluation was also supported using the questions derived from the Principle of Collaboration of Grice (1975), which allowed us to measure the intentions of the students through a comparison among the arguments given by them. With these four maxims, the actions performed by the participants were compared according to the context and the goal of each phase. We have used the questions as follows.

Maxim of quantity:

(1) Is the information given complete? (2) Is the participation excessive? (3) Is the participation poor?

Maxim of quality:

(1) Are logical elements given? (2) Are related contributions established? (3) Is there a contradiction between supporting and opposing arguments?

Maxim of manner:

(1) Is the contribution clearly specified? (2) Are icons appropriately used? (3) Are there recurrent elements?

Maxim of relevance:

(1) Does the debate go on? (2) Are context related data provided? (3) Is the main thread appropriated? (4) Is there continuity in the subject?

5.2. Analysis of the experimental results

As the main source for the results analysis, the student and teacher comments and suggestions were used. We compared these ones with our analysis and expectations of the CDebate application used by the faculty of two engineering colleges. The main results were grouped into five sections: Graphical Language, Collaborative Learning Strategy, Reflection and Intention, Group Awareness, Continuity and Activities Configuration. In the following, we consider results in more detail.

5.2.1. Graphical language

The graphical language used in CDebate gave rise to a substantial amount of comments. Students declared that it was good for an initial debate, but it has to be more dynamic and adaptive. One of the students commented: “In order to have a more specific debate, probably it is necessary to add more argumentation icons for the information representation, and I’d like to understand the one-eye icon with a simple look. However, the CDebate language was good for initial debate” (see Appendix A). This motivated us to add a new question: what other icons would you propose? The students’ answer was blank saying that they do not know about icons. Although students did not propose new comments, we observed that the system has to be open to a new vocabulary which should be adaptive to the student’s previous knowledge. However, if the language is open, how do the students learn the debate components? In this sense another student commented that “debate language helped me understand the debate components and learn how the debate was formalized” (see Appendix A). In this case, a balance could be obtained from the constructivist learning process. Thus, we are considering opening the language when the students require it, but as a first step CDebate application will use a base language.

5.2.2. Collaborative learning strategy

The students evaluated the use of CDebate as a kind of learning. That means, they compared the traditional teaching methodology with this new kind of learning: debate collaboration in the classroom. In this sense, they manifested their sympathy with the collaborative learning strategy. However, they asked for the teacher's help, because "their common classroom activities are accomplished with teacher presence" (see Appendix A). This motivated us to wonder, what is the teacher's participation and responsibility in the experience? Since a teacher is usually present in their previous knowledge activities then, if we want to develop common interfaces related to the student's previous experiences, we have to open the configuration of the CDebate platform in order to allow the teacher's presence. Nevertheless, 66% of the students commented that CDebate can be considered to be a collaborative strategy and it motivated them to think hard about the *task description*.

5.2.3. Reflection and intention

We asked students about the internal process. They commented that they reflected before making an argument. Furthermore, they added that "CDebate problems motivated us to think before writing an argument, because the argument had to be accompanied with evidence" (see Appendix A). However, in some cases, our observation was that students were focused on the application structure more than on the information task problem. Sometimes they were joking, interfering with a peer's activity: students began to erase a peer's arguments or an application problem and wrote jokes in the same workspace. This problem was overcome with concurrency control strategies. At the same time, we observed that students proposed a quick answer, sometimes without justifying the argument, and they wrote a set of arguments without a logical conjunction. This has a clear relation with the collaborative intention. Students found a way to disturb the collaborative process, because the intention was not related (at that time) with the collaborative process, which is an evident factor in determining success in this context. Clearly, the Grice Principle was an important framework for measuring intention. Unfortunately, the language functions were not enough to know intention, because CDebate was oriented to promote the referential information, and students found a way to communicate emotive attitudes.

5.2.4. Group awareness

Taking into account the Gutwin and Greenberg's conceptual framework, we observed that the students could, at any moment, have knowledge about other persons in the workspace, what they were doing and what they had tried to do. In this way, the communication of information between the students was made in an implicit way through their interactions with the collaborative whiteboard. Each one of the students agreed with the fact that it was very important to know the identity of all persons working, as well as knowing about what was happening and where exactly it happened within the collaborative whiteboard. The manipulation of the icons, representing the concepts of the debate, revealed the knowledge about the attention focus of every student. We observed that the students were always concentrating on their collaborative task and also were very attentive to what was happening with the other students.

5.2.5. Continuity and activities configuration

The CDebate activity configuration was made using the DELFOS suggestions, where each activity is configured with a constructive learning goal. In this case, students commented that "Continuity is logical and similar to going to the library and searching for information in a book; but CDebate is an organized way to do it, and it adds to the collaborative relations among students" (see Appendix A). Students frequently mistook the collaborative tasks for a *division* of labor. When a teacher constructs a learning team indicating a learning task, frequently the students divide the task into parallel sub-activities and put together all the information later on. On the contrary, CDebate activities promoted to work in a real collaborative way, arguing and discussing.

6. Conclusion

The APRI model describes the cognitive and motor processes of a collaborative learning situation organized in four stages. Its major distinctive point is that it not only focuses on the study of learning from interaction, but also on searching for mechanisms to understand inter-perception, inter-reflection and inter-intention. These elements will be able to give more information about the individual state and its relation within the work group.

The CDebate groupware application developed to study the APRI model is highly related with the process of knowledge construction. An application of this type provides an organized situation of learning that forces the students to interact and to collaborate, exposing their previous knowledge. The CDebate application through the five activities of learning ordered by constructivist objectives facilitates the development of abilities for the debate and learning, helping the process of collaborative information exploration.

There are some clear similarities and differences between CDebate and other tools for collaborative debate like *gIbis* (Conklin and Begeman, 1998), *Dolphin* (Geiβler et al., 1995) and the Horn proposal (Horn, 2000). Further similarities and differences are found in visual representation of knowledge domains like CMap, Inspiration and Semnet (Dabbagh, 2001; Cañas et al., 2003). Most of these systems are concerned with the development of collaborative learning situations, generation of cognitive maps, and use of graphical language—the functionality of CDebate as well. On the other hand, in contrast to *gIbis*, CDebate focuses on the development of an information task, which is a learning situation with higher objectives than an isolated debate. Comparing with *Dolphin*, CDebate is focused on learning constructivists' processes more than a collaborative work task. Finally, compared to the application proposed by Horn, CDebate extends the visual language required to develop a collaborative debate.

The analysis of the results of students' responses (Appendix A) suggests that CDebate triggers a high cognitive level, in which the information of group awareness, handled through a graphical language, was sufficient for the execution of a collaborative learning situation and its easy interpretation. Since the results of this research have been obtained from qualitative methodology, though helpful for evaluation of the participant behaviour, they cannot be generalized. Nevertheless, the similarity of CDebate with other cognitive tools mentioned above enables the applicability of the results on group awareness analysis reported here to this type of environment with graphical interfaces. In this way, we consider that our experience could be useful in the design of groupware application interfaces for collaborative debates.

For the study of workspace awareness (presence, activity and location of participants), we stated that the graphical language was sufficient for our study and analysis. However, for some CDebate activities (RELATION and DISCUSSION), it was necessary to add a chat text-based communication. We consider that the use of a graphical language for debate represents a new strategy for the promotion of: (1) the use of a cognitive structure in order to observe a clear cognitive process from knowledge to evaluation; (2) the dialogue, as internal reflection, before exposing an argument; (3) the defence of values and personal beliefs in an ordered way; and (4) the understanding of the composition and the elements of a debate.

In the near future, we are going to work on the development of the automatic evaluation process of intentions through the technology of agents. More precisely, we wish to integrate CDebate into an agent platform (developed in our group and called CAPNET) with the purpose of facilitating the measurement of intentions at the moment that these happen. Nevertheless, we still need to take into account more experiences to know exactly the different behaviours that an agent can exhibit facing the actions, as a consequence of the students' intentions. In order to complete this task, we will begin the construction of debate ontologies to help the agent task.

Finally, we considerer that much research has to be done in order to be able to measure and to evaluate, in a precise way, the process of knowledge construction and the critical mechanism of thought.

Acknowledgements

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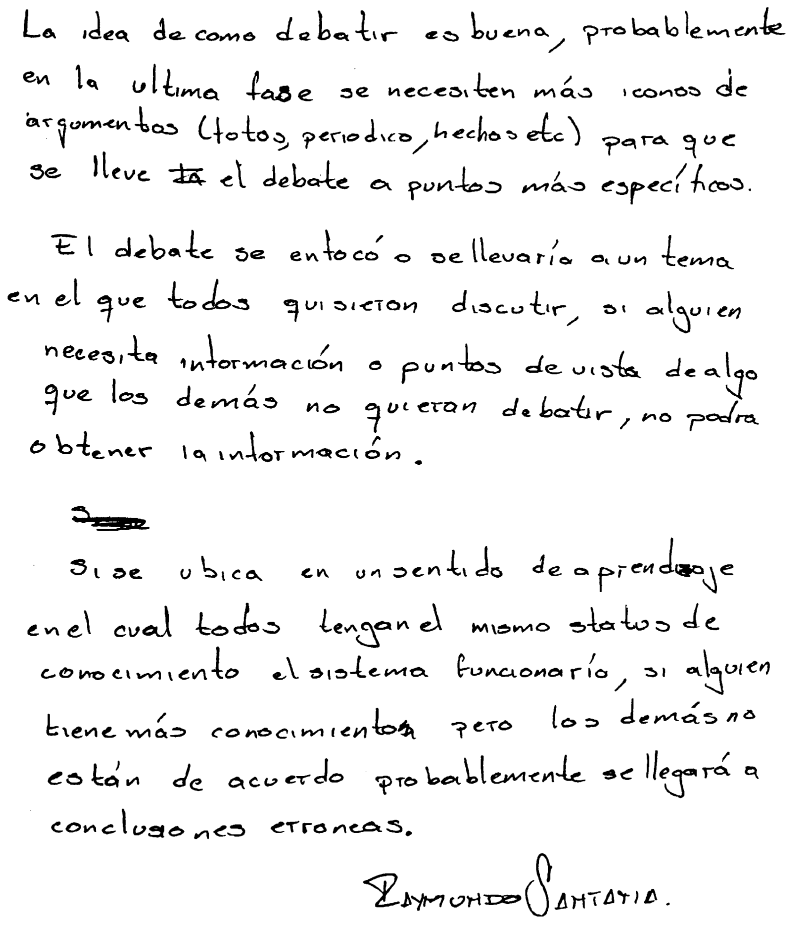
Appendix A

Some examples of answers to student questionnaires.

Excerpt 1

Part of the original document



La idea de como debatir es buena, probablemente en la ultima fase se necesiten más iconos de argumentos (fotos, periodico, hechos etc) para que se lleve ~~la~~ el debate a puntos más específicos.

El debate se enfocó o se llevaría a un tema en el que todos quisieron discutir, si alguien necesita información o puntos de vista de algo que los demás no quieran debatir, no podra obtener la información.

Si se ubica en un sentido de aprendizaje en el cual todos tengan el mismo status de conocimiento el sistema funcionaría, si alguien tiene más conocimientos pero los demás no están de acuerdo probablemente se llegará a conclusiones erroneas.

RAYMUNDO SANTANA.

Translation

The idea of debating is good, probably in the last activity more icons are needed for representing arguments (photos, newspaper, facts, etc.) so that the debate can be handled toward more specific goals. The debate focused on a subject in which everybody wants to discuss, but if someone would need information, or points of view, about something on which the others do not want to debate, we cannot obtain it.

If it is placed in a learning context, wheresense in which all participants have the same status of knowledge, then the system would work, if somebody has more knowledge but the others do not agree, probably would lead to erroneous conclusions.

Excerpt 2

Part of the original document

Opinion General:

Se debe hacer que el sistema no sea tan dependiente del chat, es decir se trate de que lo gráfico pueda ser lo suficientemente descriptivo para que se pueda guardar y manipular la evidencia del debate, creo que sería bueno que el usuario o grupos de usuarios pudieran incluir iconos que representen sus propias ideas, a su vez que estos puedan tener notas o ayudas que puedan contener la información necesaria para describir cada elemento.
Creo que es bueno la descripción mediante entidades y relaciones pero se deben definir bien los sentidos o direcciones que significan para que cuando se generen las preguntas, mantengan el sentido que se les quiere dar.

Las fases deben de ser configurables de manera de que el que cordina pueda pasar de una a otra (es decir tal vez se pueda regresar, si es necesario), y otra forma de pasar a las fases sea por votación cuando uno termine avise y encuanto terminen todos o la mayoría (q también se pueda configurar en porcentaje).
Se debe lograr que la aplicación no falle.

Translation

General opinion:

The system does not have to depend on the chat tool, that is to say, the graphical language needs to be descriptive enough so that the evidence of the debate can be stored and managed. I think it could be useful if the user or groups of users could include icons that represent their own ideas. These icons could include notes and all the necessary information to describe each element. I think that the description using entities and relations is good, but it is necessary to clearly define the sense or meaning of these entities and relations, so that when the questions are generated, they keep the desired sense. The activities must be configurable so that the coordinator could pass from one activity to another (that is to say, perhaps it is possible to come back to a previous activity, if it is necessary); when passing from one activity to another, it would be interesting if the application notified on that.

Excerpt 3

Part of the original document

Opinión general:

Hubo poco tiempo para conocer la aplicación y ésta aún se encuentra en etapa de desarrollo, pero queda la sensación de que es una buena herramienta que ayuda a tener discusiones ordenadas, donde cada participante expone sus ideas y ayuda de esta manera a formar un criterio en los otros participantes. Tal vez la experiencia sea mejor cuando se pruebe una versión más estable, pero no deja de ser sorprendente el poder conocer la opinión de otras personas que tal vez estén a kilómetros de distancia y el concepto de los pictogramas es muy interesante, creo que puede explotarse utilizando iconos más explícitos y llamativos. Sería interesante poder tener un medio de comunicación directa y en tiempo real con los otros participantes, y tal vez algún signo o señal que indique el fin e inicio de etapas.

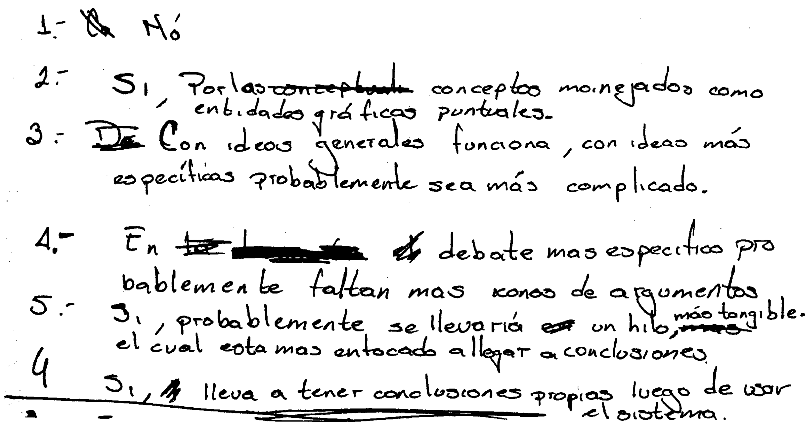
Translation

General opinion:

We had a short time to know the application and this one is still at a development stage, but I think it is a good tool that helps to have ordered discussions, where each participant exposes his ideas. It helps in this way to form criteria for all other participants. The experience could be better when a more stable version of the application can be tested, but it is really surprising to be able to know the opinion of other people who are perhaps kilometers away. The concept of pictograms is very interesting; I believe that it can be exploited using explicit icons and more showy. It would be interesting to have a direct communication media and in real time for communicating with other participants, and perhaps some kind of alert that indicates the beginning or ending of the activities.

Excerpt 4

Part of the original document

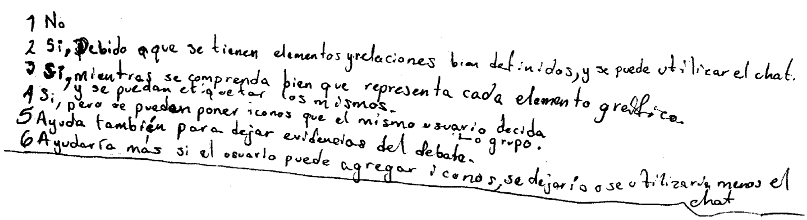


Translation

1. No.
2. Yes, due to the concepts handled as specific graphical entities.
3. With general ideas it works, but with more specific ideas probably is more complicated.
4. In particular debates probably there is a lack of icons for representing more arguments.
5. Yes, probably it would take a more tangible thread, which could be more oriented to reach conclusions.
6. Yes, it helps to obtain one's own conclusions after using the system.

Excerpt 5

Part of the original document

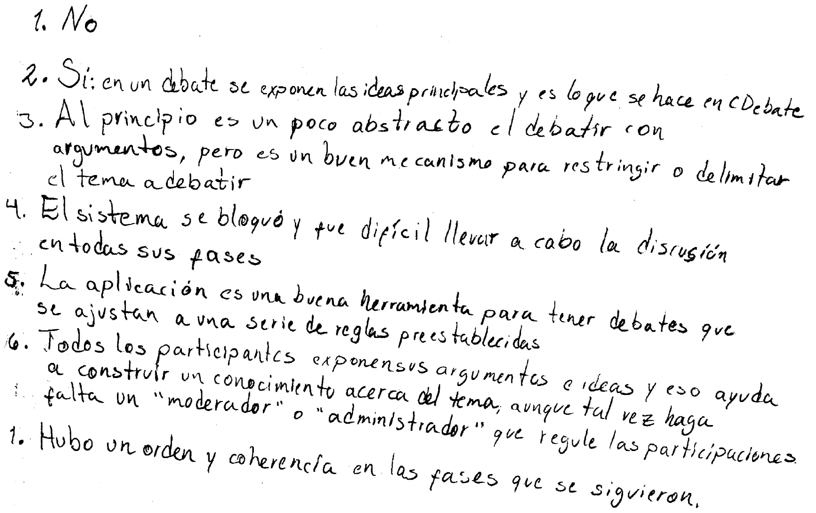


Translation

1. No.
2. Yes, because we have elements and relations well defined and the chat could be used for some activities.
3. Yes, whenever it can be understood what each graphical element represents and whenever they can be labeled.

4. Yes, but other icons can also be available, for example, those which a user or group decide.
5. Help tool to write the evidences of the debate.
6. It would help more if one user can add his own icons; the chat tool would be used less.

Excerpt 6
Part of the original document



1. No
2. Sí: en un debate se exponen las ideas principales y es lo que se hace en CDebate
3. Al principio es un poco abstracto el debatir con argumentos, pero es un buen mecanismo para restringir o delimitar el tema a debatir
4. El sistema se bloqueó y fue difícil llevar a cabo la discusión en todas sus fases
5. La aplicación es una buena herramienta para tener debates que se ajustan a una serie de reglas preestablecidas
6. Todos los participantes exponen sus argumentos e ideas y eso ayuda a construir un conocimiento acerca del tema, aunque tal vez haga falta un "moderador" o "administrador" que regule las participaciones.
7. Hubo un orden y coherencia en las fases que se siguieron.

Translation

1. No.
2. Yes, in a debate the main ideas are exposed and that is what it is done in CDebate.
3. In the beginning, debating with arguments is seems abstract, but it is a good mechanism to restrict or delimit the subject to debate.
4. The system failed onces one time and it was difficult to carry out the discussion in all its activities.
5. The application is a good tool to have debates that can be adjusted with several pre-established rules.
6. All the participants exposed their arguments and ideas, which helped to construct to create knowledge about the subject, although a 'moderator' or 'administrator' is necessary in order to regulate participations.
7. There was an order and coherence in the activities that were followed.

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