INTRODUCING SHARED-KNOWLEDGE AWARENESS

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ABSTRACT

A type of awareness not previously known is presented. It concerns the understanding a group of people has about their shared knowledge. It is called Shared-Knowledge Awareness (SKA). It is introduced in the context of a collaborative learning scenario. The paper also presents a way of estimating the amount of shared knowledge a group has. A Shared Knowledge Indicator (SKI) is defined for this purpose. An awareness mechanism graphically presents the SKI on the user interfaces. The paper proposes to build the mechanism with an agent and two analyzer modules. A preliminary experiment was performed with collaborative learning groups. The SKI was manually computed. The numerical results show the groups did not care much about shared knowledge or its awareness.

KEY WORDS
Awareness, knowledge construction, CSCL, CSCW.

1. INTRODUCTION

Awareness has become a cornerstone in computer systems design to reduce the meta-communicative efforts needed to collaborate across physical distances and in computer-mediated environments [17]. Gaver underlines the importance of supporting awareness information to help actors to shift from working alone to working together [10]. For example, Dourish & Bellotti apply this issue to shared workspaces and define awareness as "an understanding of the activities of others, which provides a context for own activity" [9]. They argue that awareness information should be passively collected and distributed rather than explicitly provided by the actors through meta-communicative activities.

This paper presents a new kind of awareness that is different to the types of awareness previously known for groupware systems. It is called Shared-Knowledge Awareness (SKA). It corresponds to the perception about the shared knowledge students have in a collaborative learning scenario. We think the shared knowledge has an important role in the result of collaborative learning processes (hypothesis 1 or H1), and the SKA could promote the construction and maintaining of this shared knowledge (hypothesis 2 or H2). Both hypotheses are expressed for computer-supported collaborative learning (CSCL) environments.

Next section presents the related work. In Section 3, the main characteristics of shared-knowledge awareness are presented. Section 4 describes a way to evaluate the shared knowledge based on the interaction among group members. Section 5 shows the preliminary results we have been obtained at the moment. Finally, section 7 presents conclusions and future work.

2. RELATED WORK

In CSCL, awareness can be used for enhancing collaborative opportunities and it plays a part in how the learning environment creates collaboration opportunities naturally and efficiently [16]. In this scenario, Goldman identified three types of student awareness: *social*, *task*, and *conceptual* [12]. These kinds of awareness are important for the success of efficient collaboration. Moreover, Gutwin also proposed *workspace awareness* which is the real-time knowledge a student requires about other students' interactions with the shared workspace. This awareness is essential if students are to learn and work together effectively [13].

Questions in Table 1, organized into the categories described above, are examples of what students consider during the collaborative activity in order to be aware of what is happening in the group as they work on their task. These questions are based in a classification given by Gutwin [13]. They represent the kind of information that each type of awareness should give to the students during the collaborative activity.

On the other hand, Yamagami & Seki have proposed the *knowledge awareness*, which gives feedback to the cooperative activities with an increased emphasis on sharing know-how of an organization [19]. Ogata & Yano have proposed another kind of *knowledge awareness*. It represents a new concept for helping a learner to find an appropriate collaborator and inducing just-in-time collaboration [15]. Notice, however, these proposals do not refer to awareness on the construction of knowledge.

Table 1. Awareness in CSCL.

Awareness	Questions
Social	What should I expect from other members of this group?
	How will I interact with this group?
	What role will I take in this group?
	What roles will the other members of the group take?
Task	What do I know about this topic and the structure of the task?
	What do others know about this topic and task?
	What steps must we take to complete the task?
	How will the outcome be evaluated?
	What tools/materials are needed to complete the task?
	How much time is required? How much time is available?
Concept	*How does this task fit into what I already know about the concept?*
	What else do I need to find out about this topic?
	Do I need to revise any of my current ideas in light of this new information?
	Can I create a hypothesis from my current knowledge to predict the task outcome?
Workspace	*What are the other members of the group doing to complete the task?*
	Where are they?
	What are they doing?
	What have they already done?
	What will they do next?
	How can I help other students to complete the project?

In CSCL scenarios, collaborative learning is effective if people succeed in building and maintaining a shared understanding of the problem [7]. For this reason, the shared understanding should be represented and promoted. A way to do it is capturing this shared understanding into an awareness mechanism. Also, the shared understanding could be promoted only if people can know its current state during the collaborative activity. Awareness on this type of knowledge is presented in the next section.

3. SHARED-KNOWLEDGE AWARENESS

SKA is consciousness on the shared knowledge of the students that carry out a collaborative learning activity, working in groups. This shared knowledge is more than the shared understanding of the problem. The shared knowledge is composed of the understanding of several aspects of the collaborative work, including coordination, strategy communications, monitoring, and shared comprehension of the problem.

Typically, knowledge is transmitted through messages among group members (see Figure 1) and shared knowledge is the product of this interaction. We think the "shared knowledge has an important role in the result of collaborative learning processes" (H1). Thus, a good strategy is to enlarge the shared knowledge (see Figure 2), because as Dillenbourg mentions, it contributes to an effective collaborative learning [7]. Soller et al. [18] argue that the way in which a student shares new knowledge with the group, and the way in which the group responds, determine to a large extent how well this new knowledge is assimilated into the group, and whether or not the group members learn the new concept. Moreover, as Clarck & Schaefer [3] mention, for co-construction to occur, participants must not only make a contribution, but their partners must accept it as well. Therefore, we think the larger is the shared knowledge, the more effective can be the learning.

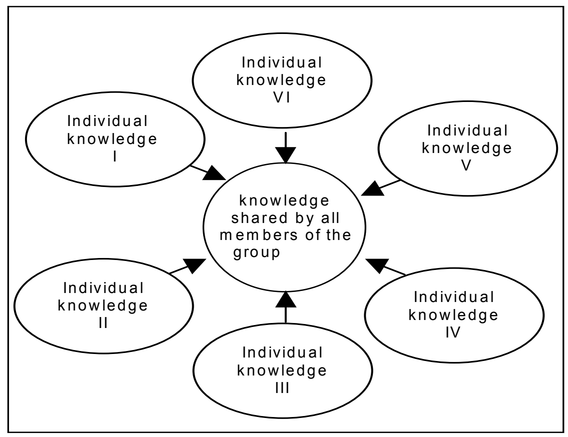

Fig. 1. Construction of Shared Knowledge.

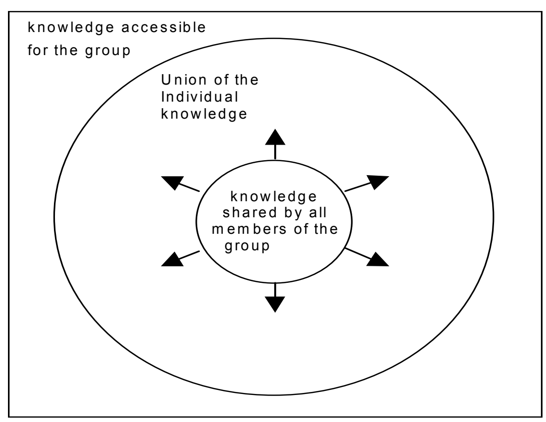

Fig. 2. SKA Strategy.

On the other hand, this kind of knowledge could be reduced or increased during the collaborative activity. We think the "SKA could promote the construction and the maintaining of shared knowledge" (H2). For constructing this shared knowledge it is necessary to wonder how one may become aware of one's own knowledge and, how the actions people do affect the knowledge of the other members within the group. It is a self-control and self-monitoring of the learning process. The questions in Table 2 are examples of what students consider during the collaborative activity in order to be aware of the shared knowledge.

Table 2. Shared-Knowledge Awareness.

Awareness	Questions
Knowledge construction (individual)	Is what I am doing helping to solve the task?
	Do I need more time/resources?
	What else do I need to find out about this topic?
	How much time is available? What is our score?
	Is what I did helping to solve the task?
	What and how did I learn from the others members of the group?
	Did I finish the work?
	What am I learning from the group work?
	What I need to know about the topic?
Shared Knowledge construction (group)	What are the other members of the group doing to complete the task?
	Is what the others are doing helping to solve the task?
	What do others members know about the topic? What do others members need to know about the topic?
	How can I help other students to complete the task?
	What did other members of the group learn from me?
	Where are the other members of the group?

The questions are divided into two categories: knowledge and shared-knowledge. The former corresponds to information people need to obtain in order to be aware of their own knowledge. Hence, it is individual knowledge awareness. The latter category corresponds to information that it is necessary in order to be aware of the knowledge of the other members of the group. Thus, it is shared knowledge.

Notice that some of the questions have been previously asked by Goldman and Gutwin in the types of student interaction they studied (*Italics* style in Table 1). However, it is also necessary to include another kind of questions. These questions concern what the other students have learned at any moment of the collaborative learning process. Next section shows the importance of SKA in collaborative learning activities. Then, section 3.2 provides a guideline to implement this awareness.

3.1 Importance of SKA

If a student is aware of her own and her teammate's knowledge, she can make well-founded strategic decisions. These strategic decisions are of the meta-cognitive type when they are made explicit and communicated to the team members in order to reason on past or future actions. Such reasoning is precisely required by the negotiation involved when the learners wish to agree on decisions [6]. Figure 3 depicts how awareness (shared-knowledge, task, concept, and workspace) could promote a positive interdependence.

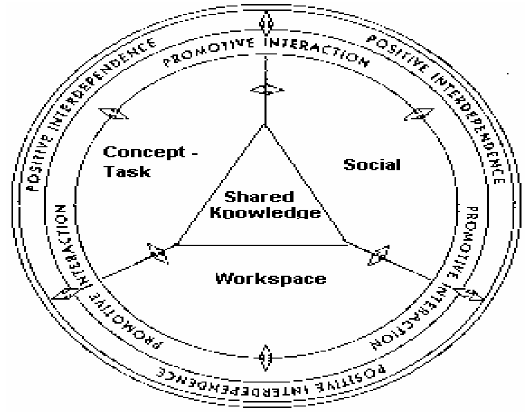

Fig. 3: Awareness in CSCL

According to Borges & Pino, awareness mechanisms become crucial for group interactions [2]. If people are aware of what is happening around them through social, task, workspace, conceptual and shared knowledge, it is possible to promote interactions among members of the group. This increase in the interactions could trigger learning mechanisms [8], and so, our first work hypothesis could be verified.

As an example of how SKA allows groups to be more effective, consider a group of students who are cooperatively trying to solve a problem.

Each of the participants maintains an awareness of what the others are doing, where they are, and she receives information about any new viewpoint concerning the problem solving (e.g., if one of the participants made a mistake). There will be sustained communication among participants to share study of the problem and to interchange solution strategies. Therefore, communicated persons are helping to make strategic decisions and change the participants' knowledge about the problem.

When an individual member of the group expresses her opinion in relation to the shared public understanding of the group, this will be an attempt to synchronize her own understanding with the group-accepted version and make clear the disagreements if there are any. Depending on the outcome of this process there may be further interaction and negotiation until a new meaning or understanding is fully accepted by the group. The key aspects of co-construction of knowledge, meaning and understanding lie on this process interaction among individuals, as well as on their shared and individual cognition [14].

3.2. Implementing SKA mechanisms

Before designing SKA mechanisms, one should try to estimate the amount of shared knowledge. Measuring this knowledge is a very difficult task, because it cannot be captured directly. Some preliminary guidelines to estimate it are given below.

In computer-supported scenarios there are two elements that can be analyzed to represent this knowledge. They are the actions the group members carry out during the collaborative work and the messages interchanged among them. The messages may transport the knowledge that is shared among the group members. The actions show if the transmitted knowledge was understood. Only the knowledge that is transmitted and understood could become part of the group shared knowledge. An exhaustive analysis of these two elements gives an idea about the amount of the shared knowledge. We are currently working on a SKA mechanism. It will be an agent that estimates the shared knowledge and provides awareness to the group members. Figure 4 shows the strategy.

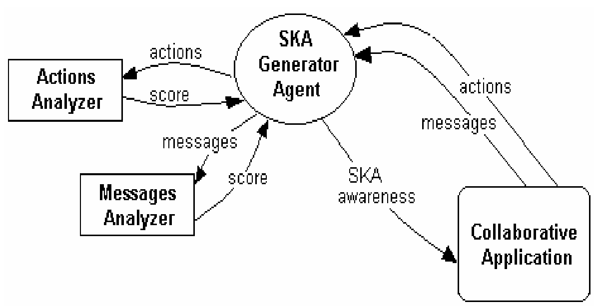

Fig. 4. SKA mechanism.

Basically, any collaborative application that pretends to implement SKA using our agent should report all the group actions and messages to the SKA Generator Agent. It captures the shared knowledge of the messages and actions through an indicator called SKI (Shared Knowledge Indicator). Based on the value of this indicator, the agent produces awareness that can be shown in the user interface of the collaborative application. The agent uses two auxiliary modules called *Actions Analyzer* and *Messages Analyzer* to carry out these tasks. The Actions Analyzer module is in charge of studying the group actions and classifying them into one of these categories: successful, non-successful, or neutral. Then, this module generates a score based on the relatively successful actions (RSA). This score represents the shared knowledge used by the students to carry out their actions.

On the other hand, the Messages Analyzer module must study the group messages. This module uses an adaptation of the CL model proposed by Soller et al.[18] to do it. This adaptation consists in a redefinition of message categories, in order to provide a better classification to analyze the shared knowledge contained in the messages. The defined message categories are coordination, work, strategy, social and others. The Message Analyzer uses these categories to generate a score based on the Relative amount of Shared Knowledge in Messages (RSKM). This score represents the shared knowledge that is transmitted in the messages. Finally, with both scores (RSA and RSKM) it is possible to calculate the value of the SKI (Shared Knowledge Indicator). We first explored to consider SKI = Sqrt(RSA * RSKM), but now we are carrying out experiments to determine how to appropriately weight RSA and RSKM. The value of SKI is provided as graphical awareness over the collaborative application user interface.

If SKI is between 0 and 0.4 then the shared knowledge is considered poor. The graphical representation of SKI presented on the user interface is shown in Figure 5a. If SKI is between 0.41 and 0.6 then the shared knowledge is considered fair and the SKA shown is depicted in Fig. 5b.

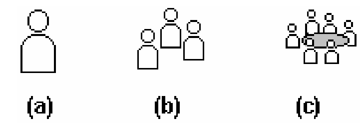

Fig. 5. Graphical SKA.

Finally, if SKI is between 0.61 and 1 then the shared knowledge is considered high and the SKA shown is Figure 5c. Next section describes an initial experiment to start validating the stated hypotheses.

4. EXPERIMENTAL DESIGN

This experiment consists of 11 groups of four students carrying out a computer-mediated collaborative learning activity. A synchronous distributed application was used to do it. The application is a labyrinth-type game. Its screen is divided into four quadrants [11]. The main activity goal is to reach the Finish Square from the start, making the smallest number of wrong moves. Since each participant has a partial view of the labyrinth, she must interact with her peers in order to solve the problem. The application records every message sent by any member of the group. Also, it records the start and finish time. The time spent in each quadrant and the number of times each participant reviews partial or total scores are recorded.

This software does not provide SKA yet. Thus, all the actions and messages occurring during this experiment were manually analyzed. We will repeat the same experiment but using the SKA Generator Agent inside the application in the near future. The groups that participated in the initial experiment were the following:

- A group of graduated students, from the course "Collaborative Systems" at Pontificia Universidad Católica de Chile, with some experience on collaborative work techniques (group 0).
- A group of people, randomly selected, who have not met before and, of course, they have never worked together (group 3).
- A group of friends who have worked as a group many times before the experience and have a good personal relationship (group 4).

- Four groups of high school students from Cumbres de Santiago School, with an average age of 15 years old. Two of these were randomly selected (group 1 and 2) and the remaining ones were friends (group 5 and 6).
- Four groups of graduate students from Universidad de Chile (Groups 7,8,9,10).

In order to validate the SKI values manually obtained, they were analyzed taking into account two indicators defined by Collazos, et al. [5], which main objective is to evaluate the collaborative learning process. These indicators are based on the activities proposed by Johnson & Johnson in [1]: use of strategies (IC1) and checking the success criteria (IC3). IC1 captures the ability of the group members to generate, communicate and consistently apply a strategy to jointly solve the problem. We are only interested in the communication component of this indicator. IC3 identifies the degree of involvement of the group members in reviewing boundaries, guidelines and roles during the group activity. Next section presents the preliminary results.

5. PRELIMINARY RESULTS

The results show that SKI scores are not good (see Table 3). As we have mentioned before, it is not only important to understand the problem in a collaborative activity, but to share that understanding with the teammates. Most groups participating in our experiment did not care much about this shared understanding and that may explain the low SKI scores.

Table 3. Preliminary Results of SKI

Group	IC1 (Com)	IC3	*SKI*
0	0.36	0.20	0.28
1	0.41	0.20	0.30
2	0.26	0.20	0.23
3	0.36	0.50	0.43
4	0.37	0.80	0.58
5	0.43	1.00	0.71
6	0.35	1.00	0.67
7	0.32	0.20	0.26
8	0.35	0.20	0.27
9	0.35	0.20	0.27
10	0.34	0.20	0.27

The groups with the best scores in the IC1 and IC3 indicators (groups 4, 5, 6) are the groups which got the best scores in SKI. Also, the groups that got the worst scores in IC1 and IC3 (groups 7, 8, 9, 10, 2), also got the worst score in SKI. Therefore, we can suspect that shared-knowledge is an important factor in the collaborative learning process.

It is interesting to notice that people who have worked together as a group before the experiment do not necessarily obtain a good SKI score.

Groups 4, 5, 6 and 0 were the groups that have previously worked together. Groups 4, 5 and 6 at least tried to work in a collaborative way. We could observe they intended to define a strategy in order to solve the problematic situation after carefully analyzing their messages. This can also be seen in the values of the IC1 and IC3 indicators. Meanwhile, two members of group 0 understood the strategy and developed a shared understanding of the problem, as it could be observed in the messages they sent. The problem was the other members of the group did not understand the strategy. Thus, this group could not solve the problematic situation. The two members of this group who understood the strategy were unaware of the poor group shared knowledge, as they were only interested in their own knowledge; consequently, they got a bad score in SKI. The values of IC1 and IC3 also show this problem. Summarizing, the groups with high shared knowledge were better than the others groups in all cases. It supports hypothesis 1. Also, these results indicate the way to calculate the SKI indicator may be right.

On the other hand, groups 7,8,3 included people who had never worked as a group before the experiment. Groups 7 and 8 got a bad SKI score, but group 3 got a fair score. This last group did not develop a good strategy (reflected in IC1), but some group members were interested in knowing what the other members of the group were doing (reflected in IC3). As we have argued above, when working in a collaborative activity, it is not only important to understand the problem, but to share that understanding with the teammates. It is also important to be aware the rest of the people are understanding the problem situation. Once someone has prepared a message, it is necessary to do more than just send it off. It is necessary to make sure that it has been understood as she intended it to be. Otherwise, she has little assurance that the discourse will proceed in an orderly way [4].

These are preliminary results when trying to validate the hypotheses. Therefore, definite conclusions can not be obtained from them. However, these results show the shared knowledge can contribute to improve the results of collaborative learning activities. It is an important support to hypothesis 1. As it was mentioned before, we are planning to repeat this experiment with the same software but including SKA as a way of start the validation of hypothesis 2.

3. CONCLUSIONS AND FURTHER WORK

In spite of the fact that awareness has received attention in the CSCL literature for quite some time now, little work has been done on knowledge construction. Shared knowledge among the group members could have an important role in CSCL activities. The preliminary results we have obtained support this hypothesis.

We introduced a new kind of awareness called SKA (Shared Knowledge Awareness) to increase and maintain this shared knowledge. This type of awareness can be provided in a graphical way by depicting the Shared Knowledge Indicator (SKI), which estimates the shared knowledge through actions and messages from the group members. We think SKA could have a positive impact on a group meta-cognitive activities by aiding in the construction and maintenance of shared-knowledge. The results of the initial experiment show there was little shared knowledge. We think this was because the group members did not know this knowledge was important for their task and there was not any awareness mechanism about it available. SKA pretends to provide this awareness and allow the group members to increase and maintain their shared knowledge, and thus, to improve the results of the collaborative learning activities.

Our future work will be to make a detailed analysis of the impact of this kind of awareness on the collaboration processes within a work group, in order to determine when and how people are aware of their own knowledge. It seems plausible that shared-knowledge awareness models may have an indirect effect on performance mediated by team coordination

4. ACKNOWLEDGEMENTS

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