

Analysis and Design of Awareness Elements in Collaborative Digital Environments: A Case Study in the AulaNet Learning Environment

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Abstract. In this paper an analysis is made about how awareness in digital learning environments relates to communication, coordination and cooperation and, consequently, collaboration. A collaboration model, where awareness occupies a central position, is presented. The awareness elements of the AulaNet environment are also analyzed, seeking to identify what awareness information is relevant, how it is generated, how the awareness elements were defined and how individuals control them. This analysis seeks to provide information regarding a project about awareness elements in collaborative digital learning environments.

1. Introduction

To be aware, in this context, is to acquire information about what is happening and what other people are doing [Brinck & McDaniel, 1997]. Awareness, which is inherent in human beings, thus becomes a central part of communication, coordination and cooperation in a work group, where to communicate is to negotiate, to coordinate is to be in tune with the other participants and to cooperate is to operate together in a shared space [Fuks, Gerosa & Lucena, 2002].

Through awareness, individuals realize the changes caused in the environment by the action of participants enabling them to direct their actions and predict possible needs [Neisser, 1976]. To be aware of the activities of other individuals is also essential for the flow and naturalness of work and in order to avoid being impersonal.

Awareness involves various cognitive aspects related to human skills. Obtaining information is rich and natural in a face-to-face situation, given that the senses are fully present in the interaction between people and environment. The participants may stay on top of things just by paying attention to what is happening around them. In virtual environments, awareness support is less clear since the means for making information available to the sensory organs of human beings are limited. Typical workstations provide information through a two-dimensional screen and, in some cases, through loudspeakers. On the other hand, in a digital environment, irrelevant information can be filtered in a way that reduces dispersion that normally permeates a face-to-face situation.

Awareness elements are elements of the shared space where information designed to provide awareness is made available. Digital environments for collaborative learning must provide awareness elements that supply the information necessary for collaboration and for individual work. Guided by their awareness, participants can create a shared understanding and coordinate themselves so that individual efforts add value to the work.

In this paper, a collaboration model in which awareness occupies a central position is proposed. The connections of awareness with communication, coordination and cooperation

are detailed in Section 2. After defining these connections, some awareness elements of the AulaNet learning environment are shown in Section 3. Section 4 concludes the paper.

2. Awareness and Collaboration

At least potentially, collaborating for complex problem solving can produce better results than individual work. Individual efforts, skills and knowledge complement each other in a group. Within a group there can be interaction between people with different understanding, alternative points of view and complementary skills [Hiltz, 1994]. By collaborating, the members of the group receive feedback that early on permits them to identify inconsistencies and breakdowns in thinking processes so that they can seek together ideas, information and references to solve their problems. The group has also greater capacity to generate alternatives in a creative fashion, surveying the advantages and disadvantages of each one of them in order to select those that are feasible in order to make their decisions [Turoff and Hiltz, 1982].

Working in a group also motivates members, since their work is being observed, commented upon and evaluated by the members of a community that they belong to [Benbunan-Fich & Hiltz, 1999]. Furthermore, the act of debating their ideas with the other members makes participants actively develop concepts, allowing them to reason and refine them.

Despite its advantages, collaborative work necessarily demands additional effort to coordinate the group members. Without this coordination, a major part of the communication effort will not be used for cooperation. For the group to be able to operate together in a satisfactory way it is necessary that the commitments that have been assumed in the conversations between the participants be realized during the cooperation. Furthermore, the coordination must deal with conflicts that harm the group.

To make group coordination possible, it is necessary to realize others' presence and know what is happening in order to make the proper decisions about the procedures to be adopted. The participants use this kind of information, known as group awareness information [Liu, Shi & Xu, 2001], to build a shared understanding about the cooperation objects and the objectives of the tasks and of the work. Being aware of the activities of one's companions, individuals will have information that helps in the synchronization of their work, coordinating themselves around individual context. In Figure 1, the collaboration model is presented.

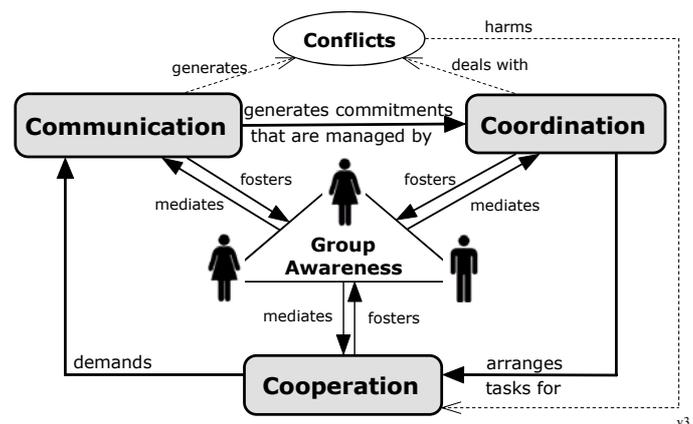


Figure 1 – Collaboration model

In the next sections the main elements of the model and their relation to awareness are detailed. It should be pointed out that despite the separation of these concepts for the purpose

of analysis, it is not always possible to consider them isolated, since they are intimately dependent and inter-related.

2.1. Awareness and Communication

Communicating is sharing [Schrage, 1995]. Throughout communication, people desire to build common understanding, exchange ideas, discuss, negotiate the meaning of concepts or make decisions. The participants of a work group must communicate to accomplish tasks that are interdependent, not completely described or that require negotiation [Fussel et al, 1998].

The members of a group communicate in many different ways. Asynchronous communication tools normally are used when one wants to encourage participant reflection, since the participants will have more time before they have to act. In a synchronous communication tool interaction is valued in view of the fact that the response time between the action of a participant and the reaction of their colleagues is short. Some communication tools are geared up for free conversation while others favor structuring via a list, a tree or a graph form [Gerosa et al., 2001]. Some communication tools currently in use are: e-mail, discussion list, newsgroup, CSCA (Computer Supported Collaborative Argumentation), voting tools, instant messaging, chat, videoconference, teleconference, telephone, etc. [Long & Baecker, 1997].

Communication is carried out by exchanging messages. Figure 2 models the transmission of a message from the sender to the receiver. The sender codes the message using the available expression elements, and the environment transmits it to the receiver, which has access to it through the awareness elements. These elements make up the Awareness Channel, where the data that is exchanged in communication transits.

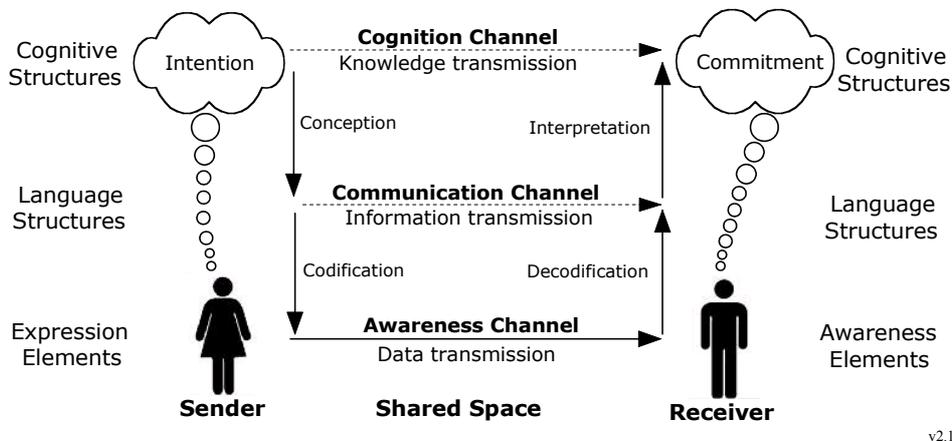


Figure 2 – Modeling the communication

In order to communicate, the sender prepares the message using the language structures proper for the conversation, that are defined by the available expression and awareness elements, by the cultural context, by the domain in question and by the individual knowledge. The message is conceived in these structures and is transmitted to the receiver, which interprets it in order to recover its meaning. It should be remembered that the environment can also supply non-verbal elements to the language structure used in the conversation, in a way that simplifies verbal communication [Gutwin & Greenberg, 1999]. For example, there are tools that use icons to represent feelings in a digital environment.

The content to be transmitted reflects the intentions of the sender, which are prepared in their cognitive structures. The content that is transmitted results in commitments on the part of the receiver. It should be remembered that when one communicates, people normally are not aware of the language structures and of the expression and awareness elements that are used,

because their attention is directed to the intentions and the commitments that result from the messages. If some type of confusion or problem is detected, the language structures (Communication Channel) or elements used (Awareness Channel) are brought into central focus in an attempt to repair the misunderstanding.

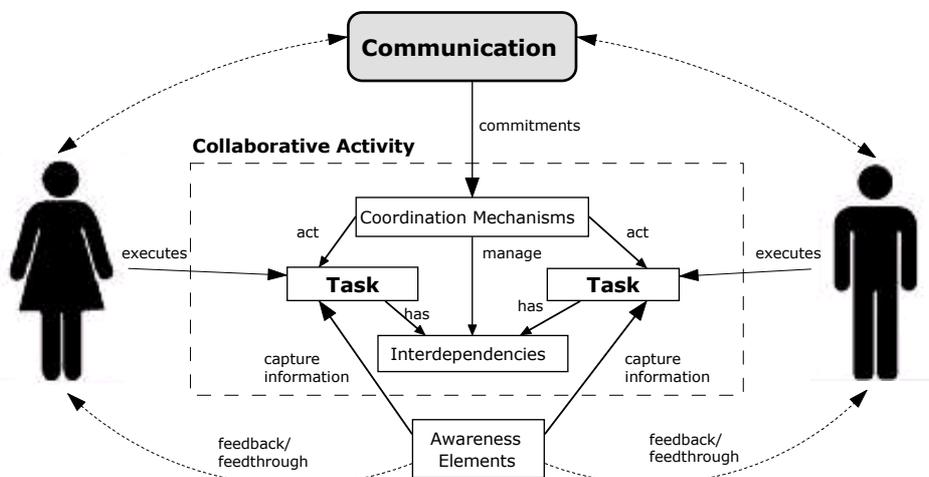
Communication is considered to have been successful if there is understanding of the message and if the content that was received is the equivalent to that which was transmitted, in the sense of causing the expected effects. The only way of obtaining indications about understanding is through the actions (and reactions) of the receivers, since they are guided by their understandings and commitments. A rupture in the communication, thus, would be discordance between the intentions of the sender and the actions of a receiver upon carrying out the commitments.

2.2. Awareness and Coordination

Conversation for action generates commitments [Winograd & Flores, 1987]. It is necessary to coordinate the activities in order to ensure compliance with these commitments and realization of collaborative work through the sum of individual work. This coordination organizes the group in a manner that avoids the loss of communication and cooperation efforts and ensures that the tasks are carried out in the correct order, at the right time and in compliance with the restrictions and objectives [Raposo et al., 2001]. Without coordination, there is a risk that the participants will become involved in conflicting or repetitive tasks.

The coordination involves the pre-articulation of the tasks, their management and post-articulation. Pre-articulation involves the actions that are necessary to prepare the collaboration, normally concluded before the collaborative work begins: identification of the objectives, the mapping out of these objectives into tasks, the selection of the participants, the distribution of tasks among them, etc. The post-articulation phase occurs after the end of the tasks and involves the evaluation and the analysis of the tasks that were carried out and the documentation of the collaborative process. The management of the carrying out of the tasks is the most dynamic part, needing to be renegotiated in an almost continuous fashion throughout the collaboration period.

The commitments assumed during the communication originate the collaborative tasks. The group coordinates itself through coordination mechanisms in a manner to ensure the execution of the tasks, respecting the tasks' inter-dependencies. Figure 3 shows the tasks coordination model.



v1.2

Figure 3. Modeling the coordination

In some collaborative tools, coordination is carried out by the so-called social protocol, characterized by the confidence in the skills of the participants to mediate the interactions and by the absence of explicit coordination mechanisms between the activities. Examples of tools that normally have these features are chats and audio and videoconferences. However, some activities require sophisticated coordination mechanisms in order to ensure the success of the collaboration. Examples of tools with explicit coordination are workflow engines, multi-user games and collaborative authoring and software development tools.

With the social protocol or with explicit coordination mechanisms, awareness information is essential for group coordination. It is important that each one knows about the work progress of each one of his or her colleagues, like what was done, what needs to be done, what are the preliminary results, etc. The awareness information is particularly necessary during the dynamic coordination phase to transmit changes of plans and to help generate new shared understanding. Without this context, the individuals are not able to measure the quality of their own work compared to the objectives and progress of the group, which might lead to unnecessary duplication of effort [Dourish & Belloti, 1992].

The awareness elements are particularly useful for carrying out tasks that cannot precisely be defined in advance, where a priori articulation is not sufficient [Raposo et al, 2001]. These ill-defined tasks are particularly common in learning activities, where learners make decisions and try to solve problems without complete knowledge about the domain [Simon, 1996]. In this kind of tasks, the division and the organization of work occur while it is being done through the coordination of the activities [Gross, 1997]. The awareness elements help to transmit the changes in plans and to generate new shared understanding. Moreover, they can inform the participants about temporal and spatial aspects of the actions and facilitate the synchronization of the individuals' tasks.

The group coordinator, for being directly responsible for coordination, normally is in more need of this type of awareness information. He or she needs to know, for example, who is or is not working, where there are conflicts of interest and what are the skills and experiences of each one of the participants. Based on this type of information, the coordinator can take the proper actions for coordinating the group [Borges & Pino, 1999]. However, the flow of information that goes to the coordinator must be planned very carefully. Most of the information about what is happening, has happened or will happen in the group has some type of importance. But an excess of information will make decision-making more difficult.

Conflict can occur due to problems of communication or of awareness, or due to differences in the interpretation of the situation or of the interest [Putnam & Poole, 1987]. The coordination should deal with the conflicts that disturb the group, such as competition, disorientation, hierarchical problems, diffusion of responsibility, etc. [Salomon & Globerson, 1989].

2.3. Awareness and Cooperation

Communication and coordination, although vital, are not enough: "it takes shared space to create shared understandings" [Schrage, 1995]. Cooperation is the joint operation in the shared information space, through the interaction of the individuals and the artifacts of the work environment. These interactions, whose objectives in general are to accomplish a task, lead to a series of new happenings that, for their part, will be reflected in the awareness elements where the individuals will seek information for planning and coordinating subsequent interaction. They cooperate by producing, manipulating and organizing information and building and refining cooperation objects, such as documents, spreadsheets,

artwork, etc. In order to act upon the objects, the members count upon expression elements, and for getting the results of their action (feedback) and the action of their colleagues (feedthrough) they have awareness elements (Figure 4).

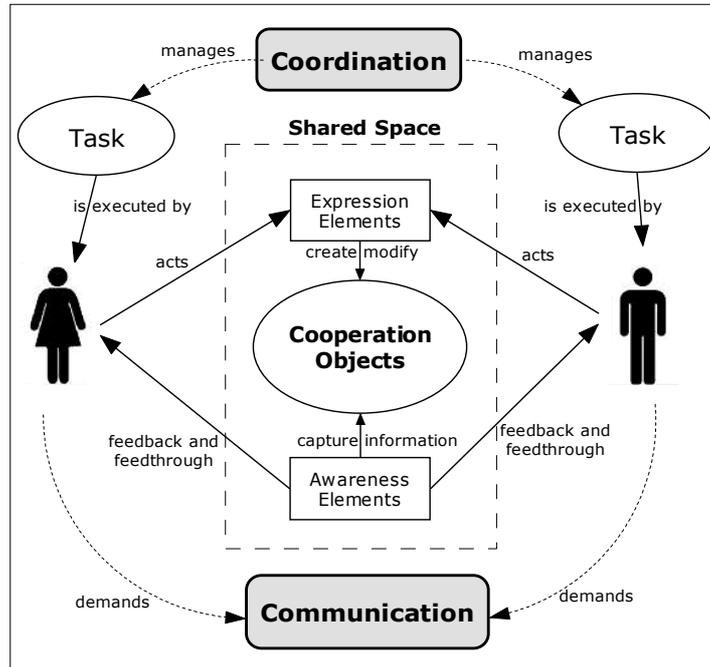


Figure 4. Modeling the cooperation

The recording of the information that occurs during the cooperation seeks to increase the understanding between people, reducing uncertainty (related to absence of information) and double-meanings (related to ambiguity and the existence of conflicting information) [Daft & Lengel, 1986]. Individuals communicate between themselves in an attempt to solve misunderstandings.

To preserve, catalogue, categorize and structure the objects produced by the participants is a way of ensuring group memory. This type of knowledge can be seen as formal knowledge. However, the so-called informal knowledge—that is, ideas, facts, questions, points of view, conversations, discussions, decisions, etc.—that occur during the process and wind up defining it is difficult to capture. Nevertheless, it permits to recover the history of the discussion and the context in which decisions were made.

Upon recording, organizing and connecting the information exchanged during the collaboration to the digital artifacts, one may investigate the thinking that led to a given artifact (design rationale) and subsequently check, within a new context, if the motives that led to the taking of the project decisions are still valid. When this rationale behind the decisions is not available, the identification of the motives and of the techniques that were used is made difficult.

There are a number of tools in the literature that use hypertext to organize group memory [Shum & Hammond, 1994]. Some of these tools make it possible to link digital artifacts to shared space. As a result, the contexts of the artifacts and the interactions are preserved, facilitating their understanding and later recovery. Group memory then is formed by the artifacts (product memory) and by the information networks composed of facts, hypotheses, restrictions, decisions, arguments and the meaning of concepts (process memory).

Two or more people possess shared understanding of a situation if they have the equivalent expectations about it, know what is happening and what is coming next [Easterbrook, 1995].

The shared understanding makes it possible for individuals to build their own work contexts in a manner that lets them work towards the common objective, supplementing the activities of their colleagues.

Individuals seek in awareness elements information necessary to assemble the context and to anticipate the actions, the needs and the intentions of their group companions. Furthermore, the awareness elements help identify the role and the tasks of each one with relation to the collaborative goals and the cooperation objects [Gutwin, Stark & Greenberg, 1995].

It is essential for individuals to become aware of the changes in the environment caused by the actions of the group members [Neisser, 1976]. These actions, which normally are part of a plan to reach a certain goal, can also be guided by awareness elements.

A non-manageable quantity of information makes the organization of members of a group more difficult, causing misunderstandings and communication breakdowns [Fussel et al., 1998]. It should be remembered, however, that the existence of information overload is extremely related to the individual. Some persons are able to deal with more simultaneous information than are others, depending upon, among other things, the maturity, skills and capabilities of each one as well as the characteristics and the level of knowledge about the topic at hand [Chi et al, 1982].

In order to avoid overload, it is necessary to balance the need to supply information with the care to protect the resources destined for work. The supply of information in an asynchronous, structured, filtered and summarized form facilitates this task [Kraut & Attewell, 1997]. A general vision of the whole should be supplied, so that individuals may select which part of the information they desire to work with, and further details could be obtained when required. The reduction in the information overload in communication can come about, for example, through structuring of dialogue and the supply of simple and representative information that helps participants identify the relevance and the context of the messages without having to read them [Gerosa et al, 2001]. Moreover, there must be some kind of control so that the information flow is not greater than the capacity of the individual to process and digest it, despite the fact that this capacity is not easily measured.

3. Awareness Elements in the AulaNet Learning Environment

Awareness is relevant for both individual and group work. Examples of awareness information that helps individual work are showing what messages an individual already has read, what are the new items since the previous visit, etc. Information about who currently is present in the environment, who is working with an artifact, among other, is oriented towards working in a group. Despite this separation, information must be designed to be complementary and to help individual work during the collaboration. Some other examples of information that generally is relevant in order to put the participant into context are the common objective, the role of each one within the context, what to do, how to proceed, what is the impact of an action, where to act, who is nearby, what can one's colleague do, what are the other people doing, the location, the origin, the importance, the relationships and the authorship of the objects [Gutwin & Greenberg, 1999].

Awareness elements are the environment interface elements through which information designed to provide awareness is disposed. While awareness elements are related to the interface, awareness is related to the human being. It involves recognition and interpretation of the information that is present in the shared space.

One should take these elements into account when designing groupware. Which awareness elements will be needed, how they should be generated, how to join them up and how to

distribute them must be foreseen. In this section, we will discuss some of these aspects with regard to the AulaNet environment.

3.1. The AulaNet Learning Environment

The AulaNet¹ is a freeware environment based upon a groupware approach for teaching and learning on the Internet. The Software Engineering Laboratory of the Catholic University of Rio de Janeiro (PUC-Rio) has been developing it since June 1997.

The AulaNet's services are organized into services of communication, coordination and cooperation. The services are placed at the disposal of the teachers during creation and updating of courses, allowing them to select and to configure which will be made available to the participants.

The communication services supply the facilities that permit an exchange and sending of information. These services include an asynchronous text discussion tool in a newsgroup style (*Conferences*), synchronous text chat (*Debate*), instant message exchange between simultaneously connected participants (*Messages for Participants*), and individual electronic mail with the mediator (*Contact with the Teachers*) and with the entire group (*Discussion List*).

Upon working in a group, a number of complex coordination problems arise. The coordination services seek to minimize these problems, organizing the group to enable cooperation. In the AulaNet the services include a notification tool (*Notices*), a tool for the basic coordination of the flow of the course (*Lesson Plan*), evaluation tools (*Tasks and Exams*) and a tool for following group participation (*Follow-Up Reports*).

The cooperation services supply the means for collaborative learning [Harasim et al., 1997], for resolving problems and for course co-authoring. In the AulaNet, the cooperation services include a course reference list (*Bibliography* and *Webliography*), a list of transferable content (*Download*) and co-authoring facilities, both for teachers (*Teacher Co-authoring*) as well as learners (*Learner Co-authoring*).

In the following section, some examples will be given of awareness elements used in the AulaNet environment.

3.2. Designing Awareness Elements in the AulaNet Environment

In order to navigate around the course, participants have a menu of services graphically represented by a remote control unit (Figure 5) that supplies navigational facilities built upon previous selections by the teacher of the communication, coordination and cooperation services. On the remote control unit, awareness information can be observed. In the upper part is the course code, offering an individual awareness element for localization and context. The remote control items make the participant aware of the services available at a given moment. Next to each menu item is a circular button. This button changes color in order to provide information about the services. A blue button indicates the service that the participant has selected, showing his location. A light orange button (highlighted in Figure 5) indicates that possible actions need to be taken. These actions include the presence of a colleague (on the synchronous communication services) or new items to be worked on, such as a new message or



Figure 5. Remote Control

¹ <http://guiaaulanet.eduweb.com.br>, <http://www.les.inf.puc-rio.br/aulanet>

content. Upon moving the mouse over the button, one sees the number of items upon which some action should be taken (items not read or not solved). A dark orange button indicates a service where no changes have taken place since the last access.

In the AulaNet Debate service, which implements a text chat as can be seen in Figure 6, there is an area where the participants who are present are listed, one where the messages are exhibited and one where participants can express themselves. Through the awareness elements (the two first areas) one can identify who is around and their profiles.

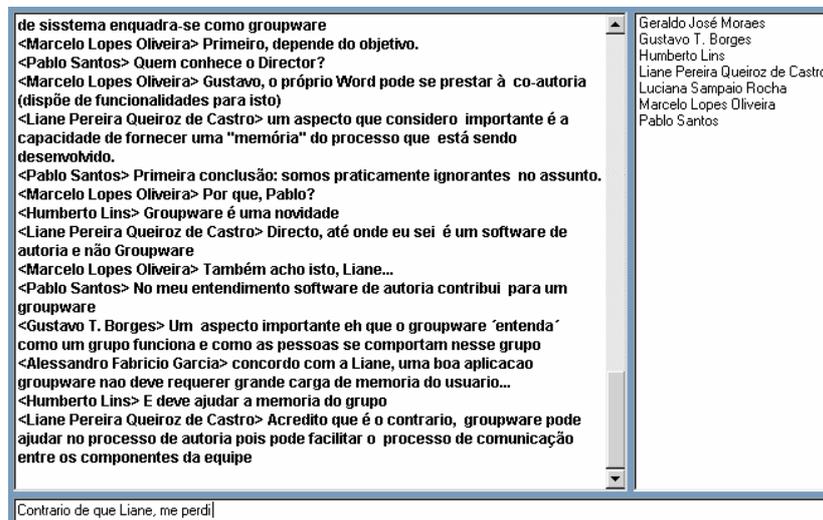


Figure 6. AulaNet Debate

On the AulaNet, whenever a list of topics is presented, as is the case of the class topics in the *Lesson Plan* or the *Conferences* forum, the quantity of unread items and the total of items of that topic are shown. Other awareness elements include the name and a description of the topic, previously supplied by the teacher, and the name of the content provider who created it. At the end of the list, totals of the quantity of topics, of the items and of the unread or unsolved items are provided.

The awareness information must provide individuals with a vision of what they will find in each one of the services, to enable them to decide one to work and to have a notion about the total volume of work that is pending. This information must be summarized in a manner that the participants may quickly obtain a notion about the quantity and the characteristics of the work to do.

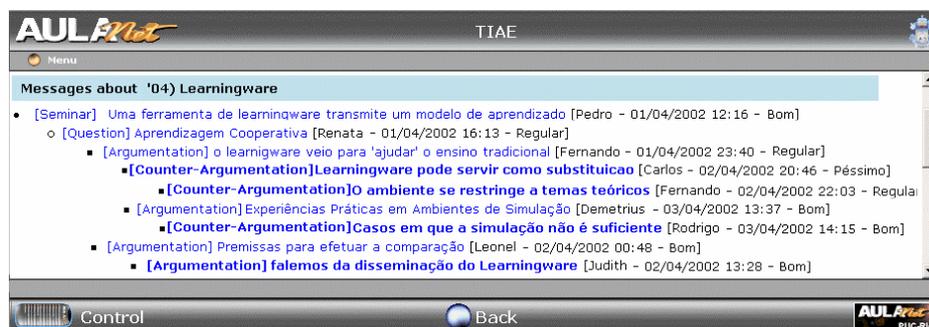


Figure 7 – Messages in a *Conference*

Upon listing the messages of the environment's asynchronous communication services, awareness information is offered in order to help participants contextualize the message, decide if it is the proper moment to access it or to locate something that is being sought after (Figure 7). The category, the subject, the author, the date and the assessment of each message

are shown. Besides this information, the messages that still have not been read are in bold face, indicating that action needs to be taken. In the specific case of *Conferences* and *Contact with the Teachers*, where it is possible to explicitly answer the messages, another piece of awareness information that is presented is the nesting of the messages. Through nesting it is possible to identify the connections between the messages, facilitating the understanding of the context.

After identifying which information is necessary, one should analyze how it could be obtained. It can be generated explicitly by the individuals or extracted by the environment. For example, upon sending a message to a *Conference*, some information automatically is extracted such as, for example, the date of transmission and the sender. But there is other information, such as the category, the subject and the body that need to be supplied by the author through expression elements, as can be seen in Figure 8. The automatic extraction of the information that is necessary to provide awareness frees the participants from having to do so, which speeds up interaction. On the other hand, by having to supply information about their activities, participants are led to reflect before acting, which is desirable especially in asynchronous interaction [Gerosa et al, 2001].

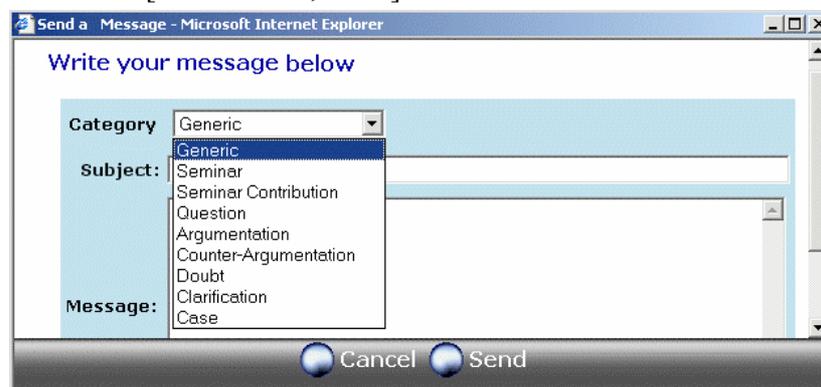


Figure 8. Posting a message to a *Conference*

Once awareness information and how to obtain it has been identified, the next step is to analyze how it could be gathered and distributed. The choice of an adequate means of implementing the awareness elements helps to avoid information overload and the poor interpretation of data. In order to choose the appropriate means, one must take into consideration factors such as the importance of the information and how often it changes.

The AulaNet offers a service called *Follow-Up Reports* (Figure 9) that seeks to enhance the group awareness about its members activities, providing subsidies for coordination. The reports summarize the quantity, extracted automatically by the environment, and the quality of contributions, supplied by the course mediator. Each contribution—messages, participation in debates, submission of content and resolution of tasks—are marked and, in the majority, commented upon by the teacher.

Participants	Discussion List 0 (0)	Conferences 8 (6)	Debate 8.08 (4)	Average Concept 8.63 (10)
Adriana	Without concept	Good / 9.82	Very active / 9.5	9.69
Gustavo	Without concept	Regular / 7.12	Very active / 9	7.48
Hiran	Without concept	Regular / 7.61	Very active / 8	8.37
Judith	Without concept	Good / 9.5	Very active / 9.5	9.5
Leonel	Without concept	Good / 9.29	Active / 6.88	8.32
Márcio	Without concept	Regular / 7.75	Very active / 9	8.85
Mariano	Without concept	Good / 10	Very active / 9.38	9.75
Pedro	Without concept	Good / 9	Very active / 9	9
Renata	Without concept	Good / 9.24	Very active / 9	9.15
Rodrigo	Without concept	Regular / 7	Low active / 3.33	7.33
Weight	0	6	4	10

Figure 9 – Follow-Up Report

The reports give an average rating of each participant per service, an average percentage for effective contributions, frequency of participation in the debates, the number of contributions per service and detailed reports for each service of the course. These reports make it possible for learners to check their performances and compare them with that of colleagues through information that is continuously updated. Furthermore, it helps the participants get to know each other better, to have a notion of how the course is going, of their roles within it and to choose other colleagues to form work groups. It also lets the mediator organize, motivate and evaluate the learners and check up on pending tasks.

3.3. Learners' Opinions about the Environment's Awareness Elements

In this section, some of the comments made by learners who took the Information Technologies Applied to Education course [Fuks et al., 2002], which is entirely taught at distance on the AulaNet environment, are presented. These comments are about awareness support in the AulaNet environment and were extracted from the messages posted on the *Conferences* and from the evaluation questionnaires applied at the end of the course. This data consolidates the last four editions of the course and it was evaluated by the mediators of the course.

The remote control unit was one of the items that was most cited: *“The elements adopted, mainly the change of color in the remote control, which indicates tasks that were not finished, and the exhibition of the quantity of unread items, facilitate the organization of a learner and the optimization of time in the environment. The change of color in order to indicate something new avoids wasting time looking for them.”* *“For me, the most useful awareness elements are those supplied by the remote control, because they tell me where new information is and it facilitates my organization in the sense of knowing what to do (to visit) first.”*

The indentation and the categorizing of the messages also were cited as ways of providing awareness information that helps to characterize the messages. *“I thought the categorizing to be very important and interesting, since it helped in the exchange of messages between the participants in the course and let one distinguish between the types of messages.”* *“I think it helps the organization a lot. You know where to find what you want and it makes looking through the messages easier.”* *“If there were no categories, I would have to open up one message after another to know what was in it.”* *“The indentation of the messages is a great help to the learner since visually the relationships between the messages are characterized.”*

According to the learners, the marking of the messages already read and content already visited was important to let them organize themselves. *“The marking of the unread messages in bold face avoids reading a message more than once.”* *“The marking of the messages that have been read is of great help to the learner. It organizes the messages and diminishes the cognitive load.”* They also said that the totaling of the items in the entry of the Conferences helped save time spent in unnecessary surfing. *“Through the quantity of unread messages on the main page of the Conferences it was possible to evaluate whether there was a need to enter the conference or not without going into it.”*

According to the learners, one service that lacks awareness elements is the Debate. What is missing are the elements to perceive who is absent: *“The list of participants makes it possible to quickly perceive the quantity and who is in the room; but it does not make it possible to explicitly be aware of which students are missing.”* The context of the messages: *“The rollover bar makes it possible to be aware of the quantity of messages that have been sent (inversely proportional to their size), and also makes it possible to estimate the temporal position of each message in the session, although this information could be more explicit.”* The sender of the messages and their role: *“There is no explicit awareness between the messages that are sent by the participants and those that are issued by the system, and there is no clear distinction between the messages of each participant nor their roles (mediator, moderator, etc.).”* Reactions of colleagues: *“In a face-to-face conversation, it is possible to perceive the interest, the understanding and affection through facial expressions, gestures, laughter, para-linguistic resources (aha, hmm), and in the Debate there are no resources for this.”* And others: *“There is no distinction between the messages issued by the participant and those destined for him or her; and there is no explicit awareness element telling what the topic of the debate is and how much time is left until the end of it.”*

Awareness information that was reported as missing were: notification by e-mail of Conferences messages; the number of connections and the time that each participant is connected to the environment; and the size and type of content. Some learners suggested that the things added since their last visit should be made available upon logging on and that there be a way of italicizing the messages from the Conferences that were of interest to them.

4. Final Considerations

In order to work in a collaborative fashion an individual must negotiate (communicate), be in tune with the other members of the group (coordinate) and operate together in a shared space (cooperate). By being aware of the activities of other colleagues involved in the work and of the impact that occurs in the knowledge generated through collaboration, the participants will have information that helps in the synchronization of the work, coordinating themselves around their individual contexts.

A suitable design of an application’s interface will make available the specific awareness elements that allows the participants to have the necessary information needed to carry on with their work. This reduces the chance of a participant disturbing a colleague just to request information that is already available in the environment [Segal, 1994]. However, it is not possible for the designer to define a priori which awareness elements will be appropriate and sufficient to convey the awareness information which is relevant for the participants in each and every moment. This process must be continuous and experimental in order to adapt the elements to the real requirements of the individuals. It is worth remembering also that each participant has her own skills, requirements and preferences. Thus, the elements must be flexible to adjust to different personal styles without overly complicating the use of the environment or making it possible to distort it. Furthermore, care must be taken to control the

flow and the quantity of awareness information to be disposed so that individuals do not feel overloaded.

A designer must foresee what awareness information is relevant, how it can be captured or generated, when and where awareness elements are required, how to present them and how to give individuals control over them. Care must be taken in all stages not to compromise the fluidity of the collaboration. An excess of information may cause overload and complicate things. The choice of the appropriate means for implementing these elements and the use of filters and customized methods of receiving information help to avoid overload and poor interpretation of data. Not always should all of the information be presented to the group. Sometimes, it should be made available in an appropriate repository, or even discarded. Similarly, some information is absolutely essential and must unconditionally be shown to the group [David & Borges, 2001].

The appropriate way of creating an interface that makes awareness information available is beyond the scope of this paper. Aspects of the graphic project should be taken into account as well as the media to be used and cognitive aspects, among others. Ideally, the groupware developer will have the assistance of an interface designer.

This paper has shown a model of collaborative work, explaining how awareness relates to communication, coordination and cooperation. This model help the designer to define the elements and the sources of awareness. This paper also has brought up some examples of the application of the concepts that were discussed, reporting about awareness elements in the AulaNet environment.

The development and the use of this environment served as a base for the generation and experimentation of the ideas contained in this paper. In [Gerosa et al, 2001] there is a report about experiments related to the categorizing and structuring of messages, showing that the organization of the shared information space could be done using awareness information about the messages exchanged within a learning group.

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