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**Interaction Map: information visualization techniques  
in Web -based distance education environments**

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## Interaction Map: information visualization techniques in Web-based distance education environments

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**Abstract.** Most Web-based distance education environments presents the information in a textual format. The interface in sequential way is used to visualize texts, and the enormous volume of data generated by these environments makes it difficult to retrieve information. This paper presents Interaction Map (InterMap), a tool to visualize information about interaction in a Web-based distance education environment - TelEduc.

**Keywords.** Information visualization, interaction tools, learning interactive environments, Web-based distance education environments, WWW tools.

### 1 Introduction

Internet has changed the way that we form communities, work and learn. Because of the characteristics of space and time independence and the possibility to turn available content into several media (text, audio and video), Internet became an appropriate technology for distance courses. With this new conception of use, many Web-based environments to support courses have been developed in the last years.

The earlier designs of those environments tried to reproduce in Internet the same available conditions of work in a traditional class. The main focus of the development of those applications was the technology with the objective to create, to present and to make available, in a better and easier way, the courses' content. In that way, these environments present a basic model that join tools for material elaboration, communication, safety access, use statistics, access to database, elaboration of exercises etc. These tools are usually divided in 3 categories: authorship, administration and students' use. In the environments there are some actors involved in the teaching/learning process: the teacher, the student, the author and the administrator of the environment. Teacher is the responsible for supplying the course, to correct the activities, to explain the students' doubts, while the author is assigned to develop the didactic material. However, nothing impedes that the same person carries out those two roles. To the administrator of the environment, the administrative task is reserved, such as the access liberation, the explanation of doubts related to

the environment etc. Students have tools for communication, automatic evaluation, searches in glossaries, annotations, creation of personal pages and accompaniment of notes.

There are several environments available to be used, freely or not - e.g. the TelEduc environment (TelEduc, 1998). The Institute of Computing (IC) and the Núcleo de Informática Aplicada à Educação (NIED) - UNICAMP have been developing this environment since 1996 and it has been supporting several courses with contents of several areas. In TelEduc, as in several others environments, in spite of the authorship and administration tools that aid in the creation and offer of courses, the teacher continues to have difficulties to accompany the students in the same way as in a traditional classes. In the Web, teachers do not have the technological resources that allow it to be done. In that way, the teacher ends up taking advantage of electronic spreadsheets or annotations in paper to try to organize the information. As the access to the information is not facilitated, in most cases, teachers end up designating an assistant to help him/her to accompany and to assist better the students. In other cases, he/she does not make that accompaniment in a satisfactory way and this ends up provoking a lack of motivation in the group (Harasim et al., 1996).

In the traditional classes, the participants use the face-to-face communication that supplies many visual tracks such as glance, gestures and body posture (Vilhjálmsson & Cassel, 1998). Thus, it is possible, for instance, to know if a person has difficulties, who is interested in the subject of the class, who has parallel talks etc. Those visual tracks help the teacher to accompany the students better, because it gives subsidies for the teacher to decide the best time to interven. In Internet, when we enter in any of these environments, the student or the teacher do not "see" other people sharing the same space, but they just see a group of tools that present and organize the information generated in the courses. This information is usually represented in the sequential and textual manner.

In a recent experience in TelEduc, with a great number of students, we could verify several of those difficulties enumerated by the teachers. One of the main doubts was about the students' participation. Most of teachers got to know who sent more messages, but the ones that interacted little or never interacted passed unperceived. Teachers wanted to meet the students that exchanged messages. This could indicate change of experiences and groups formation, but it is very difficult to obtain that information with the current design of TelEduc. Even quantitative data, such as the amount of sent messages, is difficult to obtain. Then, it is necessary, that those participation and interaction data be represented in an easily visible manner. In any learning situation, the interaction among the participants (teachers and students) is a mechanism of extreme importance. Through the interaction, it is possible change of experiences, to establish partnerships and cooperation. In order to be able to analyze the interaction in the courses, it is necessary to appeal to new alternative forms of data representation. Internet as a virtual space with countless resources besides text, allows different and more significant representations for that mass of data. The literature (Tufte, 1983, 1990; Card et al., 1999) presents several information visualization techniques that allow us to see the information "hidden" or not available in the textual representation.

The Interaction Map tool - InterMap - was developed to allow the interaction data visualization in Web-based distance courses. This tool contributes for the teacher to have a better vision of the interactions in the course and consequently they could aid the students in their learning process. InterMap uses information visualization techniques to represent graphically the data of the TelEduc's interaction tools (mail, bulletin board and chat).

This article is organized in the following way: in the section 2, the theoretical referential is presented focusing the information visualization area; in the section 3, the InterMap tool is described; and finally in the section 4, are presented conclusions and future works.

## 2 Information Visualization Techniques

The information exploration should be a pleasant experience. However, many researchers alert for the information overload and anxiety (Shneiderman, 1998). Nowadays, human-computer interfaces designers are involved in the development of powerful methods for research and information visualization, trying to promote a smoother integration of technology with the task.

Visualization, in general, is the use of images to represent significant information (Stasko et al., 1997). There are several focuses such as Scientific Visualization, Information Visualization, Geographical Visualization, Business Visualization, Statistical Visualization, Process Visualization and Software Visualization. All types share a common goal - to transform data in something with more meaning; in other words, a useful visual representation so that the human observer can have a better understanding. Nowadays, this transformation is accomplished with the aid of the computer through graphic resources. Everything needs to be informed so that there is a perceptive and cognitive understanding on the task of searching information by the people that use these visualizations.

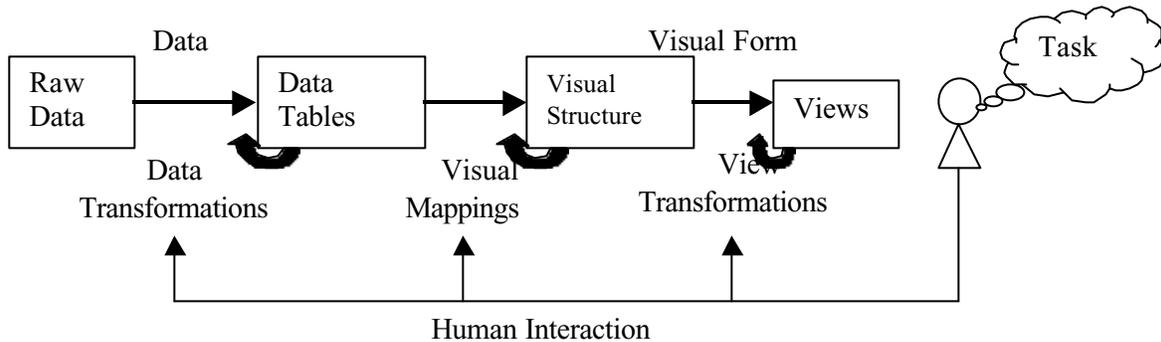
According to Card et al. (1999), Information Visualization is the use of computer-supported, interactive visual representations of abstract data to amplify cognition. The objective of representing visually abstract data is help researchers to see a phenomenon in the data, using perception to reduce cognitive effort.

To explore information is a difficult task, and it becomes more complicated, when the volume and the diversity of the data grow. If information is contained in a page, it is easy to find it, but if it is in a book or even in a library, the task becomes much more arduous. As the volume of data grew a lot, in the last years, these have been stored in structured database systems, for which it was developed a search language that became a pattern - the language SQL (Structure Query Language). With this language, users can specify commands to accomplish search, as for instance, book's title, author, etc. Syntax of SQL language can become quite complex for lay users. In many cases, a representation through a map or picture is much easier to use or to understand than the textual description. For instance, if the user wants tourist information on a certain Brazilian city, it is simpler to locate in a map of Brazil presented in the screen. Of course, if the tourist ignores the geographical location of the city, perhaps it is easier to seek through an alphabetical list. However, visual representations became more attractive for providing orientation or context, to enable selection of areas, and to provide dynamic feedback. Abstract information visualization has the power to reveal patterns, groups, differences, exits of statistical data, computer directories, collections of documents, among others.

The human beings possess notable perceptive skills, and information visualization is clearly dependent of those properties. Users can analyze, recognize and remember images quickly, and they can detect subtle changes in the size, color, format, movement and texture. They can point a simple pixel inside of an image with several pixels and to drag an object to accomplish an action.

But so that the visual representation of data (Figure 2.1) is effective for the people, it is important that this mapping preserves the data. Card et al (1999) suggest a reference model to map the data in visual forms. In that model, the first transformation works the Raw Data storing it in

Data Tables. A second step foresees the choice of a better Visual Structure (linear, map, tri-dimensional, temporal, tree) for the data and finally View Transformations like the inclusion of graphic parameters (position, climbs) are added to create Views.



**Figure. 2.1.** Reference model for Visualization (adapted Card et al., 1999, p. 17)

To conclude the reference model it is necessary to contemplate the human interaction completing the cycle between visual forms and control of the visualization parameters in the accomplishment of some task. The more obvious form of interaction is the direct manipulation that allows for instance, to drag a node of graph for the center of the screen (Donath, 1995). Human interaction with these Visual Structures and the parameters of the mapping create an information workspace that takes to the development of a visual sense. In the real life, that sense combines a series of complex loops. That space reveals properties of the information that takes to new choices. The techniques developed for the information visualization involve forms of representation of data (2D, 3D, trees), human interaction (dynamic queries, direct manipulation) and tasks (overview, zoom, filter, etc.).

Without using techniques to represent graphically data of communication between actors (teachers and students) in the environments, it becomes difficult to notice countless important aspects of the interaction. TelEduc, as most of the environments, possesses an interface that represents the interaction information in a textual and sequential way. Figure 2.2a and 2.2b present the e-mail and bulletin board interfaces respectively in TelEduc.



**Figure. 2.2a.** Screen of the e-mail



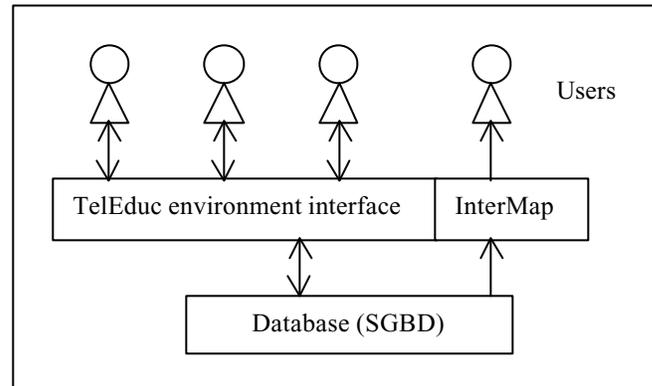
Figure.2.2b. Screen of the bulletin board

In spite of several existent forms to represent the conversation, the essential problem is to identify the salient data and to represent it accurately and intuitively (Donath et al., 1999). In the next section, the InterMap tool is described. This tool maps graphically Teleduc's interaction data.

### 3 InterMap: interaction visualization

Most of interactions in Web-base distance education environments are done through text. Text has countless qualities, as a way to change ideas, but it is deficient when we want to see social information, as conversational tone, groups and patterns of activity. This difficulty is worsened by sequential representation form of registering, storing and showing most of interaction tools in the environments. In the case of a course with countless participants, it becomes practically impossible, for instance, to accompany the change of conversation rhythm in a bulletin board. This situation becomes more complicated, when participant is absent of the group for a period of time, because the number of messages can increase a lot and he/she loses conversation context. To help participants to apprehend structure and history of conversation, as well as relationships among individuals in a course, new interfaces designs for data visualization are necessary.

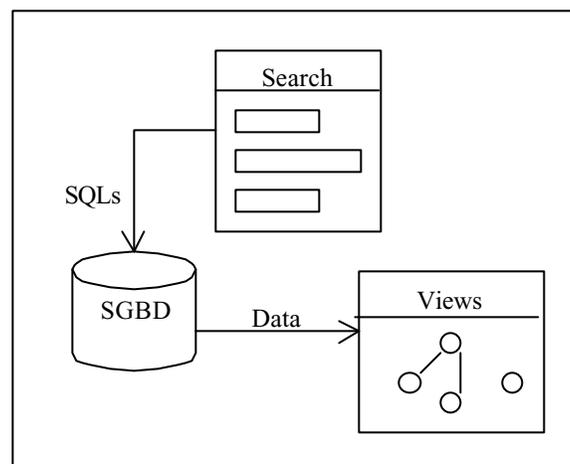
In that way, InterMap has been developed as a first resource to help teachers to have more information about students' participation, identification among partners and groups formation. Figure 3.1 illustrates an outline of the Teleduc architecture integrated InterMap.



**Figure. 3.1.** TelEduc architecture

In this figure, the database of TelEduc is shown, in which are stored all data generated during a course. Besides that, the figure shows environment interface and users interacting with the system. InterMap is represented in the same layer as TelEduc, however it is not drawn inside of the environment, because it can be used in a specific course or to analyze the whole database. TelEduc was implemented to be accessed through browsers (Netscape, Internet Explorer, for instance). In the figure 3.1, all the arrows, except the relative to the InterMap tool, are bi-directional representing the actions of search and inclusion of data that can be accomplished by users of the environment. The arrows related to InterMap are one-directional because the tool searches the data in the database and presents it visually to users without doing modifications in the database.

An diagram of InterMap architecture can be seen in the figure 3.2. InterMap is divided in two main parts: a search interface and information presentation interface (views). In the search interface, which resembles a form, all possible parameters for search definition are presented to user. After defining the parameters, SQL commands are sent to the database. The result of search is treated and presented visually in the presentation interface. In the same way as TelEduc, InterMap was developed to be executed through browsers.



**Figure. 3.2.** InterMap architecture

The main functionality of InterMap tool is the mapping of interaction and participation of actors involved in a course in TelEduc. For that, it uses several forms of graphic representation, such as graphs, charts and color code. Some screens that map data of e-mail, bulletin board and chat are

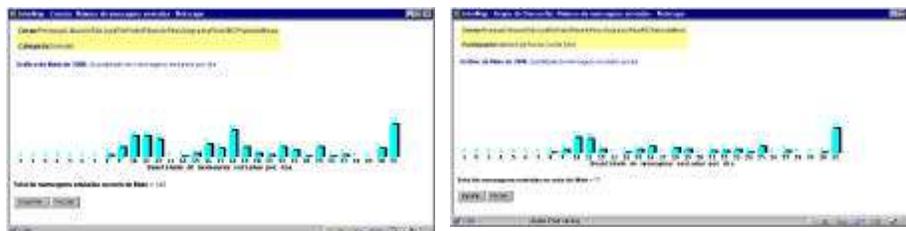
used in this paper to illustrate the application of the information visualization techniques explored in the InterMap tool.

One of the first difficulties pointed by teachers is how to know which is the effective students' participation in the courses. One way to obtain this information is through the amount of messages sent by e-mail or bulletin boards. However, to look for that information observing messages one by one in mailbox is very difficult. To be effective, this information has to be easy to obtain at any moment of the course. InterMap presents this kind of quantitative information in a facilitated way. In the figure 3.3, a screen is presented with options for the formulation of a search. User can define the presentation kind (graph or table); the month; the period (day, week or month) and the category (all participants, only students or only teachers). The figure 3.3 presents a screen with the result of a search about the amount of messages sent in the month of June (by week), for all participants of a course offered in TelEduc in the period of May to July of 2000.



**Figure.3.3.** Screens with search by week and result data represented in chart

As the search result is presented graphically in a new window, it is possible to see several charts at the same time and to compare those results, sometimes with surprising results. Besides the visualization of messages sent by period, it is also possible to visualize the information by participant. For that, it is only necessary to define the search selecting parameters in the search screen. In that case, teacher can have a better idea about student's participation individually or of whole group. The figure 3.4 represents graphically the search result of the amount of messages sent in the month of May for all teachers and for a specific one.



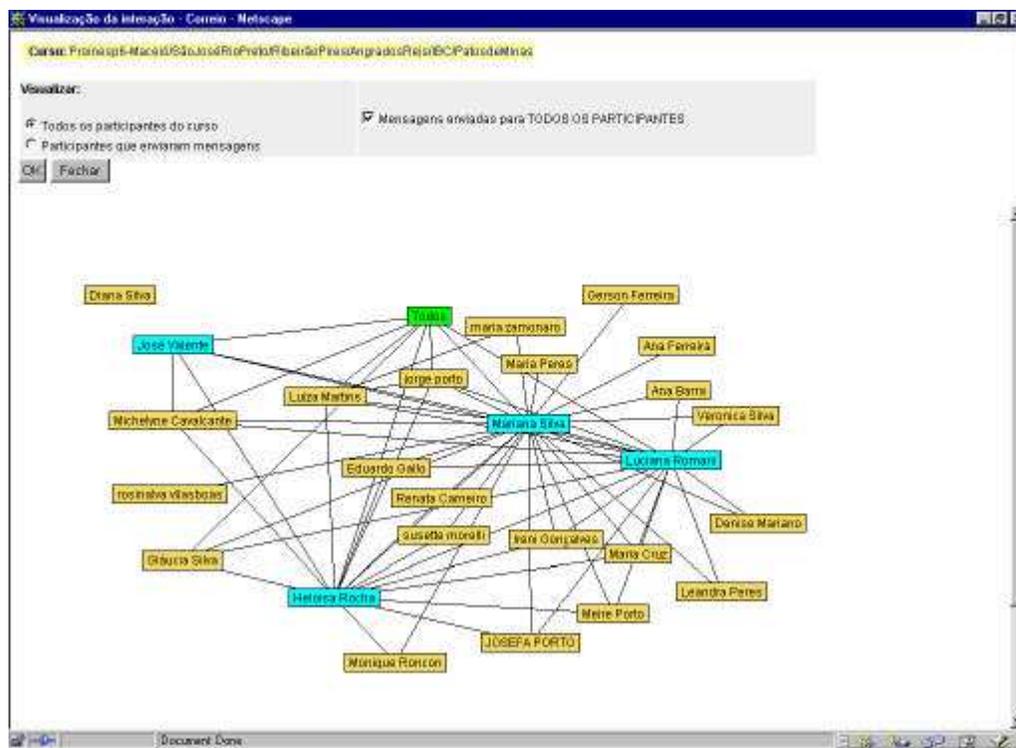
**Figure. 3.4.** Screens with charts for all teachers and for a specific one

We used code color to distinguish teachers and students in the InterMap tool. In whole tool, teachers are represented by cyan color and students are evidenced in orange.



information in the mass of data, it is necessary a different way from the previous ones. We use other information visualization techniques to solve that problem. An alternative was the representation of the data through a graph structure, which is defined in a simplified way as a finite group and not emptiness of vertex and edges. In InterMap, the vertexes (nodes) represent people - that is, participants in the course - and the edges represent the change of messages among them. Then, if participant A sends a message to participant B, an edge is drawn linking the two nodes "A" and "B". In that representation, nodes without edges indicate that such participants did not send and not receive messages.

In the figure 3.6 it is presented a graph that represents the interaction among participants of an example course. Nodes in blue color represent teachers, nodes in orange indicate students and one node in green evidences all participants in the course. In e-mail tool of TelEduc, we can send messages to all participants. In this visualization we wanted to show in evidence all people that have sent messages for all participants. When we select a node of the graph with a mouse click maintaining the mouse button pressed, this node and all edges that leave it change color, facilitating the visualization. Besides, it is possible to modify the presentation of the graph selecting a node and dragging it with the mouse. Using the dynamic queries techniques, users can modify the visualization dynamically through controls in the top of the window.



**Figure. 3.6.** Interaction visualization

In the Bulletin Board tool, we used charts and graphs to map participation and interaction data as in the E-mail tool. However, in this case, the graphs have a different interpretation. Nodes represent people - participants in the course - and edges represent a reply to messages in the bulletin board. Then, if the participant "A" sends one message for the list and he/she receives a reply of the participant "B", an edge is drawn linking two nodes "A" and "B". In that visualization, nodes that

do not have edges indicate participants that did not send messages or did not receive reply to their messages.

Besides, there are others representations that allow us to see the conversation flow in the Bulletin Board. There is the structure of reply, which is possible to visualize all first messages about a specific subject and reply to those messages. This visualization method can be seen in the following figure. The initial messages are represented by green points and reply are in red. With this representation is possible to evaluate who has initiative in the group to propose new subjects and who have participated with replies. Each point in the map represents the message and we can see the message in detail when we click in this point with the mouse.

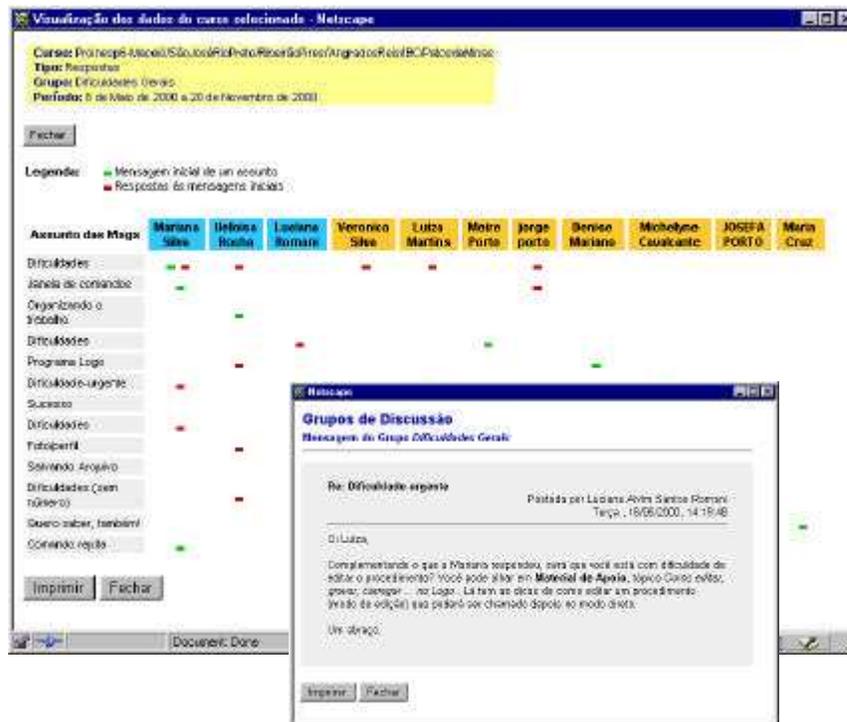


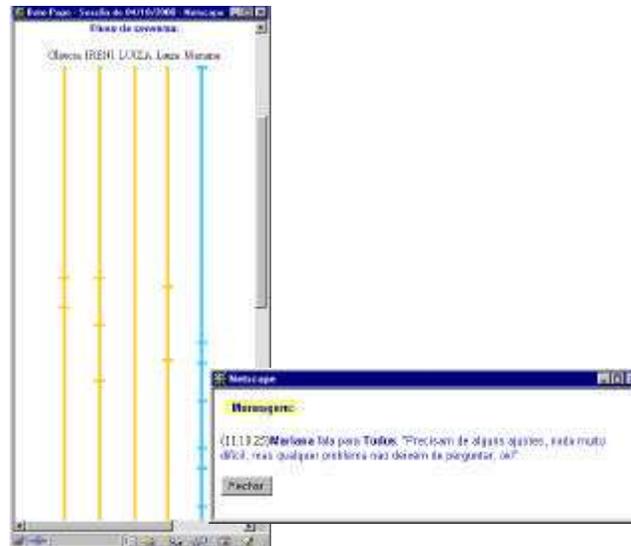
Figure. 3.7.: Visualization of messages and replies in the Bulletin Board

Another way to visualize conversation flow is by observing the teacher's intervention. In this representation, all messages sent to the bulletin board are mapped through points. Blue points represent the teachers' messages and orange points map students'. This visualization is shown in the figure 3.8.



**Figure 3.8.** : Information visualization about teacher's intervention

In the Chat tool, we used information visualization techniques like charts and graphs too. Besides, it is possible to visualize conversation flow during chat sessions. In this case, we use lines and colors to do this mapping. The figure 3.9 represents the visualization of a chat session with lines representing time and marks identifying messages. As all visualizations in InterMap, blue color represents teachers and orange represents students.



**Figure 3.9.** Conversation flow in chat session

With this interaction map, teacher starts to have "similar tracks" as if he/she were in a traditional classroom, where he/she sees the students' interaction physically. It is evident that in a traditional classroom, he/she has natural mechanisms that allow to notice a series of other aspects, as body posture, voice intonation, etc. However, this new form to presented data, gives important subsidies for teacher to accompany students in a more effective way.

## 4 Conclusions and future works

With InterMap tool, a first treatment was given on TelEduc's data with the objective of helping in the information visualization about interaction data of Web-based distance courses. The data mapped by InterMap is quantitative and the teachers should do the qualitative analysis of those data, on that first moment, in order to avoid misunderstandings. For instance, an individual that sends a great amount of messages during a course is not always the student that contributes more to the course. It is necessary to certify of the coherence and content of your messages. During the course which data was used as example in this paper, we observed one student that sends a great quantity of messages with contents with little significancy. Still in that course, other students obtained better performance without exceeding the number of messages. In the same way that in the traditional courses, the teacher has a fundamental role in the accompaniment and orientation of the student.

There are two aspects that still were not treated by InterMap: social aspects and qualitative analysis of the mass of data. In the literature (Donath et al., 1999; Sack, 2000) there are some jobs that aim at representing social information in virtual communities and others that present a semantic analysis of data of bulletin boards. However, there are not still great results in Web-based educational environments.

We salient that the use of information visualization techniques to map interaction data is an important step to help teachers to do a better accompaniment of the students and consequently to contribute for the improvement of their teaching/learning process. Besides, applying these new representation forms can diminish the people's cognitive effort involved in a course and to give subsidies to aid them to take knowledge of the social world in the course.

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