



TrAVis to enhance online tutoring and learning activities

Real-time visualization of students tracking data

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Abstract

Purpose – This paper presents a part of our research work that places an emphasis on Tracking Data Analysis and Visualization (TrAVis) tools, a web-based system, designed to enhance online tutoring and learning activities, supported by computer-mediated communication (CMC) tools. TrAVis is particularly dedicated to assist both tutors and students in the task of exploiting tracking data of communication activities throughout the learning process. This paper focuses on the technical aspects of TrAVis, the visualization of students' tracking data and the experiment we have conducted in an authentic learning situation.

Design/methodology/approach – A mixture of iterative and participative approaches has been adopted for the design of TrAVis. Different versions of TrAVis were built during the progress of our research. The major changes in each build have particularly involved the conceptual design of data indicators of students' activities and the visualization techniques of the data indicators. Both case studies and experiments have been made to evaluate TrAVis.

Findings – This paper demonstrates how TrAVis provides a new experience in visualizing and analyzing students' tracking data. While it shows the originality and novelty of the system, it also reveals the potential benefits of TrAVis to both tutors and students in their online tutoring and learning activities.

Research limitations/implications – The result from the experiment is not sufficient to evaluate some specific aspects of TrAVis. As a matter of fact, the lack of user's feedback did not enable us to justify whether or not the proposed data indicators would be actually used by the users.

Practical implications – The data indicators shown in this paper are computed based on the real needs of the participants in the learning process. Online questionnaires were used and face-to-face interviews have been made to study the needs of the users throughout this research work.

Originality/value – One of the particularities of this research is the proposed system, TrAVis, objectively designed to better support the tutors in the tasks of monitoring and evaluating students on CMC tools. Plus, TrAVis is distinguished from the existing systems by its capacity in computing substantial data indicators, allowing the tutors to efficiently visualize and analyze both the process and the product of students' activities.

Keywords E-learning, Communication technologies, Tracking, Data analysis

Paper type Research paper



1. Introduction

Researches in e-learning are involved in improving learning environments by the use of technology. They cover countless topics that place equal emphasis on all three elements: technologies, learning, and improvements in learning (Scott and Vanoirbeek, 2007). As we progress, we witness a big change of research interests in e-learning toward the learning process and the participants. More attention has been paid to the improvement of

technologies that better support participation and interactivity (Manson, 2007). Those technologies include computer-mediated communication (CMC) tools, which are employed to extend the content and interaction of a class because of their advantage in providing users with a great variety of ways to communicate between them.

For many reasons, communication is an essential component of education. It brings progress to the work of education in various disciplines, advances the interests of society, and bridges cultural differences (Morreale and Osborn, 2000). In an e-learning context, communication has undoubtedly always been an important part of the learning process. Whilst it usually creates opportunities for learning to take place, it also enables the sharing of information, the confrontation of ideas and thoughts which contribute to learning (Pearson and Sessler, 1991; Metallinos, 1992; Ford and Wolvin, 1993; Allen *et al.*, 1999). More evidence to back up such an argument can be found in the research effort of Morreale and Osborn (2000) along with a thorough study of nearly 100 articles, which emphasizes the importance of communications in various contexts, from the contemporary life to the specific learning situations.

In e-learning, communications are made on CMC tools and can be called CMC activities. Berge and Collins (1995) pointed out that the CMC tool is recognized as an essential element in distance learning, as it promotes a type of interaction that is often lacking in the traditional teacher-based classroom. In addition, CMC tools have many advantages over other media in terms of combining group communication features of face-to-face communication; time and place independence and mediated communication features of distance education (Liu, 2002).

Thus, far, CMC tools are strongly recommended for both tutors and students. Many research results have proven that using CMC tools allows the participants to achieve a better learning performance (Chou and Liu, 2005), overcome many traditional barriers of distance and times (Bromme *et al.*, 2005), and gain flexibility in learning (Dutton *et al.*, 2002). However, if we take a closer look at the use of CMC tools in distance learning, CMC tools alone do not always enable the participants to fully control their activities in the way they do in a traditional learning situation. As a matter of fact, the interactions between tutors and students are not person-to-person, but computer-mediated and online, which makes it difficult, for example, for the tutors to monitor the students' activities or to locate the problems encountered by the students. Besides, from a technological standpoint, CMC tools were not originally built to allow the tutors to perform student monitoring.

Acknowledging the practical issues related to using CMC tools, we put our research efforts into providing support to the participants in the learning process. More precisely, the research efforts focus on tracking the students' activities on CMC tools, and exploiting the tracking data to assist both tutors and students, during and after their activities in a learning environment.

This paper presents a part of our research work by placing an emphasis on Tracking Data Analysis and Visualization (TrAVis) tools, which was designed and developed for real-time visualization of students' tracking data on web-based CMC tools (i.e. discussion forums, chat, blog, wiki, etc.). It is structured as follows. Section 2 gives an overview of our research effort and discusses some related research works. Section 3 is dedicated to a presentation of the technical aspects of TrAVis. Some examples of tracking data analysis and visualization with TrAVis are given in Section 4. The experiment of TrAVis in an authentic learning situation is presented in Section 5.

2. Research context and related works

2.1 Tracking CMC in distance learning

Online learning with CMC requires a significant investment of resources, and involves considerable effort from various participants, particularly the tutors. As such, they bear a great responsibility in fostering the learning process with effective pedagogical concepts and strategies. For example, it is extremely important for a tutor to encourage the interactions between the students, supervise and animate their discussions. Meanwhile, with the current support of CMC tools that are often limited to communication means, the tutors are compelled to neglect other important facets of tutoring, such as student monitoring or evaluation when they are in a distance learning situation. As for the students, they often request technical support to enhance their learning experiences, such as being able to self-monitor on CMC tools in order to assess their own activities. But instead, the support they obtain still strongly rely upon their teacher's commitment and are usually constrained by other factors related to distance and time. It is needless to remind how crucial self-monitoring is to the students in increasing more appropriate behaviors in the classroom, boosting completion of homework assignments, improving both academic performance and social skills, and reducing disruptive behaviors (Trammel *et al.*, 1994; Carr and Punzo, 1993; Hallahan and Kauffman, 2000).

Having studied these issues, we addressed the importance of tracking CMC in learning situations for the benefits of tracking data to online tutoring and learning enhancements. The findings from our previous work revealed that the concept of using tracking system is recognized as a contributing factor to the high-quality education in terms of teaching enhancement and learning guidance. Also found in Jermann *et al.* (2001), a review of a variety of systems that make use of learning tracking data to assist the learners in mirroring their activities and to guide them throughout the learning process. Further evidence can be found in the research works of Komis *et al.* (2002), Després (2003), Hardy *et al.* (2004), Mazza and Botturi (2007) and Dyke *et al.* (2009).

In our previous work, an explicit tracking approach has been proposed for the implementation of tracking systems for a great variety of CMC tools. It focuses on a tracking mechanism capable of observing different types of user action and interaction on CMC tools. We discussed in detail this research effort in May *et al.* (2008). Later, we pursue our research by focusing on exploiting the collected data to design "data indicators" that support tutors in terms of student monitoring and evaluation. For the sake of comprehension, data indicators can be referred to a piece of information, usually presented in a visual form and may feature the process of the considered "cognitive system" learning activity, the characteristics or the quality of the interaction being performed on a technology-based learning environment (Dimitracopoulou, 2005). Data indicators provide means of abstracting, synthesizing, inferring, and visualizing the information that they feature. Obtaining data indicators is a complex process. It involves many phases, among which the transformation of data indicators in graphical representations. Further discussion in this paper centers on TrAVis and the real-time visualization of data indicators of CMC activities. The given examples of visualizing students' tracking data will demonstrate how TrAVis support the tutors in terms of gaining awareness and making pertinent analysis of students' activities, outcomes, effectiveness, etc.

2.2 Some existing tools for visualizing CMC activities

Data indicators give considerable assistance to both tutors and students in online learning situations. Found in the following research works, there are three main types of assistance: awareness, assessment and evaluation. Each of the three types is correlated to the nature of data indicator and the computerized system that computes it.

ARGUNAUT (De Groot *et al.*, 2007) is an awareness tool that provides data indicators of online discussions between users (i.e. students and teachers). Its main objective is to support the teachers in their endeavor to increase the quality of synchronous discussion in collaborative learning situations. The original indicators of users' discussion were first seen in the research work of Gerosa *et al.* (2004). They displayed the links of discussions in a tree form, giving an awareness of the discussion dept and how users interacted among each other. Later, we have seen iHelp (Brooks *et al.*, 2006), another awareness tool that aims to improve the user collaboration throughout their communication activities. For example, iHelp assists the teacher in supervising the communication process between students.

Regarding assessment tools, they are dedicated to the analysis of various aspects of a communication activity. As seen in Donath (2002) and Shaul (2007), to assess the productivity of a student in a group discussion, the teacher can analyze the participation level of that student (e.g. number of messages posted or replied in a discussion forum). In the same context, Gibbs *et al.* (2006) suggested a tool that offers means to analyze the temporal and spatial dimensions of students' discussions. The proposed data indicators are illustrated in a form of activity map, allowing teachers to observe and assess communication characteristics such as the degree of participations of a student.

Beside gaining awareness and making assessment of student activities, evaluating students is also needed. From a teacher standpoint, the evaluation, in the context of CMC, can be carried out based on the communications made among the students and the results of the communications. Mazza and Dimitrova (2003) suggested CourseVis to the teachers who wish to visualize the social aspect of student discussion. Not too far from CourseVis in terms of information visualization, Discussion Interaction Analysis System (DIAS) of Bratitsis and Dimitracopoulou (2005) is a web-based system that supports the teachers in analyzing students' interactions on a discussion forum. Data indicators computed by DIAS mainly serve for the evaluation of the social dimension of each student. Last but not least, Graphical Interactive Student Monitoring (GISMO) is a tool, developed by Mazza and Botturi (2007). GISMO visualizes behavioral and social data of students' activities on a discussion forum. Its objective is to help teachers evaluate the involvement of the students in the communication process during the course activities on a learning platform (e.g. Moodle).

Our primary observation regarding the existing systems is that most of them are exclusively dedicated to the teachers. Only a few are accessible by the students. Moreover, students are usually allowed minimal access to the tools due to their restricted user rights, as well as their roles in the learning process. As a result, students always receive less support in visualizing and analyzing their CMC activities. This is not to mention that most of the existing systems were not intentionally built to enable students to perform self-monitoring.

Other observation is relevant to the assistance of the data indicators proposed by each system. It is worth mentioning that a communication activity consists of a variety

of user interactions and contents exchanged over a CMC tool. Therefore, it needs to be described with adequate and pertinent information to help users identify the level of interactions of their communication activities. On top of that, the visualization of data indicators is also crucial. In this regards, the proposed systems must be equipped with a friendly graphic user interface (GUI) components, allowing users to manipulate the tracking data and particularly to compute graphical data indicators, which are representative and easy to view. However, some existing systems provide only the overview of users' activities, often in a unique form. Such deficiency might turn tracking data visualization and analysis into a time consuming task and less effective.

To sum up, the study on the existing systems leads us to propose TrAVis, which is objectively designed not only for the teachers but also for the students. Plus, TrAVis is distinguished from the existing systems by its capacity in computing substantial data indicators, allowing users to efficiently visualize and analyze both the process and the product of a CMC activity –, i.e. describing how an activity is carried out and what the output is.

3. TrAVis design and development

3.1 Overview

TrAVis is a technological solution that enables users to directly access the tracking data repository via a GUI, to compute the data indicators in graphical representations, and to visualize them in different forms and scales. For tutors, TrAVis offers three tools to monitor in real time an individual or a group of students throughout the course and communication activities. More particularly, TrAVis assists the tutors in making assessment and/or evaluation of several aspects of the students (e.g. social, cognitive, behavioral aspects, etc.). For students, TrAVis is a “reflective tool” or in other words, a guide that assists students to gain an insight on their activities via their tracking data, thus allowing them to self-assess.

For instance, TrAVis allows the students to acquire an overview of their personal learning progress, their participation rate in social interactions, or other statistical data from their communication activities.

It should be noted that in this paper, we only focus on teachers as users of TrAVis for the reason that students are using TrAVis for self-monitoring and self-regulation, which suggests a further discussion with a different perspective.

TrAVis is dedicated to users with different backgrounds and experiences in using computerized systems. Hence, it is crucial for us to consider a guideline in the design of TrAVis in order to make it more accessible and customizable to users with limited technical skills. The development of TrAVis is guided by a number of rules that lead to an achievement of good quality engineering process in relation to the architecture design, or the evolution of TrAVis for further usage. Therefore, for the reasons of flexibility and accessibility, TrAVis is developed with web-based technologies. Our main objective is to share TrAVis with the e-learning community, a part of which regularly seeks additional technological solutions to support data analysis and visualization practices. On top of that, TrAVis is carefully designed to be accessible by non-computer specialists who often request technical support in using a particular tool to make use of tracking data. While TrAVis is an independent platform, designed to be applied to a wide range of CMC tools, it is also built upon multi-component architecture (Section 3.3). The significant advantage of such architecture is that each component can

be individually modified. Moreover, it is practical for us to be able to add extra features or new functions to improve a particular component without having to alter the whole architecture of TrAVis.

3.2 TrAVis design approach

We have adopted a mixture of iterative and participative approaches in the design of TrAVis. Different versions of TrAVis were built during the progress of our research. The major changes in each build have particularly involved:

- the conceptual design of data indicators; and
- their visual forms.

It is important to point out that designing data indicators is as challenging as proposing how to visualize them. As a matter of fact, an indicator designed with a complicated visual form might not facilitate both the visualization and the interpretation of the information that it features. Consequently, the proposed indicators might not always be any help to users. This then, suggests that not only the construction of more intuitive, representative and compelling indicators are required, but also the necessity of increasing the ease of use in their visualizations.

In respect of the conceptual level of data indicators, we referred to the research efforts of Mangenot (2008) that focused on different levels of user interactions during CMC activities in learning situation. More precisely, Mangenot distinguished the four levels of interaction – aggregation, discussion, cooperation and collaboration, which reflect the form or the modality of a communication activity. For instance, while the aggregation level refers to the activities of an individual user, the collaboration level refers to the collaborative activities of a small group of users. Examples of data indicators are given further in Section 4.2. Our main objective is to propose different sets of data indicators to support the visualization and analysis of each level of interaction. Accordingly, we identify at first the significant information describing the latter and how it is represented in a visual form easily interpretable by the users.

Regarding the data indicator visualization, we employ various data visualization techniques to construct the visual forms of the indicators. The visualization of the indicators is shown in a form of “User Control Panel” that varies from statistical data in tabular format, to synthetic information in graphical representations. Meanwhile, we also add “visualization variables” that allow the transformation of the indicators, depending on their type, from one visual form to another. More precisely, the visualization can be technically varied according to the following variables:

- “User”, refers to the number of users that appear in the representation of the indicator. For instance, this variable enables indicators of an individual user, or multiple users, to be visualized either separately or together.
- “Scale” or the scope of information that an indicator covers. For instance, an indicator of a CMC activity can either describe the global overview (high level) or the detail of the activity (low level).
- “Chronology” or the temporal aspect of an indicator that allows users to display data indicators with a specific date and time or even within a period of time (i.e. an interval of time) –, e.g. displaying every interaction of a user on CMC tool between day 1 and day 2 and from time 1 to time 2.

3.3 TrAVis architecture

Figure 1 shows a simplified version of the multi-component architecture of TrAVis. It consists of a tracking data repository and four major components including “Interface”, “Data processing”, “Data analysis” and “Data visualization”:

- (1) *Interface component.* Developed with web-based technologies that include DHTML, CSS, AJAX and JavaScript, the interface of TrAVis is flexible, allowing users with limited technical skills to easily manipulate it. For example, users have choices between manually filling the visualization parameters and selecting them from a preset list. Figure 2 shows a screenshot of a visualization tool, among others, currently available to TrAVis users.

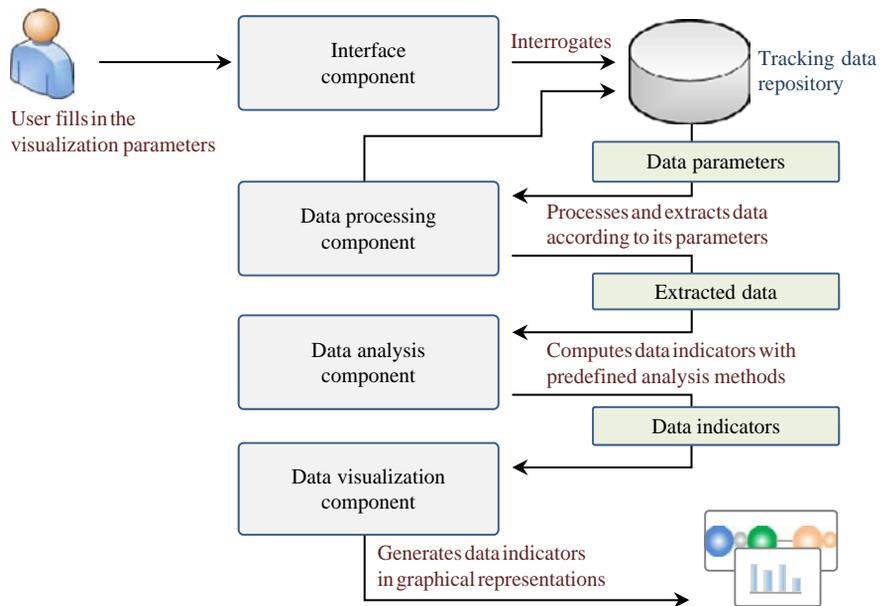


Figure 1. Multi-component architecture of TrAVis



Figure 2. A screenshot of a visualization tool of TrAVis

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- (2) *Data processing component.* Data processing also refers to access and manipulation of data that are stored in the tracking data repository. While the latter is implemented with MySQL server, processing data is completely done with SQL queries. Developed with PHP, data processing component is mainly a library of SQL queries formalized to perform a variety of operations, among which the extraction of necessary information from tracking data repository that serve for the construction of indicators.
 - (3) *Data analysis component.* This component consists of a number of predefined data analysis methods that are dedicated to the production of indicators. Technically, the analysis methods are coded in PHP as a set of functions with parameters, dynamically changed according to the data received from data processing component. New functions to compute new types of indicators can be added to this component without having to modify the source code of other components of TrAVis.
 - (4) *Data visualization component.* This component contains two graphics libraries and various visualization techniques coded in PHP as a compilation of functions, to display the data indicators in graphical representations. While we chose pChart, an open source PHP class oriented framework for the development of this component, we also designed a proper graphics library (GL), called TrAVis-GL, to ensure a large part of data indicator construction in TrAVis.

4. TrAVis to analyze and visualize tracking data

In this section, we give some examples of data indicators that feature both quantitative and qualitative information regarding user communication activities on discussion forum. It should be noted that discussion forum is a reference CMC tool that has been used in our case studies and experiment. Nonetheless, our research covers a variety of CMC tools, both synchronous and asynchronous. Computed by TrAVis, different sets of data indicators we present in the following sections can be used to:

- demonstrate how TrAVis provides a new experience in visualizing and analyzing tracking data of CMC activities on discussion forums; and
- emphasize the originality and novelty of the proposed data indicators and their potential benefits to both tutors and students in their online tutoring and learning activities.

4.1 Visualize in real time a user activity

One of the three visualization tools of TrAVis is called “Time Machine” due to the technical capacity of retrieving the information from the tracking data repository and computing data indicator on the fly.

This makes it a particularly efficient tool for users like tutors who wish to observe in real time the ongoing activities on the discussion forum.

Figure 3 shows the view screen of Time Machine with the list of the activities of a user (Tdelille). With this view, we can move up and down the activity list (A) and update it in order to get the most recent activities performed by Tdelille. Each activity is represented as a horizontal bar and in a unique color. When we select an activity by clicking on a bar, the detail information of the activity is displayed at the right part of the screen (B) with an “extra menu” (C), allowing us to view other activities that are

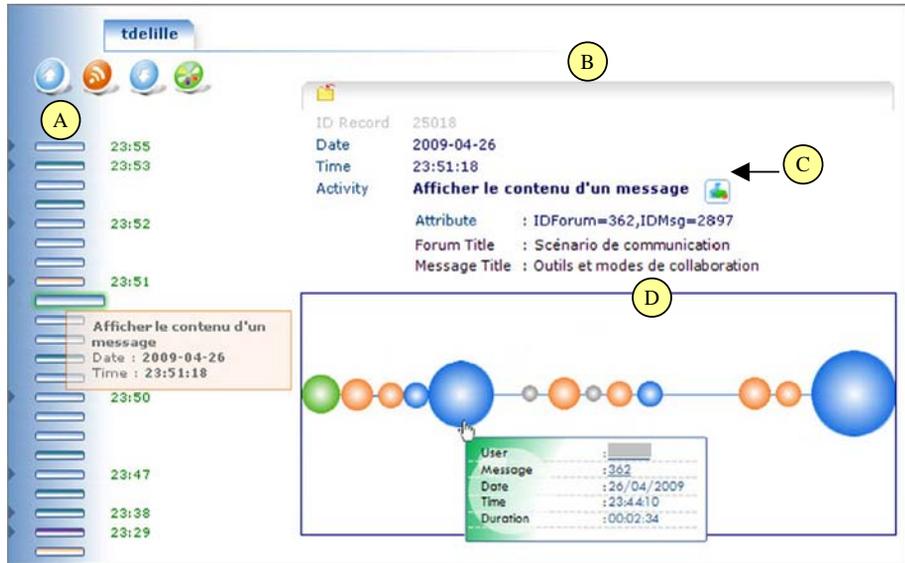


Figure 3.
List of user activities
displayed on Time
Machine view screen

related to the current activity. In Figure 3, we are viewing an activity of Tdelille while reading a message “Outil et mode de collaboration” (IDMsg = 2,897) in the forum “Scénario de communication” (IDForum = 362). From that view, we choose to display who else read the same message that Tdelille is reading (D). It is important to mention that we are not claiming that we can prove if a message was really read by a user, but we can tell if a message has not been entirely read. For example, if a user has only rapidly displayed a long message (e.g. less than 3 seconds) without touching or moving the vertical scrollbar downward the bottom, the displayed message must not have been entirely read by the user.

Each sphere shown in portion (D) of Figure 3 represents an activity of displaying a message and the diameter of the sphere is proportional to the time spent by each user reading the message. The distance between two spheres represents the time gap between two different readings. A sphere can be one of the following four colors: orange, blue, green or grey. The green sphere notifies us that the user read the message by having moved the vertical scrollbar downward to the end of the page (reading till the end of the message). The orange sphere indicates the fact that the user has simply displayed the message without touching the scrollbar. The blue sphere signifies that the user has displayed the message and has moved the vertical scrollbar downward, but not to the bottom of the page (i.e. partial reading). The grey sphere indicates that the window displaying the message has been left inactive –, e.g. user minimizes the window leaving the message unseen.

In practice, Time Machine can assist the tutors to efficiently monitor students by navigating among the past and the current activities of the student with or without a specific time slot. It can be used as a “User Control Panel” that enables tutors to access to other types of indicators. As shown in Figure 4, an indicator that features the statistical data related to four other different activities on a discussion forum.

4.2 Visualize user's level of interaction in a communication activity

We have mentioned in Section 3.2 that data indicators computed by TrAVIS are also dedicated to support the analysis of different levels of interaction between users during a CMC activity. Presented in a radar graph, each indicator can be restricted to one single user (Figure 5) or extended to multiple users (Figure 6).

A radar graph is a convenient visual form, providing simultaneous observation and analysis of different aspects of user activity. What is more, a radar graph can be illustrated dynamically with an arbitrary number of variables where the values can be both quantitative and qualitative information of an individual or a group of users' activities. Figure 5 shows an example of aggregation data indicator that reflects the users' activities being performed for mutual benefit. It can be used to describe the activities of each individual user but in the context of pooling the resources in the discussion group. The five data points of the radar graph summarize the following activities of a user Tdelille:

- (1) connection frequency;
- (2) threads started;
- (3) messages posted;
- (4) message replied; and
- (5) message quoted.



Figure 4.
Overview of a student's activity on a discussion forum

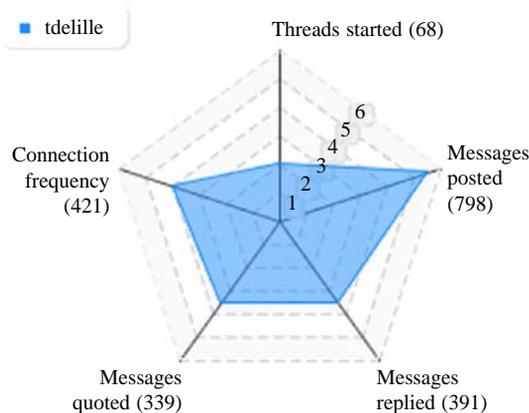


Figure 5.
Data indicator for aggregation level

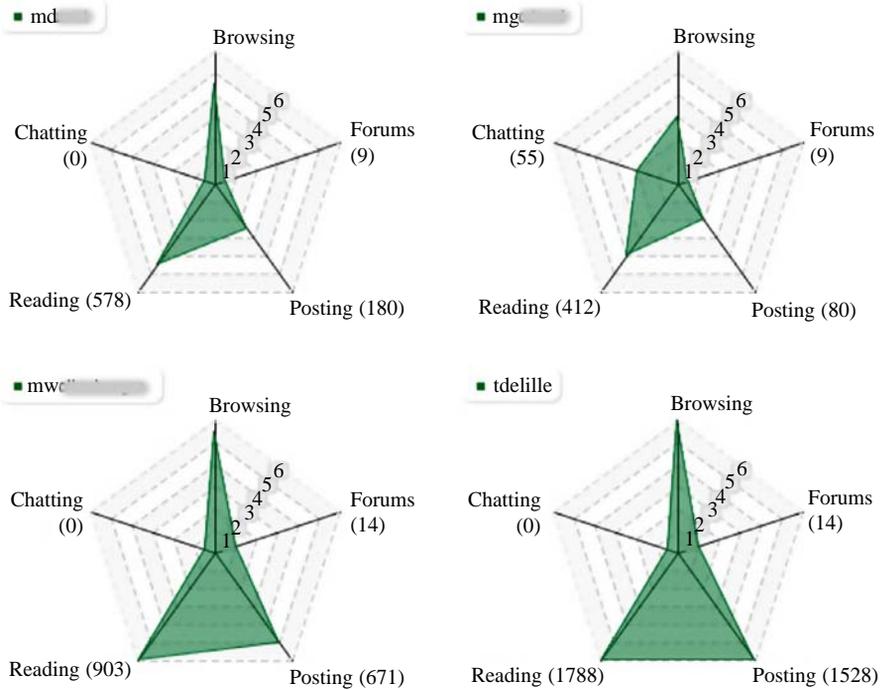


Figure 6.
Data indicator for
discussion level

The proposed indicators at the discussion level, as shown in Figure 6 feature the discussions between users. Such indicators refer to quantitative information regarding user interaction (e.g. number of messages posted in a discussion forum) and to the content exchanged throughout the communication activities (e.g. message content, document, etc.). In practice, analyzing the discussion indicators leads to an identification of the level of social interaction and the activeness of a user during the communication activities. For example, from Figure 6, the number of forums a user participated could reflect the interest of the user in making discussions in the forums, which belong to other groups or are dedicated to other discussion topics. Meanwhile, the number of messages a user read and posted in the forum could reveal how active the user was in interacting among other users.

More interestingly, the visualization of users' communication activities is not limited to a single activity, a single user or a single group of users. The cooperation data indicators computed by TrAVis feature specific exchanges of a small group of users. They are commonly used to identify the activities of individual users who participate in the discussion for a common purpose or benefit. For example, the cooperative data indicators enable a teacher to identify the part of contribution a student made by comparing it to the rest of the group.

The collaboration level of a communication activity refers to the group activity being carried out to reach a common goal. There are few differences between cooperative and collaborative data indicators from a technical standpoint with respect as to how they are computed and displayed. Users are to judge with their own personal

points of view the collaborative aspects of an activity. However, the collaborative data indicators focus on the product of communication activities of a group of users within a defined time span. Owing to this condition, the analysis of collaboration level of a communication activity is time-dependent and usually realized from a group of users' perspective. Figure 7 shows an example of visualization of two groups of users on three forums that have the same structure, dedicated to the group discussion to perform the same collaborative task. Each radar graph, filled in with a distinct color, gives a quick perception of the forum that has the most participation rates (e.g. access frequency, number of threads, files, messages and participants).

Via Figure 7, we can observe that group A has more intense interaction than group B in almost the three forums. The analysis of interactions among group discussion leads to an evaluation of various aspects of the collaboration level of each group. For instance, it can be carried out to:

- compare the participation rates of both groups during the collaborative task; or
- to evaluate the productivity rates of one group in relation to another, according to the number of messages posted or files created and shared.

Thus, far, we would like to emphasize that TrAVis offers means to users to visualize data indicators of CMC activities in different manners. However, the interpretation of information featured in each data indicator is still strongly reliant on user's personal point of view and analysis objective.

5. TrAVis in an authentic learning situation

5.1 Overview of the experiment

Beside the three case studies we have conducted since 2007 (May *et al.*, 2008), an experiment in an authentic learning situation with the participation of both tutors and students of French as foreign language (FFL) from Stendhal University of Grenoble III, has been successfully carried out in late 2009.

Total of 13 students and three tutors have participated in the experiment, which lasted for three months. It is worth mentioning that FFL is a two-years-professional-master course to train learners to be tutors, specialized in French language teaching.

Our experiment took place with one of the course modules, titled "Creating Pedagogical Scenario" during which the students worked together with the support of

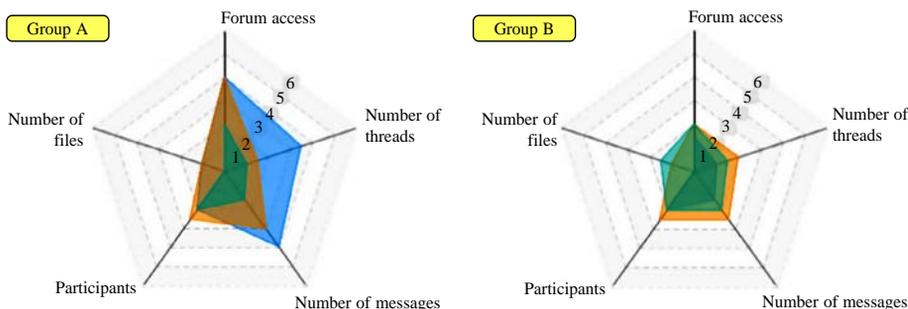


Figure 7.
Data indicator for collaboration level of two groups of users

Moodle and discussion forums to create a learning scenario for a French class. Separated into groups, the students were supervised by tutors. Each group had several learning tasks undertaken by group discussions in a collective manner –, e.g. the discussion on the organization, negotiation and distribution of the tasks among the group members, etc. At the end of the course module, the students were evaluated by their tutor as a group and individually. Throughout the experiment, the tutors used TrAVis to monitor the interactions between the students and to evaluate different aspects of the students' communication activities. The students, on the other hand, used TrAVis to visualize their progress in the group activities and to compare their profiles with the rest of their group members.

The main objectives of our experiment are to:

- evaluate the functional level of TrAVis from the point of view of the tutors and students; and
- study the impact of TrAVis in an authentic learning situation like FFL.

Thus, at the end of the experiment, we used a questionnaire to study the feedbacks of the participants regarding the usability and the utility of TrAVis in the context of FFL.

5.2 Discussion on the result of the experiment

In this section, we present some data from the experiment and the result analysis of the questionnaire. First, we look at Table I, which summarizes the quantitative data of the communication activities of the three groups of students.

Table I reveals a very interesting aspect related to the intensity of the communication activities of the students. Notably, within a period of less than three months, 330 discussion threads were created in 28 forums and over 2,804 messages were exchanged among the students. It shows that, on average, 36 new messages were posted per day and each user posted around 215 messages throughout their learning activities.

Regarding the questionnaire of TrAVis, we received seven responses (one tutor and six students) despite several invitations we made. While statistical data from the questionnaire are interesting, users' comments are the most significant and beneficial to the qualitative analysis of the usability and utility of TrAVis.

5.2.1 Usability of TrAVis. Despite the fact that most of the participants are non-specialist computer users, they find TrAVis easy to use, as mentioned in the comments below:

The tool is very handy. I can instinctively use it from the beginning and without a user's guide.

This comment is very interesting as it points out that even without a user's guide, the participant could easily operate TrAVis. From a developer standpoint, it is important for us to ensure TrAVis the most practical to the users so that they will not have to spend time exploring how to use it, but start to exploit immediately, its functionalities

Table I.

Quantitative data of the communication activities from the experiment	Number of discussion forum	28
	Number of discussion threads	330
	Number of messages	2,804
	Number of files	92

and services. Some other participants expressed in a few words to give their appreciation on TrAVis interface design. As found in the two following quotes:

I found the interface very cheerful and colourful. There are many buttons but they all seem to be necessary to enable the information searching at a specific point.

The interface is very pleasant to use.

Besides, the good evaluation scores and positive comments on using TrAVis, some minor difficulties were also stated as follows:

Even if I appreciated the interface, and gave it a good score, it took me a while to understand the functionality of the project (TrAVis).

At the beginning, I had a little difficulty understanding the purpose of each tool.

In spite of having created a technical guide to assist the users in maneuvering different tools of TrAVis, we recognize that some practical issues might eventually occur when users get to experience TrAVis for the first time. From the experiment, we found out that the difficulties students had were commonly not related to using TrAVis, but to the unfamiliarity of the graphical data indicators and the associated analysis concepts.

5.2.2 Utility of TrAVis. In terms of evaluating the utility of TrAVis, we focus on the design approach of the proposed data indicators and their visual forms. Below, we quote some comments, reflecting how participants perceived the utility of the data indicators and the impact of using TrAVis in their online learning practices. It is important to mention that some of the students from the experiment have already been practicing their teaching activities alongside their FFL training courses. As yet, their comments, as presented below, describe their appreciation on TrAVis from both student and teacher standpoints:

It allows the teacher to analyze and evaluate dynamics and practices of his students. Besides, the frequency of connections, the 4 indicators (aggregation, cooperation, discussion, collaboration) allow the online tutor to evaluate the engagement and the learning motivation of each participant.

TrAVis allows visualizing the trajectories of practices so the tutor can proceed to an instructional adjustment in a realistic situation.

I am positive about the innovative learning approach that the use of TrAVis may imply [...]
It gives me a whole new perspective on practice, learning, identity dynamics and motivation.

Such comments drew our attention to one crucial aspect regarding how the four levels of data indicators actually help the tutors not only to identify the different levels of interaction among the students, but mostly to evaluate the engagement and the learning motivation of each student. Another student had been a little more specific on the use of the data indicators from a student perspective:

From the perspective of a learner, but also of a tutor, we can technically observe a group of learners and their activities on the tool (i.e. forum) as well as monitor the participation of each individual. When we manage a group, taking into account the participation of the group is difficult, which can be a contributing factor to the failure of the project. Therefore, a tool like TrAVis could quickly become interesting and certainly essential.

The evaluation of TrAVis also reveals some issues related to the representation of the data indicators. As expressed in the following comments, the visual forms of some data indicators cause some difficulties in the information interpretation, which obviously require the participants to spend more time on the visualization:

I would say that it is not obvious at first glance. It took me quite a while, and I need some practice and concentration to figure out what I could make use of each functionality.

Some graphics, such as indicators for collaboration, are for me a little difficult to understand (having said that, I only spent a few minutes to visualize those indicators and I have not actually used them).

From a global perspective, the experiment has been a great experience for our research team. The evaluation we made on TrAVis turned out to be very positive. In fact, the data from the questionnaire showed good appreciation of the participants on TrAVis. Additionally, both students and tutors clearly expressed their points of view on the utility of TrAVis in their online tutoring and learning activities.

In addition, they also provided us with significant feedback on the issues related to TrAVis they encountered during the experiment, which are most helpful for the improvement of TrAVis in both technical and practical aspects. However, they did not provide us with information to evaluate whether or not the proposed data indicators reflect the reality of the CMC activity.

6. Conclusions and future work

In this paper, we presented TrAVis, a technological solution that we are providing to the participants in the learning process with an objective to enhance their skills in analyzing and visualizing CMC tracking data. Two significant characteristics of TrAVis are:

- (1) the accessibility; and
- (2) the production of data indicators.

Indeed, TrAVis is not only dedicated to users with different backgrounds and experiences in using computerized systems, but also customizable to users with limited technical skills. Furthermore, while most tools are only addressed to the teachers, TrAVis is specifically designed to be accessible by both teachers and students. In regard to tracking data exploitation, TrAVis provides a new experience of visualizing data indicators in graphical representations, in multiple visual forms and in different scales, from a global view of group activity to a detail of each individual user actions. Besides, the analysis and visualization of data indicators can be made in real time.

The experiment we conducted has been a valuable opportunity for us to put TrAVis into an authentic learning situation. We were able to demonstrate to the participants the benefits of using TrAVis in their actual practices. While the experiment was considered a success, we also achieved our main goals – evaluating TrAVis from the point of view of both teachers and students of FFL.

We are currently working with other research teams on the improvement of TrAVis to answer better the real needs of the participants in various learning contexts. We are planning to use TrAVis in a more complex learning environment, where the

communication activities among the participants are performed on a number of CMC tools (i.e. discussion forum, chat and wiki). Our main objective is to:

- investigate new types of data indicators to be computed by TrAVis; and
- study how they can be beneficial to online teaching and learning enhancement.

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Further reading

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