



Is the unfolding of the group discussion off-pattern? Improving coordination support in educational forums using mobile devices

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ABSTRACT

A forum is a valuable tool to foster reflection in an in-depth discussion; however, it forces the course mediator to continually pay close attention in order to coordinate learners' activities. Moreover, monitoring a forum is time consuming given that it is impossible to know in advance when new messages are going to be posted. Additionally, a forum may be inactive for a long period and suddenly receive a burst of messages forcing forum mediators to frequently log on in order to know how the discussion is unfolding to intervene whenever it is necessary. Mediators also need to deal with a large amount of messages to identify off-pattern situations. This work presents a piece of action research that investigates how to improve coordination support in a forum using mobile devices for mitigating mediator's difficulties in following the status of a forum. Based on summarized information extracted from message meta-data, mediators consult visual information summaries on PDAs and receive textual notifications in their mobile phone. This investigation revealed that mediators used the mobile-based coordination support to keep informed on what is taking place within the forum without the need to log on their desktop computer.

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1. Introduction

In asynchronous communication, learners participate at a time and a place convenient to themselves and appropriate to the task, having more time to reflect before composing their contributions. Quieter members have more opportunity to contribute (Straus, 1996) and learners that may feel that they do not have enough time to prepare their thoughts in a fast-paced discussion have a better opportunity to expose their ideas in less time-limited way (Funaro & Montell, 1999). The asynchronous format also contributes to organization, reflection and deeper discussion, since participants have more time to contribute (Scardamalia & Bereiter, 2006), which may increase perceived learning (Wu & Hiltz, 2004).

Educational forum is an asynchronous textual communication tool, largely used to delve deeper into a course subject. Participants contribute more thoughtfully, working their arguments and backing up their ideas with evidence before turning them into essays (LaGrandeur, 1996). Participants also share their thinking with each other, comment on each other's ideas and find partners that share interests in order to get into a deeper discussion (Bull, Greer, McCalla, & Kettel, 2001). By formulating ideas in writing and receiving feedback from peers, learners' knowledge and thinking skills are socially constructed (Benbunan-Fich & Hiltz, 1999). Group structure provides social support and encouragement for individual effort.

In order to reach the educational purpose of a forum, coordination of learners' activities is necessary. A forum demands close attention of the mediator, mainly in the initial sessions when participants are not used to the adopted methodology yet. The mediator coordinates the forum so that the discussion does not drift to a non-productive direction, assuring that the flow of information is neither too monotonous nor unmanageable (Salmon, 2000). Mediators maintain continuous monitoring over the entire running of the session, ensuring that learners participate with consistent and well-structured arguments, and intervening promptly when they identify problems. Mediators demand regular contributions in an appropriate timeframe to avoid dispersion and stimulate better contributions.

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Learners also organize themselves to carry out their tasks. Learners constantly check the content of the topics that are in debate, choose which of them to answer and prepare their argumentations. They self-regulate their participation according to their colleagues' participation.

In order to carry on their coordination activities, mediators and learners must be aware of the forum unfolding. To be aware, in this context, is to acquire information about what is happening and what other people are doing (Brinck & McDaniel, 1997). Awareness involves various cognitive aspects related to human skills. Virtual environments filter irrelevant information in a way reducing dispersion that normally permeates a face-to-face situation. Relevant information is timely summarized and supplied.

As it is impossible to predict when a message arrives – there can happen both a period of inactivity and the arrival of several messages in a short period – mediators constantly connect to the environment to be aware of the unfolding of the discussion. Besides this sometimes annoying operation, mediators have to collect and analyze a large amount of disperse data. Environments may offer computational support for this activity so mediator can decide the proper moment to intervene.

This article presents a piece of action research that illustrates how developers may improve coordination support in educational forums, offering summarized awareness information in reports and notifications through mobile devices. This investigation involves a course applied completely at a distance in a web-based environment. In Section 2, collaboration, awareness and the use of reports and notifications to support them are further discussed. Section 3 presents the scenario where this research was conducted. Section 4 presents the analysis of some message characteristics that may offer indications about off-pattern situations. Section 5 presents how the mobile environment was used to better support forum coordination. Section 6 concludes this paper.

2. Reports and notifications to support awareness for coordination

Coordination plays a fundamental role in collaboration. In order to collaborate, members of a group communicate, coordinate themselves, and cooperate. The diagram shown in Fig. 1 summarizes the 3C Collaboration Model, originally proposed by Ellis, Gibbs, and Rein (1991). Coordination is the link connecting the other two C's in order to achieve collaboration (Fuks, Raposo, Gerosa, & Lucena, 2005). Group members deal with conflicts and organize themselves in a manner that avoids losses of communication and cooperation efforts. Without coordination, there is a risk of misunderstandings, disorientation, conflict, and tasks duplication. The mediator is the one responsible for the coordination of an educational forum, but learners also organize themselves in order to achieve their goals and accomplish their tasks.

In some systems, coordination is enforced by computer-supported mechanisms—“a specialized software device, which interacts with a specific software application so as to support articulation work” (Schmidt & Simone, 1996). On the other hand, loosely integrated collaborative activities, such as those in chats, videoconferences, and forums, are socially coordinated. To coordinate themselves, participants use the standing social protocol, characterized by the absence of any computer-supported coordination mechanism among the tasks, trusting the participants' abilities to mediate interactions. Coordination, in these situations, is contextually established and strongly dependent on mutual awareness.

Awareness information is particularly useful for carrying out tasks where a priori articulation is not sufficient (Raposo, Magalhães, Ricarte, & Fuks, 2001). These ill-defined tasks are particularly common in learning activities, where learners make decisions and solve problems without complete knowledge about the domain (Simon, 1996). In these tasks, the division and the organization of work occur dynamically through the coordination of the activities (Gross, 1997). Awareness elements inform about changes in plans thus generating shared understanding. Moreover, they inform the participants about temporal and spatial aspects of the actions and facilitate the synchronization of the individuals' tasks.

Through awareness information, participants detect changes in plans and understand how the work of their colleagues is getting along: what was done, how it was done, what are the preliminary results, and what needs to be done until it is finished (Gutwin & Greenberg, 2002; Dourish & Bellotti, 1992). In a forum, it is important to know, e.g., how many posted messages there are, who sent them, how many posted messages were evaluated, and what the characteristics of good messages are. Without this context, participants are not able to measure the quality of their own work compared to the objectives and progress of the group.

Different ways of classifying awareness information appear in the literature. Kirsch-Pinheiro, Lima, and Borges (2003) classification points out that the activities executed in synchronous and asynchronous ways demand different types of awareness information. While in a synchronous activity, participants are interested in what is currently happening, in an asynchronous activity participants also need to know what happened while they were offline. According to Prinz (1999), for a groupware to be successful, it is nec-

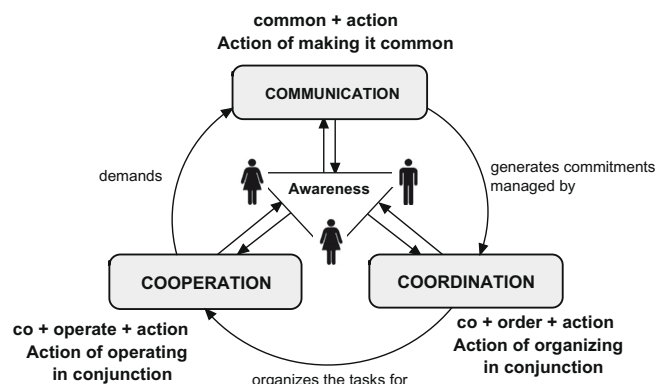


Fig. 1. Diagram of the 3C Collaboration Model.

essary to present task-oriented awareness information and social-oriented awareness information. Carroll, Neale, Isenhour, Rosson, and McCrickard (2003) classify awareness information in three categories: action, social, and activity. Activity awareness regards awareness of the overall situation and of other people's plans and understandings. This kind of information is decisive for the coordination effort. Gutwin, Stark, and Greenberg (1995) classify awareness information as social, task, concept, and workspace. Workspace awareness information is related to the events that are currently happening on the shared workspace. Otjacques, Noirhomme, Gobert, and Feltz (2006) suggest a categorization for workspace awareness information through two dimensions: "granularity" (awareness information for an individual or for the group) and "identification" (awareness information presented in anonymous or identified form).

In this work, the coordination support makes available task-oriented and action-oriented awareness information regarding what is currently happening in the forum. Even using an asynchronous tool, participants not connected to the desktop's Learning Management System web interface should be aware of what is happening within the environment, either by receiving notifications regarding the unfolding of the forum or consulting web pages via PDA. The coordination support also makes available aggregated and anonymous workspace awareness for the forum mediator.

The mediator should identify who is working properly, where there are conflicts of interest, what are the skills and experiences of each one of the participants, which are the group difficulties, and whether deadlines are being met. Based on this type of information, the mediator takes the proper actions for coordinating the group. Although most of the information about what is happening, has happened, or will happen in the forum has some importance, an excess of information might hinder more than help. 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). Awareness information should be dense, to decrease the cognitive overload, but without omitting important information (David & Borges, 2001).

Some groupware, like AulaNet (Fuks, 2000), Moodle (2009), and Sakai (2009) offer activity reports that may mix textual and visual representation of the interaction. However, these reports usually present pieces of information in an inadequate tabular form and are difficult to understand (Mazza & Dimitrova, 2004). Tufte (1983) introduces the following design principles needed for a successful visualization, namely, show the data, avoid distorting what the data have to say, present data in a condensed way, make large data sets coherently, encourage inferential processes, provide different perspectives on the data and have a clear objective. Thus, the offering of visual information that provides an overview of the collaboration context within a forum.

Computer-based Interaction Analysis is a recently emerged research field, needed due to the complexity of interactions occurring within collaborative systems (Bratitsis & Dimitracopoulou, 2007). Several works in the literature use interaction analysis for improving collaboration. The Degree system (Barros & Verdejo, 2000) records actions performed by learners, and offers quantitative and qualitative analysis, used by a software agent that offers tips on improving interaction. It provides an analysis of the interaction from three perspectives: the group performance in reference to other groups, each member in reference to other members of the group, and the group by itself. Synergo (Avouris, Margaritis, & Komis, 2004) builds on the object-oriented collaboration analysis framework (OCAF) where learner interaction and workspace actions give rise to a collaboration factor (CF). This factor provides a degree of collaboration and is graphically displayed on the time axis, facilitating the analysis of collaboration over a set period.

Padilha, Almeida, and Alves (2004) propose the use of data mining techniques to analyze interaction data and an awareness agent to capture, categorize and store contribution types, and offer performance reports based on these data. Soller (2004) proposes the use of a quantitative interaction analysis combined with artificial intelligence methods in order to assist the teacher. Gogoulo, Gouli & Grigoriadou (2005) propose Learner and Group Indicators, calculated from the interaction analysis, to estimate collaboration behavior in terms of the individuals' and the group's points of view. Feng and Heffernan (2005) describe the types of reports designed to provide real time findings to teachers in their classrooms. Daradoumis, Martínez-Monés, and Xhafa (2006) propose a layered framework for the study and analysis of group interaction and group scaffolding, defining learning activity indicators at several levels of description. SIAM (Scheuer, Muhlenbrock, & Melis, 2007) provides automatic analysis of interaction data by developing a data logging and analysis system based on machine learning techniques. The DIAS system (Bratitsis & Dimitracopoulou, 2008) is a forum that offers extended monitoring and interaction analysis support, through interaction analysis indicators: amount of users, amount of messages, thread depth, thread width, and mean number of words. DIAS and GISMO-graphical interactive student monitoring system (Mazza & Burotti, 2007) make available visual information on learner participation, informing, e.g., the performance in quizzes and the amount of messages sent, accesses to the environment, and running threads. Patriarcheas and Xenos (2009) incorporate forum characteristics, namely messages time, group size, and volume of information into a formal language aiming to determine the impacts on the effectiveness of the tool.

Several collaborative systems notify participants of what it is taking place while they are not connected to the environment or when the application's window is not visible on their computer screens. Notifications of pre-defined events or off-pattern interactions may free the participants from the task of constantly checking the environment to monitor new contributions. Systems that support learners and mediators evaluation of their individual and group activities basically follow a cycle of collecting data from participants' interaction, indicators selection, comparison with an ideal situation and, optionally, notifications generation (Jermann, Soller, & Muehlenbrock, 2001).

Collaborative systems forums such as that of AulaNet, Moodle, and BCSCW (Appelt, 2001) use email messages to inform the group about the posting of a forum message. Currently, mobile computing provides a suitable way to deliver these demands for information. The widespread use of cellular phones has given rise to several applications that make use of notifications: in the educational area, there are investigations on notifications informing about deadlines, tutorship requests, and forum unfolding through SMS messages (Nonyongo, Mabusela, & Monene, 2005; Chiu & Choi, 2005) or cell phone wallpapers (Nakahara, Kazaru, Shinichi, & Yamauchi, 2005). Popup windows are used to inform the arrival of a message in the mailbox, as in the case of Gmail (2009), and the arrival of a participant in the environment (MSN Messenger, 2009).

This investigation proposes the use of visual information summaries and notifications via mobile devices in order to enhance forum coordination support. In order to ensure that mediators do not have to immediately inspect each individual posted message, a set of message characteristics that can be extracted without the need of human inspection are provided, namely, message chaining, category, size, and timestamp. Next section presents the scenario where this investigation took place.

Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday
Subject Study (Class Plan and Web searches)						
			Seminars (Conferences)			
			12hs		14hs	
						Debate 13 às 14hs

Fig. 2. Course dynamics.

3. Scenario and methodology

In order to conduct this research in a realistic environment (Dennis & Valacich, 2001), the coordination support proposed in this investigation was applied to the Information Technology Applied to Education course (ITAE), which has been offered solely online by the Pontifical Catholic University of Rio de Janeiro (PUC-Rio) since 1998. The course runs on the AulaNet learning management system. Some points of the course's dynamics are illustrated by Fig. 2.

In the ITAE course, the group learns, mainly, through the interaction of its participants in collaborative learning activities (Gerosa, Pimentel, Fuks, & Lucena, 2004). Learners read selected content about the weekly topic, research to enhance their understanding about it and, then, take part in an asynchronous discussion about three specific questions regarding that topic. This discussion consumes 50 h taking place within the AulaNet Conferences service, which implements a forum as illustrated in Fig. 3. Then, they participate in a chat through the Debate service to converge the discussion. They repeat this dynamics during the following 8 weeks.

In the forum discussion, one learner plays the role of “seminar leader,” being responsible for preparing an initial message followed by three questions, referred by group members to develop their argumentation. The message is graded and commented, so learners understand what they can improve and what they got right. Seminar mediators stimulate learners' participation mainly in the initial sessions and act promptly when a message is not posted in the proper thread or showing a wrong category. Monitoring and grading messages and individual participation is a task that consumes considerable time, as was also observed by Nakahara et al. (2005).

This investigation uses action research as the research method. In this method, the investigation is carried out by means of successive actions aiming at solving or mitigating a specific problem in a real environment (Herr & Anderson, 2005). The action research is carried out in cycles, which successively refine the research towards a better understanding of the problem and solution appropriateness. In this action research, the 4-step cycle “plan, act, observe, reflect” is adopted (Kemmis & McTaggart, 2005).

Next section presents in more detail the message based analysis that provided the awareness information for coordination support in this investigation.

4. Forum characteristics analysis

In order to provide summarized and updated information about the unfolding of the discussion, message chaining and message meta-data are analyzed. This section presents the analysis of some characteristics – message chaining, category, size, and timestamp – originating from the discussion collected from eight editions of the ITAE course.

4.1. Message chaining

Communication tools structure messages in different ways: linear (list), hierarchical (tree), or network (map). The list structure is suitable for communications in which the chronological order is more important than the eventual relationships among messages, such as

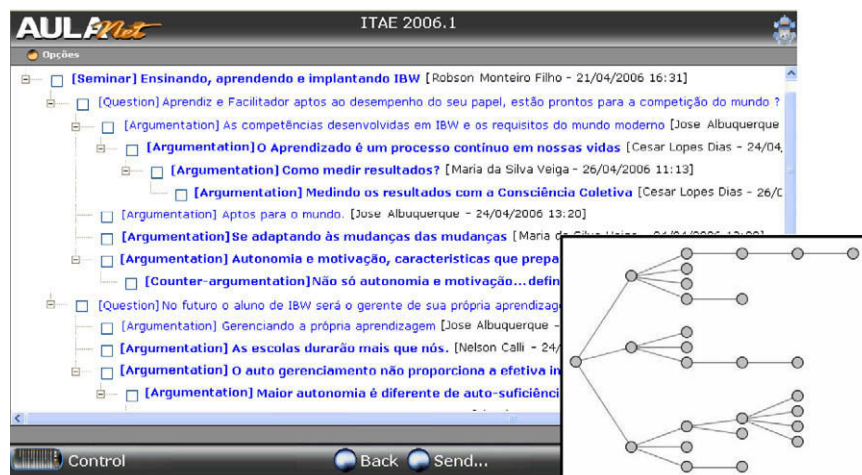


Fig. 3. Piece of a dialog in a forum and its graphical tree representation (content in Portuguese).

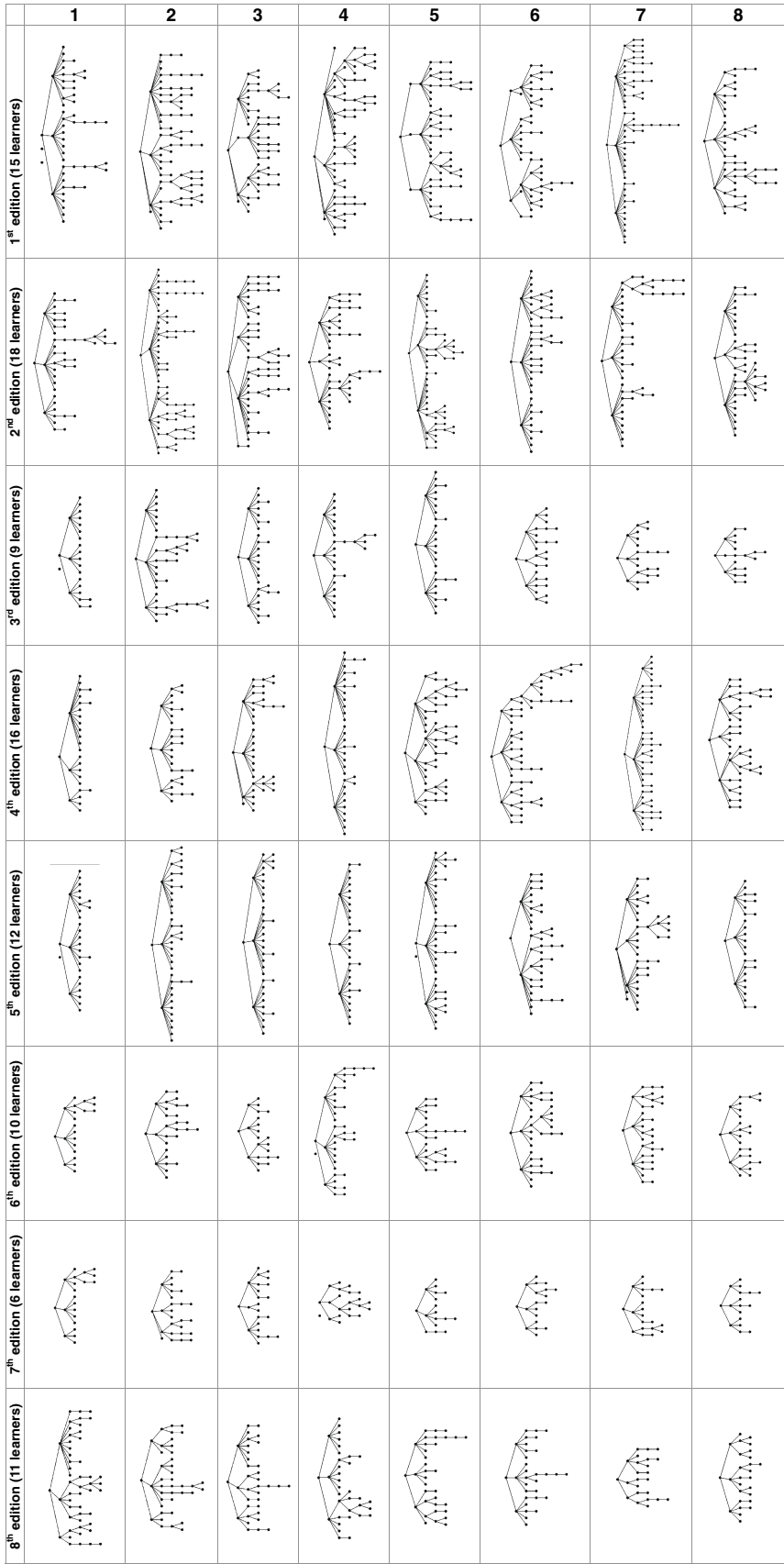


Fig. 4. Trees extracted from the eight weekly seminars of the course.

news, warnings, and reports. A tree-structured communication, on the other hand, separates the discussion into diverging lines: it is not possible to link a message in a branch to a message in another branch, and thus the tree always grows wide (Stahl, 2001). The structuring of

communication into a tree enables the visualization of the width and depth of the discussion. Finally, communication structured into a map format aims discussion convergence.

Conversation representation in a graphical form bestows a deeper analysis (Kanselaar et al., 2003, chap. 3). The format of the resulting tree indicates the depth of the discussion and the level of interaction. Depending upon the characteristics of the tree, mediators evaluate at a glance off-pattern situations. In the case of a tree being wide but not very deep, learners are limiting themselves to directly answering just a few messages without talking to the participants that replied to that same message. If one of the branches of the tree is too deep, it indicates that learners are concentrating too heavily on just one aspect of the discussion or an interpersonal conflict may have taken place. Too many leaves indicate too many messages without a reply (Pimentel, Fuks, & Lucena, 2003).

Fig. 4 presents the trees extracted from the eight weekly seminars of eight editions of the course. Looking at their discussion tree, learners and mediators have an insight on how discussions are progressing. For example, it can be seen that in the fourth and fifth editions the trees are deeper, indicating an increase of interaction among learners. On the other hand, in the second edition the trees got progressively shallower over the semester. Comparing different course editions it is also possible to observe that normally the corresponding tree of the first seminar is the shallowest one, because learners are not used to the seminar dynamics yet (Gerosa, Pimentel, Fuks, & Lucena, 2005). It is also possible to visually compare the depth of the seminars of a given edition with those of other editions; it is difficult to perceive it by simply observing the message structure in the AulaNet Conference service web interface.

In order to further the analysis, statistical information about the trees is used. In the first four seminars of the second edition, the average level of the tree was 3.0 and the percentage of messages without answers was 51%; in the last four seminars, the average tree level was 2.8 and the leaves were 61%. Fig. 5 illustrates a dialog in the beginning of the course in the second edition and a dialog at the end of it, where there are more messages without answers. There are also two dialogs of the fourth edition illustrating the opposite situation.

The trees shown in Fig. 4 and the charts in Fig. 6 indicate that in the fourth edition, there was an increase in interaction during the course: the trees were getting deeper while the amount of leaves was decreasing. The average depth level was 2.2 in the first four seminars, increasing to 3.0 in the last four, while the percentage of leaves, which indicates the percentage of messages without answers, went from 69% in the first four seminars to 53% in the last four. Another indication of the increasing interaction level of this edition is the increase in the number of posted messages.

Comparing the discussion trees during the progress of the course, the mediator can intervene when the interaction level decreases, which is indicated by a decrease in the average depth level, an amount of messages decrease, and a number of leaves increase. The average number of messages per level is also be used to figure out how the discussion is unfolding.

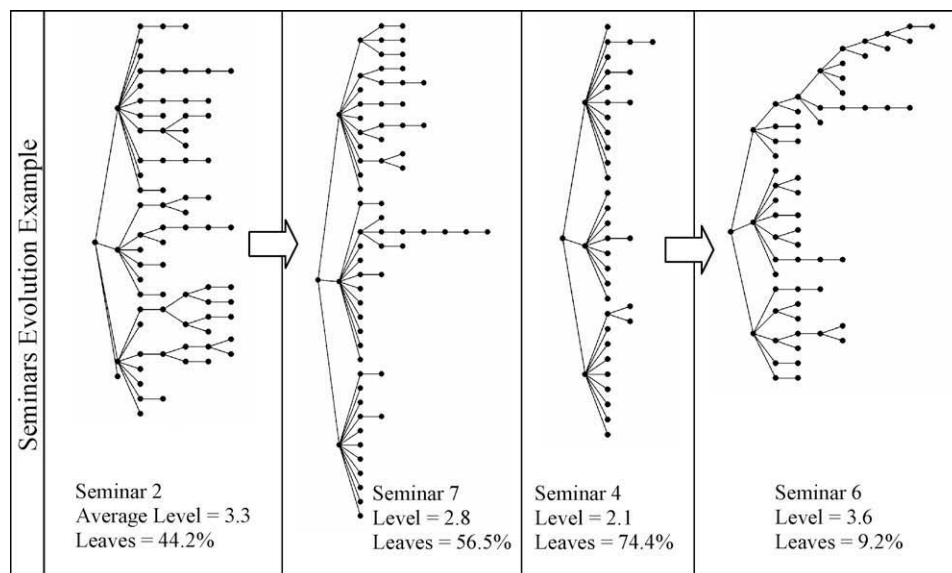


Fig. 5. Comparing trees from different editions.

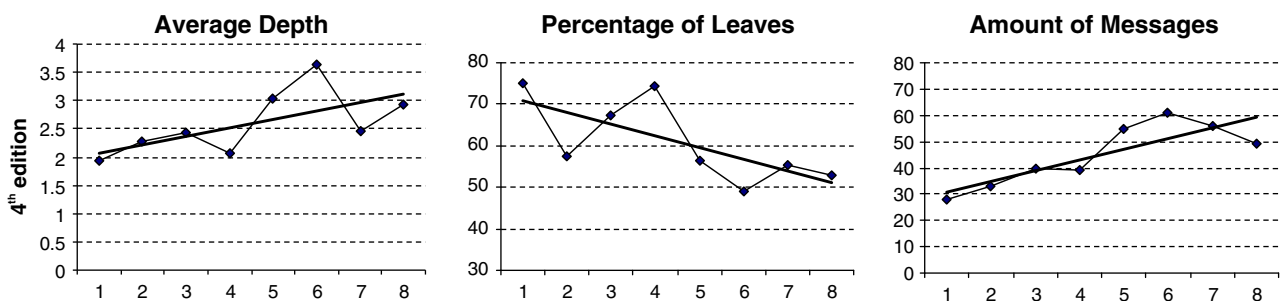


Fig. 6. Depth level, percentage of leaves and amount of messages per seminar.

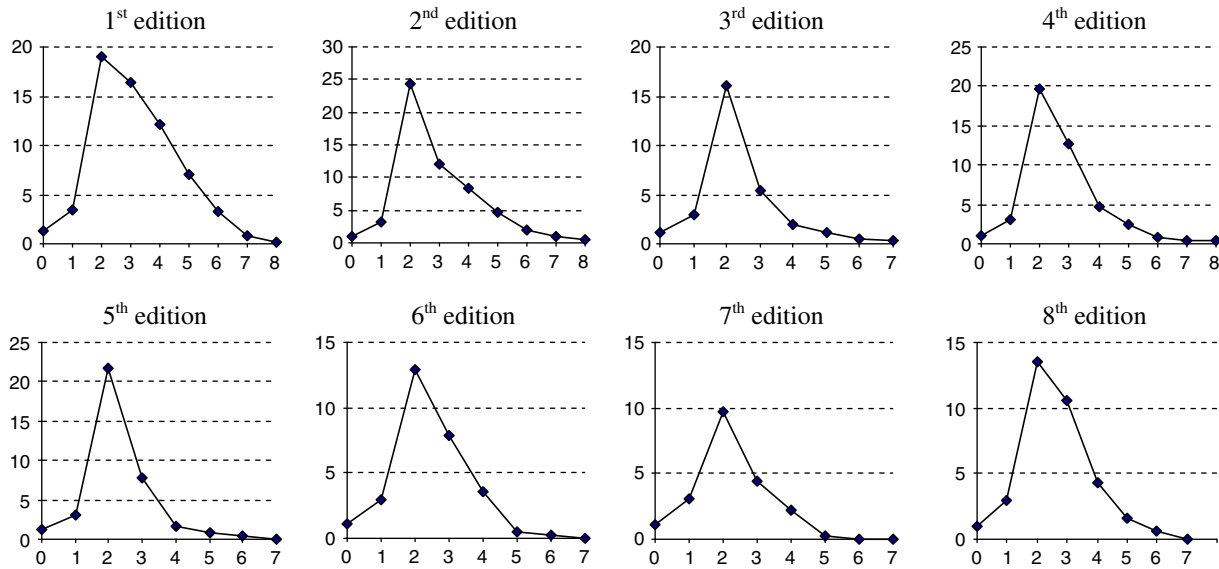


Fig. 7. Average quantity of messages per tree level per course edition.

The average amount of messages per tree level is shown in Fig. 7. They follow a pattern repeated in each edition of the course. In level 0, where only the seminar message is posted, there is only one message. In level 1, there is an average of three messages, which are the three questions of the seminar leader. Level 2 contains the messages responding directly to each question, thus raising the quantity of messages. In level 3 and thereafter the amount of messages tend to decrease. Mediators are supposed to intervene whenever the amount of messages in a given level of the tree clearly departs from this pattern (Gerosa et al., 2005).

4.2. Message categorization

When visualizing the seminar interactions, learners identify the messages categories between brackets, together with their title, author, and timestamp (as illustrated in Fig. 3). The teacher defines the category set according to the objectives and characteristics of the group and their tasks. Learners select the appropriate category from a given list while preparing their message, providing semantics to the messages relationships. AulaNet offers follow up reports about the categories usage, which identify participants characteristics and tasks accomplishment (Fuks, Gerosa, & Lucena, 2002).

The categories adopted in the ITAE course reflect its dynamics. They were originally based on the IBIS' node types (Conklin, 1988), but were refined based on their use. Currently, the categories defined in the course are: *Seminar* and *Question*, posted by the seminar leader; *Argumentation*, used by learners to answer the seminar leader questions *Counter-Argumentation*, to state a position contrary to an argumentation; and *Clarification*, to request or clarify doubts about a specific message.

On the left side of Fig. 8, there is a subset of a seminar, and in the right, the corresponding tree. The categories indicate the semantics of the relationships between messages. For example, message 4 is a counter-argument to message 3, message 5 questions message 4, message 6 answers message 5, and so forth.

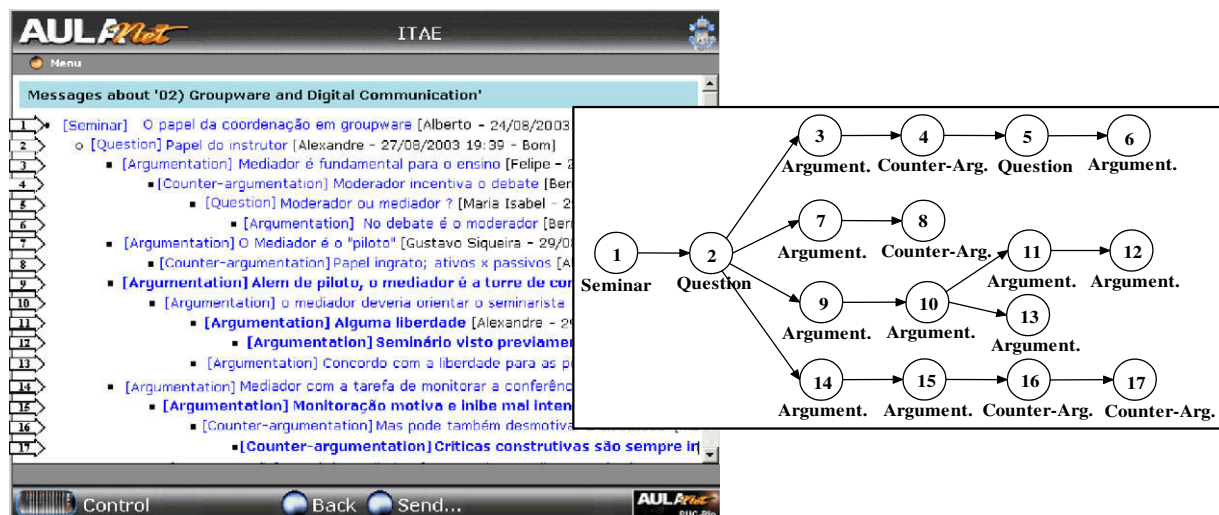


Fig. 8. Example of a tree derived from a seminar (content in Portuguese).

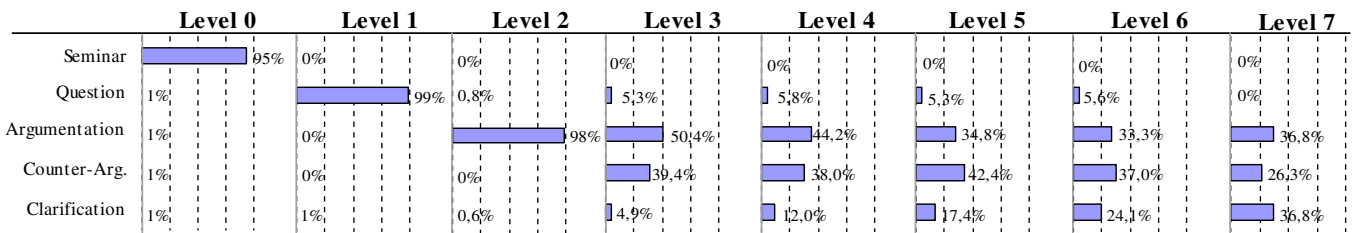


Fig. 9. Percentage of utilization of the categories per tree level.

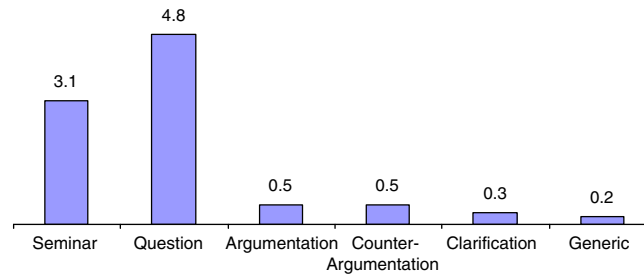


Fig. 10. Average amount of answers of messages in each category.

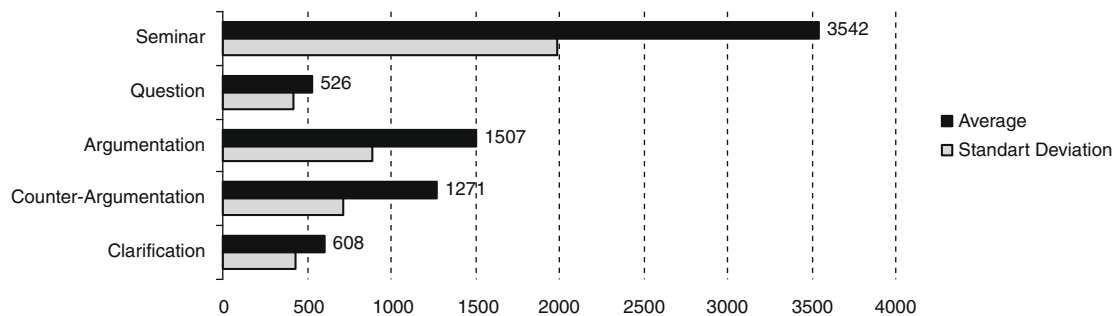


Fig. 11. Amount of characters per category.

Fig. 9 presents the percentage of messages of each category in the different depth levels of the forum. As expected, one observes that in level zero (the tree root), the predominant category is *Seminar*, in level one it is *Question*, and in level two it is *Argumentation*. The *Counter-Argumentation* category begins to appear in level three and its relative usage increases over the levels; the use of the *Clarification* category begins to appear as of level one (it is possible to clarify a seminar or a question). Choosing a wrong category or posting a message in the wrong thread changes the expected shape of the tree. It is important that mediators ensure the correct use of the categories from the very beginning so that participants understand the dynamics of the discussion and the semantic behind its use. Mediators have the means to change the message category when they identify a misuse.

Category inspection helps in identifying problems. For example, if a tree or a branch contains only argumentation messages, probably there is no clash of opinions and ideas taking place, which is unsound for the argumentation practice. Similarly, excessive counter-argumentation asks for mediators' attention. The group might have got into a deadlock or there may be interpersonal conflicts taking place. In the second edition, for example, there are 17 threads where 3 or more counter-argumentation messages were posted in cascade, 9 in just one seminar. This kind of off-pattern situation asks for further investigation and possible intervention by the course mediator.

In a seminar, each category of message has a different expected number of replies as illustrated by Fig. 10. This measure helps to identify problems, by cross-referencing it with other characteristics, like message size, and timestamp.

4.3. Message size

As each category has a different semantic and influences the way that messages are composed, message size analysis, measured in terms of characters¹, was made for each category. Fig. 11 present statistical data about the size of the messages, showing that each category has a distinct average size. When a message size clearly differs from the average for its category, it may be an indication of a problem that should be

¹ In this investigation, the amount of characters is the measure for the size of a message. Based on it, the amount of words and paragraphs is estimated. Within the messages, the amount of characters has a high correlation (99.5%) with the amount of words and one word has an average of 6.5 characters. The correlation between characters and paragraphs, and between words and paragraphs, is 76% and, on average, a paragraph contains 32 words.

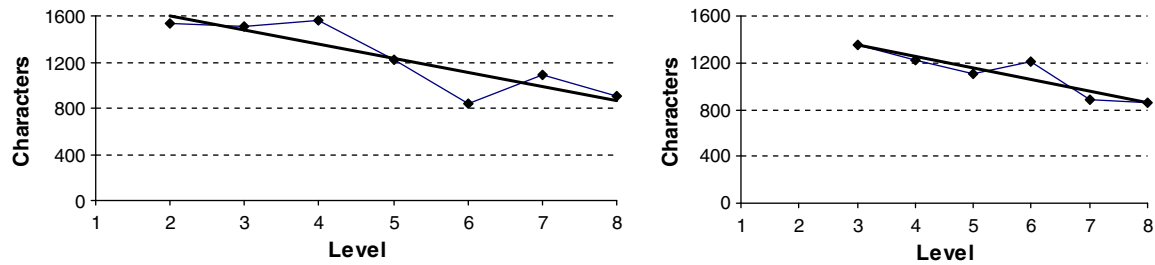


Fig. 12. Amount of characters in messages per level of the argumentation (on the left) and counter-argumentation (on the right) categories.

further investigated by the mediators. The *Seminar* category is the one having the largest messages, followed by *Argumentation* and *Counter-Argumentation*. The shortest messages are those belonging to the *Question* and *Clarification* categories.

In one edition of the course, one of the learners said: “When we counter-argue we can be more succinct, since the subject matter is already known to all.” When everybody knows the subject, the learner can go directly to the point that interests her. This is clear in the chart in Fig. 12, which cross-references message size and level. The chart shows a decline in the average amount of characters per level in *Argumentation* (correlation coefficient = -87%) and *Counter-Argumentation* (correlation coefficient = -91%) categories. The analysis was restricted to these two categories because *Seminar* and *Question* do not appear in higher levels and *Clarification* seems to be level independent regarding size (correlation coefficient = 48%).

The expected amount of characters for a given message helps mediators identify problems. Fig. 13 presents a chart showing the amount of characters versus the average grade of the messages using the *Seminar*, *Argumentation*, and *Counter-Argumentation* categories. It can be seen that messages having an amount of characters much lower than expected normally get a lower than average grade. As there is a difference in the characteristics of the messages depending on the category, the evaluation criteria should be adapted to each message type. In addition, learners should have access to the message analysis for improving their understanding about the task.

Each message category also brings with it a different average grade. In the ITAE, *Seminar*, *Question*, *Argumentation* and *Counter-Argumentation* have close average grades, which are, respectively, 6.7, 6.1, 6.8, and 6.9. Messages of the *Clarification* and generic category have a low evaluation, 2.3 and 2.6, respectively, which indicates that normally learners choose or use wrongly these categories.

4.4. Message timestamp

In ITAE, the seminar runs for 50 h: from 12 noon Monday to 2 pm Wednesday. Fig. 14 presents the hourly rate of messages posted during seminars. Until the fifth edition, there is a burst during the last 5 h of the seminar. In some cases, more than 50% of the messages were posted during this period. This phenomenon has been dubbed “Student Syndrome” (Goldratt, 1997). The act of sending contributions near to the deadline disturbs an in-depth discussion, given that last-minute messages will neither be graded nor answered during the discussion period. This might be the reason for an excessive amount of leaves on the trees in some seminars, hence, less interaction.

Another analysis based on the message timestamp is the average time it took to be posted after the seminar started, average time it took to be posted after the parent message was posted and the average answer time. Table 1 presents these data. A *Seminar* message, for example, takes in average 0.9 h to be posted. If the message takes too long to be posted, the mediator should be notified. The *Question* category is posted in average 2.8 h after the previous message, the *Argumentation* after 37.9 h and the *Counter-Argumentation* after 14.8 h.

Based on the analysis of the seminar characteristics presented in this section and on the practical experience in several course editions, some changes in the dynamics were made in order to improve seminar quality.

In order to avoid the Student Syndrome unwelcome behavior in the course, mediators encourage the earlier sending in of contributions. Unfortunately, our experience with this course has shown that this encouragement does not work. In the course's sixth edition, the last four seminars had a different grading rule than the first four seminars: if until the 25th hour the learner had not sent half of the expected amount of messages, all the messages sent during the following 25 h would have its grade divided by two. The percentage of messages sent during the last 5 h of seminar fell from 33% in the first half of the course to 13% in the second half (last four seminars). Nevertheless, now there are two, although shorter, 25th hour and 50th hour peaks. However, now mediators and learners have, respectively, more room

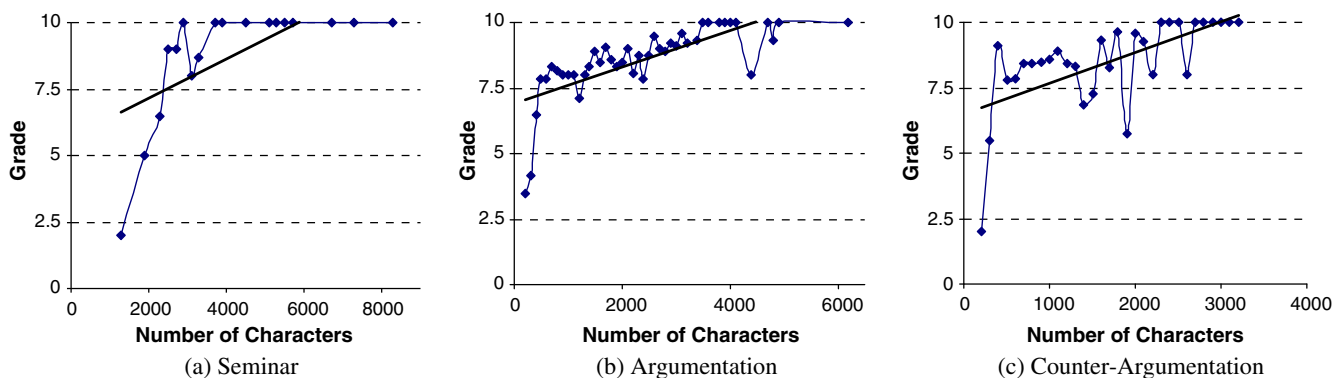


Fig. 13. Amount of characters versus grade per category.

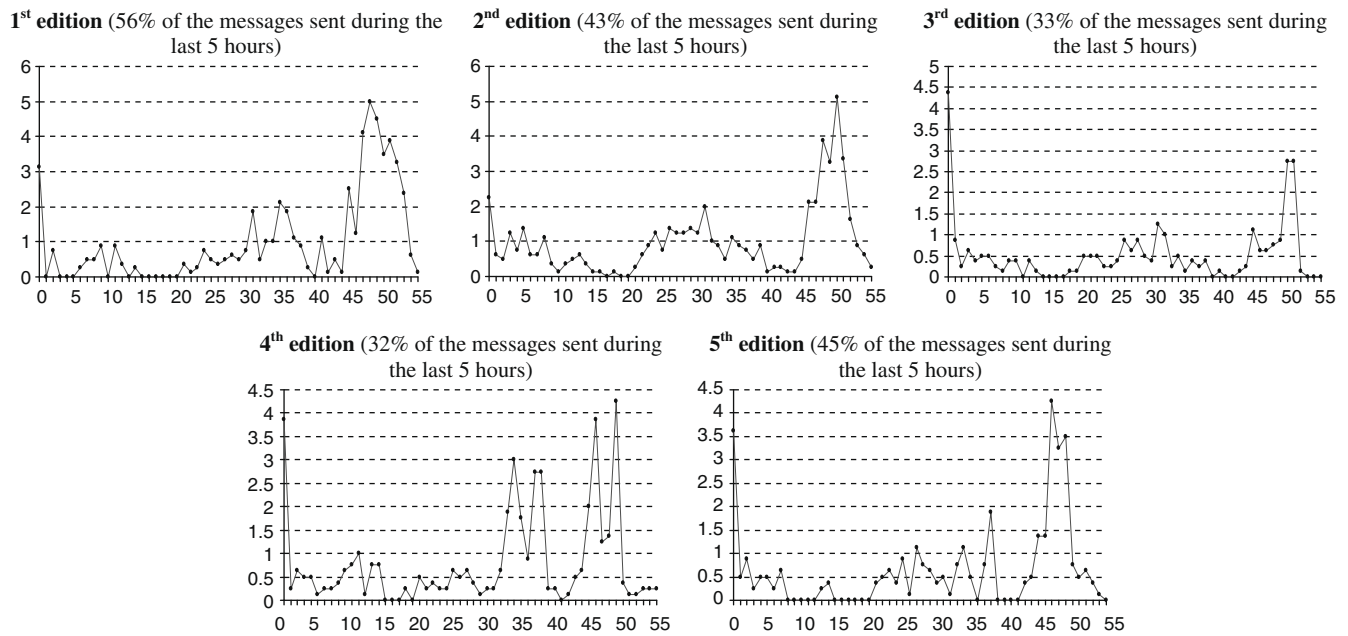


Fig. 14. Average hourly rate of messages of the 8 seminars from the 1st to the 5th edition.

Table 1
Timestamp-based message analysis.

Category	Seminar start	Parent message	Answer time
Seminar	0.9	0.0	5.6
Question	10.8	2.8	32.2
Argumentation	32.8	37.9	13.1
Counter-argumentation	39.2	14.8	9.7
Clarification	43.7	11.3	12.6

to grade and answer the first batch of messages. The same situation appears in the seventh and eighth editions, where all eight seminars were graded based on the aforementioned rule. Fig. 15 presents the comparative chart of the amount of posted messages during the last five hours in all editions. Changes in the dynamics started in 2004.1(2) showing just 13% of messages posted on the 50th hour and 18% in the seventh (2004.2) and 20% in the eighth (2005.1) edition.

Message characteristics, namely, message chaining, category, size, and timestamp, are used to summarize and present visual information about the discussion unfolding for identifying off-pattern situations. Next section presents a piece of action research to investigate the use of mobile devices presenting visual information summaries for improving forum coordination support.

5. Improving forum coordination support

Mediators must access the forum tool and gather information about the seminar in order to keep updated about the unfolding of the seminar. However, most of the time, these tasks are *demanding* or *impossible* to perform. The impossibility of accessing the environment

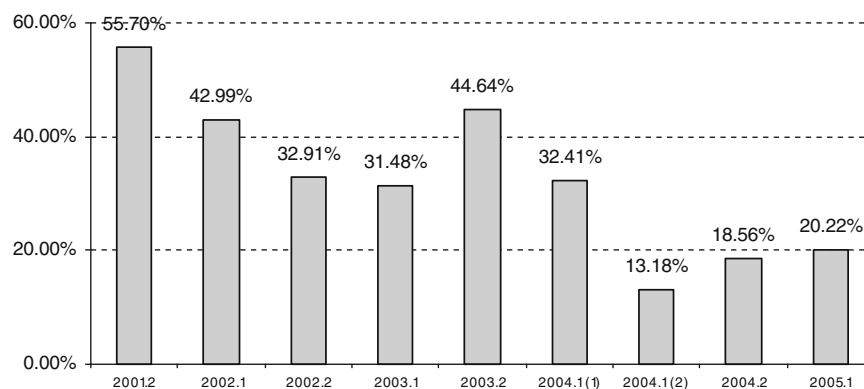


Fig. 15. Percentage of posted messages during the last 5 h of discussion in each edition of the course.

Table 2

Difficulty level for a mediator to keep updated about the forum unfolding.

	Difficulty level: impossible	Difficulty level: demanding
Action: accessing the environment	Mediators do not have the appropriate technology to access the environment when they consider it necessary	Mediators need to act deliberately to access the environment
Action: getting information	There is no way to get the information mediators need from the environment	Mediators need to perform calculations and comparisons to extract the needed information

takes place when a mediator needs checking the seminar in a given moment or with a pre-defined regularity but has no access to a desktop computer. To access the environment is demanding when a mediator, has to remember to check constantly the forum, thus interrupting some current task. Moreover, if the environment does not supply some specific desired information, for example, number of some learner logins, or if the information is only available as raw data and the mediator has to perform calculations to get the desired information, it is demanding to obtain information. Table 2 summarizes these difficulties.

To improve forum coordination, we propose offering the mediators summarized awareness information about the discussion unfolding combined with indications of off-pattern situations delivered via PDAs and mobile phones. PDAs deliver visual and statistical information about the seminar, and mobile phones receive SMS notifications related to the unfolding of the seminar and off-pattern situations. These visual and statistical information and SMS messages are presented in subsections 5.1 and 5.2, respectively.

The coordination support discussed in this work was investigated during four editions of the ITAE course: 2005.1, 2005.2, 2006.1, and 2006.2. Each action research cycle was conducted during a course edition and each cycle is presented according to its action research phases. In the Plan phase, a solution to mitigate a mediator difficulty is presented. Its implementation and application within the ITAE course are presented in the Act phase. The Observe phase presents the collected data, and, finally, in the Reflect phase an analysis of these data and results is presented. The research objective is to investigate what could be developed or enhanced in order to improve forum coordination support in a learning management system through awareness information obtained from the automatic processing of specific message characteristics.

5.1. Visual information summaries through PDAs

5.1.1. Cycle 2005.1 – plan

The first cycle dealt with the difficulty on the part of mediators to access the seminar in the absence of a desktop computer to connect to the learning environment. As a proposed solution, a PDA version of the AulaNet Conference service, called AulaNetM, was implemented and was made available to mediators (Lucena, Lucena, Fuks, & Filippo, 2006).

5.1.2. Cycle 2005.1 – act

The AulaNetM Conference support was implemented in 2005.1. Now mediators could access the seminar tree structure page (Fig. 16) and read the messages. PDAs were used during half of the course to compare their participation in the seminar with and without the device.

5.1.3. Cycle 2005.1 – observe

In order to collect data on the use of the service, all accesses to the AulaNetM pages were recorded in a log. Additionally, three questions were included in the AulaNetM login screen to identify in which situations mediators access the environment: which wireless network they connect to, whether the access was planned or opportunistic, and whether a desktop computer was available. Both mediators used PDAs belonging to the university. Wi-Fi access was available in the university campus. Open question interviews were done with both mediators at the end of the course.

5.1.4. Cycle 2005.1 – reflect

The answers of the qualitative interviews and the activity logs showed that they both identified opportunities and effectively used the PDAs, for example, in the restaurant queue or at a moment when all laboratory computers were busy. They considered that having the



Fig. 16. Snapshot of the AulaNetM seminar opening page (content in Portuguese).

chance of using the service in an opportunistic situation was advantageous for the mediation work. Both reported the frustration of not being able to use the service in certain places and situations because of poor signal quality or the absence of a wireless network. A mediator observed that the service “would have been more useful if I could use it in more places,” while the other one stated that the absence of connectivity “interfered a lot,” as he encountered several situations when he wished that he “could access the course through the PDA... but could not.”

One of them reported that they sat together in a campus bench, and partitioned the messages waiting for grading looking at the tree representation in the PDA. In the interview, the same mediator summarized the relevance of the coordination support offered by AulaNetM saying, “I found it very useful to see the tree through the PDA. It is a synthesis of the seminar. This makes the PDA very useful, for instance, to determine if I have to rush to a computer to grade messages or if I can wait a little longer.” This statement shows the mitigation of the difficulty “it is impossible to access the environment” by the availability of the Conference service in the PDA version.

The other mediator requested a report on the amount of messages posted by a learner and the amount of messages posted per hour. This is an indication that the mediators’ difficulty “it is demanding to obtain information on the seminar” indeed takes place, as these pieces of information appear as raw data on the seminar opening page.

5.1.5. Cycle 2005.2 – plan

Based on the 2005.1 cycle, it was decided to present the structure of the seminar graphically, highlighting its tree format and showing visual information summary of message meta-data on the PDA (Fig. 17).

5.1.6. Cycle 2005.2 – act

A new AulaNetM page was included showing the following seminar information: total amount of messages, average amount of characters per message, average amount of words per message, average tree depth level, leaves percentage, amount of messages posted by category, amount of messages posted by a participant, and the amount of messages posted in each hour of the seminar period (Fig. 17b). Another extra page presented three charts: amount of messages, average depth level, and average leaves percentage per seminar in a specific edition (Fig. 17c). Finally, a third page presented charts about the amount of messages, the average tree depth level, and the average leaves percentage, now cross-referencing the data of a specific seminar, e.g., the seventh one, with the same seminar on the eight previous course editions (Fig. 17d). The extra pages were available to the mediators only in the last four seminars.

5.1.7. Cycle 2005.2 – observe

The same data sources of the previous cycle were consulted: navigation log, open question interviews, and the service’s login page questionnaire. The same two mediators took part in this action research cycle.

5.1.8. Cycle 2005.2 – reflect

The qualitative interviews showed that the mediators approved the inclusion of the tree in its graphical form to follow seminars, but did not identify situations to use the visual summary information. However, they reported that mediation work was lighter in this semester, because fewer learners took the course. They took turns to follow the eight seminars and did not check them frequently. One of the mediators commented that the visual summary information would be more useful for post-course evaluation.

5.1.9. Cycle 2006.1 – plan

Given the low level of mediation work in the previous edition, this cycle repeated the investigation carried out in the previous cycle. An investigation regarding the use of SMS notifications for coordination support was simultaneously conducted and it is presented in the next section.

5.1.10. Cycle 2006.1 – act

In this phase, the previous coordination support was offered again. Additionally, one of the campus wireless networks extended its range to include a new building floor and the other network became more stable.



Fig. 17. (a) Seminar tree structure; (b) visual info of a seminar; (c) visual info of three seminars in the same edition; (d) visual info of the seventh seminar in different editions.

5.1.11. Cycle 2006.1 – observe

The same data sources of the previous cycle were used.

5.1.12. Cycle 2006.1 – reflect

The mediators approved and considered that the seminar structure presented in a graphical form is a relevant summarized piece of information. Mediators have an “at a glance” view of what is taking place on the seminar without having to read and analyze the messages to identify situations that may demand their prompt action, thus mitigating the difficulty “it is demanding to get information in the seminar.” A research carried out with GISMO (Mazza & Burotti, 2007) presented similar results: the instructors considered that with the information made available in a graphical form they “immediately” got information that would demand time and effort to obtain otherwise.

One mediator commented that he used the seminar structures to “understand and coordinate the discussion.” In two seminars, he identified a problematic situation based on the seminar structure – many messages answering the same question, without discussing it – and intervened. For this mediator, the tree structure presented in AulaNetM was useful to be aware of the main structure of the discussion and the eventual “chainless” of the seminar structure.

Regarding the use of the visual information summaries made available in AulaNetM, both mediators considered them important and relevant, but they only used them occasionally. For one of them, that happened because they lacked the habit of using them in the desktop version of the service. Indeed, the interviews revealed that they even forgot that this feature was available in the AulaNet desktop version. The other mediator reaffirmed her statement of the previous semester: that the visual information summary would be more useful for post-course evaluation.

During the interview, one of them complained that the values presented in visual summary information were too similar for her. However, this mediator was able to observe that one specific seminar of that course edition shown much different values compared to the same seminar in previous editions. The offering of visual information comparing different course editions seemed to help identifying unusual seminar unfolding, but was not sufficient to characterize them as off-pattern.

The mediators stated in the interviews that they only carried the PDAs for the sake of the research, because they were satisfied with their mobile phones and traditional agenda. Moreover, the support given through PDAs might have been untimely given that the PDAs belonged to the university and the difficulty in connecting them to the wireless networks.

5.2. Notifications regarding off-pattern situations, and the unfolding of the seminar

5.2.1. Cycle 2006.1 – plan

The cycles of action research carried out in the 2005.1 and 2005.2 editions indicated that the AulaNetM mitigated the difficulty “it is impossible to access the environment” by enabling access to the course through PDAs connected to wireless networks. However, mediators had problems with the use of the device and of wireless networks and did not adopt the PDA as a personal assistant. Besides, with AulaNetM, mediators still had to act deliberately to access the environment and keep informed about the unfolding of the seminar (difficulty: “it is demanding to access the environment”).

In this context, the mobile phone is the personal device owned by the mediators which basic operations they already master. Mobile phones operate in their carriers’ coverage areas and are not restricted to the coverage areas of computer networks. They may also operate in the “push” mode, as an alternative to the “pull” mode when the mediator checks a seminar via a PDA or a browser. With a “push” service, mediators receive information without having to look for it, making it possible to investigate solutions to mitigate the difficulty “it is demanding to access the environment.” In this case, the service chosen was the SMS service through which mediators received short messages about the unfolding of the seminar.

Notifications were configured to inform mediators of situations that diverged from the expected pattern and potentially demanded their intervention (Fig. 18a): low seminar activity, low or high participation of a learner, low or high amount of replies to a question, low or high percentage of tree leaves, non-categorized messages and incorrectly chained messages. The notifications informing on the participation of a learner and the amount of answers to a question were triggered only on the second day of the seminar, because within the first day off-pattern situations are not always well characterized.

Two other types of notifications for each seminar were investigated: “N messages posted since date/time” and “M messages graded since date/time,” as may be observed in Fig. 18b. These notifications inform about the six questions that identify important aspects in the supply of awareness information (Kirsch-Pinheiro et al., 2003): the posting of new messages (what) by learners (who) and about the publication of new grades (what) by mediators (who) since the previous notification (when) in a seminar (where). It was established that this information was going to be sent via SMS messages (how) with a frequency (how many) determined by the seminar level of activ-

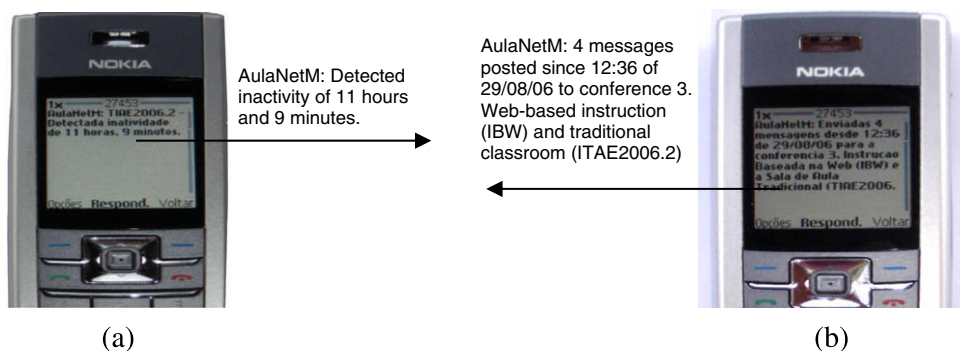


Fig. 18. Notification regarding: (a) an off-pattern situation; (b) the unfolding of the seminar.

ity, that is, every time N messages were posted or every time M messages were graded. A silent time between 10 pm and 10 am was adopted. At 10 am, these two types of notifications were sent independently of the amount of messages posted or grades completed during the night. The notifications about the unfolding of the seminar were also sent to the learners.

The awareness information provided by notifications is classified as aggregate and anonymous (Otjacques et al., 2006), because it provides information about a group (the amount of messages posted or graded in a given period) without disclosing names. The objective is to inform the group about its activities as opposed to presenting a partial view, such as “your message has been answered” or “your message has been graded.”

5.2.2. Cycle 2006.1 – act

The notification service planned for this cycle was implemented as a client/server service of AulaNetM. For the server module, a software agent periodically checks the seminar status and sends the SMS notifications whenever necessary. The agent framework used was Jade, which includes an execution environment and enables the use of agents in mobile devices through the Leap extension package (Caire, 2005). The sending of SMS messages was accomplished through the Java library Comunika SMS (2008), supplied by a third-party company hired for distributing SMSs to the recipients' mobile carriers.

As in the previous cycles, the new services were available in four of the eight seminars. In this cycle, the off-pattern notifications were active in the last four seminars, concomitantly with the use of AulaNetM visual information. The notifications informing message postings and evaluations were active from seminars 3–6 to both mediators and learners.

5.2.3. Cycle 2006.1 – observe

The data sources used in this cycle were a questionnaire on mobile phone usage profile filled by both mediators, navigation records from AulaNet, report of SMS messages supplied by AulaNetM and by the company that distributes the SMSs, and open question interviews.

5.2.4. Cycle 2006.1 – reflect

In this cycle, mediators received 60 notifications of off-pattern situations and 41 notifications about the unfolding of the seminar (Table 3). The use of SMS notifications changed the mediators' routines. Both stated that they did not need to check the seminar that frequently anymore, reducing that way the “stress” involved in the seminar mediation. One of the mediators reported that “with SMS I can logon only when the mobile phone rings” and that notifications let her remain relaxed. For the other mediator, SMS prevented him from having a “bad surprise” whenever he checked a seminar and identified an off-pattern situation. According to him, “if I’m aware that a problem is happening, I can prepare myself to act. I can organize myself and act immediately, or I know I can act in 1 h... depending on the problem.” This mediator also reported another change in the way he had mediated the seminars after the introduction of SMS notifications: he started to grade messages in chunks of 10 to trigger a notification. Both mediators used the notifications about message grading to learn that the other mediator already worked on the task. One of the mediators also commented that she used the notifications regarding message posting to estimate how much work she would have to do in the near future. Both mediators also stated that there were occasions they logged on the AulaNet to correct some off-pattern situation after being warned by a notification that the situation had already been fixed by the other one.

Mediators considered the notifications that demanded immediate action, e.g., the ones urging the change of an incorrectly categorized message or the deletion of an incorrectly chained message, as the most useful coordination support. Notifications regarding the posting and grading of messages, seminar inactivity, learner participation, and amount of replies to a question helped mediators to know how the seminar was unfolding. One mediator considered that off-pattern notifications were more useful in the initial seminars.

Both mediators disliked receiving notifications informing the percentage of tree leaves and took no notice of them. They considered that they were receiving too many notifications about a seminar characteristic that was not helpful for them. Regarding annoyance, despite not reading every notification just the mobile phone vibration was a cue that there was activity going on in the seminar. Moreover, the receiving of SMS notifications was a novelty and that motivated them. Regarding privacy, one of the mediators commented that the notifications informing learners about message grading exposed mediators' working hours on ITAE.

5.2.5. Cycle 2006.2 – plan

The same notifications of the previous cycle were investigated, now with some configuration changes. One of the changes was lessening the excessive number of notifications regarding the percentage of tree leaves. This time, notifications regarding off-pattern situations were sent to mediators during the four initial seminars.

5.2.6. Cycle 2006.2 – act

The amount of messages configured to trigger the message grading notification was changed to 4, which is the same that triggers the message posting notification. Mediators were also more committed to grade contributions during the seminar period. The notifications on

Table 3
Amount of notifications sent per notification type (2006.1 ITAE edition).

Notification type	Notification about...	Qty
Low seminar activity	Off-pattern situations	10
Low/high amount of replies to a “question”	Off-pattern situations	9
Low/high learner participation	Off-pattern situations	14
Low/high percentage of tree leaves	Off-pattern situations	12
Non-categorized message	Off-pattern situations	12
Incorrectly chained message	Off-pattern situations	3
Message posting	Unfolding of the seminar	27
Message grading	Unfolding of the seminar	14
	Total	101

Table 4

Amount of notifications sent per notification type (2006.2 ITAE edition).

Notification type	Notification about...	Qty
Low seminar activity	Off-pattern situations	9
Low/high amount of replies to a “question”	Off-pattern situations	7
Low/high learner participation	Off-pattern situations	12
Low/high percentage of tree leaves	Off-pattern situations	4
Non-categorized message	Off-pattern situations	6
Incorrectly chained message	Off-pattern situations	2
Message posting	Unfolding of the seminar	21
Message grading	Unfolding of the seminar	12
	Total	73

the percentage of tree leaves were set to lower than 20% and higher than 70%, decreasing the amount of times this notification was triggered. The notifications regarding off-pattern situations were sent to mediators during the four initial seminars. The (action-)researcher replaced one mediator.

5.2.7. Cycle 2006.2 – observe

In this cycle, the same data sources of the previous cycle were used. The researcher received spontaneous comments from learners throughout the eight seminars via AulaNet communication services.

5.2.8. Cycle 2006.2 – reflect

In the 2006.2 cycle, 40 notifications regarding off-pattern situations and 33 regarding the unfolding of the forum were sent. 8 messages (11%) were not sent during the seminars. Besides that, comparing with data of the previous cycle, the number of notifications informing the percentage of tree leaves was reduced to a third (from 12 to 4), as may be observed in Table 4.

Acting as a mediator, the researcher considered that the notifications provided a good general overview of the seminar. Even working for many hours at a computer, she relied on notifications to stay informed of occasional problems, reducing the need to logon in the AulaNet to check the seminar frequently (“it is demanding to access the environment”). She considered the notifications regarding non-categorized message and incorrectly chained message the two most relevant, in agreement with the statements of the two mediators of the previous cycle. The researcher considered the notifications useful throughout the eight seminars, not just in the initial ones. Besides that, in the last seminar, learner participation usually decreases and a notification warning about this situation helps.

6. Conclusion

This paper presented an action research taking place in a real environment – the ITAE course and AulaNet LMS. This research investigated coordination support for mitigating forum mediators’ difficulties in keeping track of the unfolding of the discussion. The difficulties were related to the necessity of accessing the environment when a computer or a network was not available and when it was necessary to make calculations regarding forum data to better analyze whether the discussion is unfolding well. The analysis of message characteristics automates part of this task and helps identifying off-pattern situations.

Message chaining is useful to analyze threads individually and the tree as a whole. Message categorization provides semantics to messages interconnection, helping to identify the accomplishment of tasks, incorrect message nesting, and the direction that the discussion is taking. The analysis of message timestamp makes it possible to identify the Student Syndrome phenomenon, which gets in the way of the development of an in-depth discussion. Discourse structure and message categorization also help to organize the recording of the dialog, facilitating its subsequent recovery.

Coordination support was extended via mobile devices. In the pull mode, mediators use the extension of the AulaNet Conferences Service for the PDA to check the forum whenever a computer is not available, through visual information summaries. In the push mode, notifications are received via SMS messages on mobile phones, relieving them from constantly checking the forum to no avail. Notifications about off-pattern situations is offered, based on summarized meta-data message information, such as low forum activity, low degree of learner participation, and message without category. These unusual situations may be figured out by comparing information extracted from previous editions. These analyses may also be used to develop filter for intelligent coordination and mechanisms for error reduction.

A well-coordinated forum is a valuable tool to foster reflection in learning, to share information and points of view, and to interconnect the group (Benbunan-Fich & Hiltz, 1999). Mediators aided by visual information summaries and SMS messages are aware of the unfolding of the forum “at a glance,” even before inspecting the content of the discussion. Mediators should understand the visual information summaries and notifications as aids for their coordination effort: final decision and judgment are still up to them.

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