Interpretation Issues in Monitoring and Analyzing Group Interactions in Asynchronous Discussions[1]

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Abstract. DIAS is an Asynchronous Discussion Forum Software, mainly developed in order to offer extended monitoring and interaction analysis support, by providing a wide range of indicators jointly used in various situations, to all discussion forae users (individual students, groups, moderators/teachers or even researchers/observers), appropriate for their various roles in different activities. In this paper we focus on the explanatory and interpretation issues that arise when the integrated Interaction Analysis (IA) features are used by a teacher – moderator. The importance of applying additional interpretative value to seemingly simple quantitative measurements is highlighted through several implemented case studies. Our research indicates that the teachers' tasks can be supported using such approaches. More complex diagrams, with potentially increased underlying interpretation power, provide a more insightful examination of the status and evolvement of a discussion, as well as the contribution and performance of the participants (as individuals or as groups). Students cooperate more fruitfully, by utilizing IA indicators for assessing and selfregulating their actions, thus facilitating the moderator's tasks. It relies upon the moderator to manage this aspect of such tools to his/her benefit. Core objective of this paper is to outline the importance of appropriate *Interpretation* of the IA indicators. The notion of *Interpretative Schemas* is deployed and their potential exploitation is thoroughly explored, using examples from real teaching settings. In fact, the significance of interpreting visualization data in a combined way and from different perspectives is designated, leading to the conclusion that this issue needs to be further researched.

Keywords: Interaction Analysis, Asynchronous discussions, CSCL, CSCW

1 Introduction

Computer Mediated Communication (CMC) tools, allowing communication among users by means of networked computers, for the purpose of discussing topics of mutual interest, are actually used in educational, working, or every day life contexts. In particular asynchronous discussion forae are nowadays widely used in formal or informal educational contexts, applying principles of constructivism, emphasizing in social interaction during learning activities (Gunawardena et al, 1997; Collins & Berge, 2001; Corich et al, 2004). Recently, research is focusing towards finding methods for the evolvement and support of critical thinking through interactions, taking place within asynchronous discussions, in order to achieve high quality learning (Stahl, 2006). Such a goal requires tools, frameworks and

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methods for the facilitation of monitoring, and/or self-reflection and therefore selfregulation that could be supported by the automated analysis of the complex interactions that occur.

Our approach tries to meet these goals by applying Computer based Interaction Analysis (IA) techniques, taking into account quantitative data. IA is an emerging field of research, focusing in analyzing interactions among users, borrowing elements from the Computer Supported Cooperative Work (CSCW), Computer Supported Collaborative Learning (CSCL) and AI (Artificial Intelligence) research fields (Dimitracopoulou & Bruillard, in press). We have developed a discussion forum platform with integrated IA tools called D.I.A.S. (Discussion Interaction Analysis System). Our aim is to support all users (moderators, learners, researchers, etc) and facilitate discussion learning activities (Bratitsis & Dimitracopoulou, 2005; 2006a; 2006b, 2007a), by implementing a wide range of IA indicators. Our system was built mainly for use within a learning context, but can also be used for other purposes, such as open-audience discussions forae within corporative networks, scientific networks, etc (mainly in the CSCW spectrum).

In the current paper, a general overview of our approach and the interpretation issues that arise is presented, focusing on the teacher’s perspective. Since a teacher, using asynchronous discussions as a learning activity, operates as a moderator too, the terms teacher and moderator will be used as synonyms henceforth. The rest of the paper is structured as follows: the theoretical background of the research is deployed in section 2, where analysis approaches in order to measure quality aspects of asynchronous discussions are examined. The importance of intense interaction among discussions’ participants, as a prerequisite for the development of *Critical Thinking* and *Knowledge Construction*, at extension, is highlighted. The significance of the moderating tasks, along with the emerging difficulties is cited, underlining the necessity for the construction of corresponding supporting tools. In section 3 an overview of the existing Forum Type software, implementing supporting tools is presented, along with emerging drawbacks. The DIAS system and the integrated supporting tools, in the form of IA indicators, are described in section 4. The *Interpretation* issue is thoroughly addressed, by providing an example of an Interpretative Schema, while trying to demonstrate how the analysis point of view may differentiate the conclusions deriving from the system's diagrams. In section 5, the implemented research studies are described and the emerging results are presented in section 6 and further discussed in section 7. Finally, future work issues are addressed in section 7.

2 Theoretical Background

Critical Thinking is a process that allows learners to gain new knowledge through problem solving and collaboration. It focuses on the process of learning than just attaining information, involving discovering how to analyze, synthesize, judge and create-apply new knowledge to real-world situations (Walker, 2005). While implementing discourse activities by means of asynchronous discussion forae, higher levels of interaction are needed to encourage learners to think critically. Since Mason described her model of qualitative discussion analysis and the five dimensions introduced by Henri (1992) up to the approach of Gunawardena et al (1997) and the *Community of Inquiry* model developed by Garisson et al (2001), the importance of the interactions of a person within a community is underlined, in order to achieve critical, high order thinking along with internal reflection. As pointed out by Dillenbourg (1999) it is necessary for the learner to externalize his/her thoughts and ideas in order to achieve proper reflection, thus promoting writing messages as discussion forae to an ideal reflective process. Literature points out that intensive discussion and social interaction may lead to multiple knowledge construction phases (Schellens & Valcke, 2005).

Several categories have been proposed for differentiating approaches, addressed to a teacher – moderator attempting to detect and evaluate quality aspects of online discussions (Corich et al, 2004). We distinguish two major categories: a) surface analysis through activity reports and quantitative measurements which indicate the possibility of quality within a discussion, and b) in depth, quality analysis approaches (Stahl, 2006). The first category approaches propose measuring dimensions that indicate the extent of collaboration in a discussion (and therefore the quality), such as the amount of messages in a thread (Harasim, 1993), thread depth for distinguishing important threads (Hewitt, 2003) or mean number of words (Benbunan-Fich & Hiltz, 1999). On the other hand, one may find approaches for measuring argumentation quality, knowledge building through critical thinking and collaboration level in asynchronous discussions. Most of them consist in analyzing the message content by applying proper coding schemes. They introduce certain analysis dimensions, including user participation, cognitive, metacognitive and interactive behavior, but they are considered to be time consuming (Henri, 1992; Gunawardena et al, 1997; Garisson et al, 2001). A review of the literature also reveals important work on the design of collaborative learning activities, asynchronous discussions in particular, which emphasizes on the importance of the moderator's role and the teaching strategy to be followed (Palloff & Pratt, 1999; Reimann, 2003).

During discourse activities, several issues need to be attended in order to sustain discussions and facilitate knowledge construction, such as reduced user participation, off topic argumentation, untimely confrontation of arising difficulties and problematic user behaviors. It is the moderator (Salmon, 2005; Hewitt, 2003; Walker, 2005) who designs the activity pattern, assigns roles, divides labor, monitors, advises and takes all the necessary actions, in order to ensure proper conditions for high order thinking and learning. All these tasks result in a huge work load (Gerosa et al, 2005), which increases exponentially to the participants' group size. Brace-Govan (2003) gives an example of discussion forum activity in the context of a university course, with a group of 20 students contributing with half a page messages, twice a week. This results to a total of 200 pages of written material, which is increased significantly, in the case of two or three parallel courses and groups. Besides, building the communication medium and providing initial instructions is not adequate (Hiltz, 1997). Proper design and constant effort is required in order to sustain an adequate level of collaboration (Jerman et al, 2001; Barros & Verdejo, 2000). Good moderating is popularly viewed as one way to improve quantity, quality and depth in online discussions (Hewitt, 2003). This includes decisions based on monitoring users' interactions and estimating the current status, using proper tools. For that matter we can distinguish: a) Mirroring/Awareness tools, b) Metacognitive tools, and c) Advising/Moderating tools (Jermann et al, 2001; Reimann, 2003).

Summarizing, the importance and difficulty of the moderator's tasks are widely accepted and evinced in literature, highlighting the need for corresponding supporting tools. On the other hand, Reimann (2003) states that even the most successful community requires a system to monitor and sanction members' behavior, but this works best when the monitoring is carried out by the members themselves rather than an external authority. Thus part of the monitoring and regulating process should be carried out by the participants themselves, undertaking a portion of the moderator's work load. Action based collaboration analysis (Muehlenbrock & Hoppe, 1999) has been proposed as a framework for applying meaning to quantitative interaction information, thus supporting collaboration management.

At extension, our main research axis is peer support in asynchronous discussion learning activities in order to trigger metacognition, leading to selfregulation, as well as to facilitate the moderator's tasks. Our intention is to build tools, applying IA techniques in discussions' activity data, visualizing quantitative information. Computer based IA provides information directly to technology based activities' participants, in order to assist them in self assessing their activity. The IA process consists in recording, filtering and processing data regarding system usage and user activity variables, in order to produce the analysis indicators. These indicators may concern: a) the mode or the process or the 'quality' of the considered 'cognitive system' learning activity; b) the features or the quality of the interaction product; or c) the mode, the process or the quality of the collaboration, when acting in the frame of a social context forming via the technology based learning environment (Dimitracopoulou et al, 2005).

The IA results are presented to the participants in an appropriate format (graphical, numerical, literal), interpretable by them. The corresponding information provide an insight of their own current or previous activity allowing them to reflect on a cognitive or metacognitive level, and thus act in order to self-regulate their activities. Additionally, IA provides information to the activity observers-moderators, in order to analyze the complex cognitive and social phenomena that may occur. The expected outcome is the optimization of the activity through: a) better activity design, regulation, coordination and evaluation by the forum moderator, and b) refined participation and learning outcome for the students through reflection, self-assessment and self-regulation.

3. Related Work

While examining Forum and Forum type software, we find that commercial or open source products, such as WebCT, WebWiz and PhpBB provide minimum analysis information. Most of them present simple usage indicators, such as activity information (number of messages posted and read), a few statistical indicators (most and least busy day, etc), online users, number of messages per day, number of unread messages, etc. We consider this minimal information available at the moderator's service, which supports forum usage only as a subsidiary tool of a Learning System (Bratitsis & Dimitracopoulou, 2005).

Several new and promising approaches implementing graphical representations of asynchronous discussions' features and parameters can be found while reviewing recent literature. For example, the i-Bee system visualizes relationships between users (appearing as bees) and keywords (appearing as flowers) in online messages, in real time. It also provides snapshots of past discussions and animations. The distance between flowers and bees, their status (e.g. flying/sleeping bee, blossomed/closed flower) and their orientation depend on discussion parameters, such as keyword usage frequency and recent user activity (Mochizuki et al, 2005). According to empirical studies, using video recording, the researchers argue that their system helps students to orient in a discussion. It is addressed mostly to the learners' selfregulatory processes. Moderators may use this system in order to acquire an overview of the learners' orientation within discussions and detect messages containing selected keywords. Researchers state that the system needs additional development, in order to further assist teachers – moderators.

Another example of using powerful visualizations via metaphors is the i-Tree system which visualizes the discussion status on mobile phones using a tree representation. The tree corresponds to a single user, whose activities designate its appearance. Thereby the tree's log and branches are related to the number of messages, the leaves' range and color correlate to message reading, the fruits depend on the answers the user has received and the appearance of the sky is designated by the whole discussion status (Nakahara et al, 2005). Using an experimental and a control group, along with evaluative questionnaires, the researchers reported increase in the users' tendency to only read messages and replies. On the other hand, they seemed to lack attention to the learning goal of the activity, by being more interested in the appearance of their individual tree. Understanding of the metaphor decoding was not completely examined, failing to explain why students missed some functionalities of the representation. Finally, this system was not intended to be utilized by a teacher – moderator.

Mailgroup is a Forum Type Tool with integrated analysis tools emerging from the Social Network Analysis (SNA) field. It implements an alternative method for representing message sequence in asynchronous discussions, taking into account both chronological and logical constituents (Reyes & Tchounikine, 2005). SNA was used to examine the effect of this method in the actual communication, concluding that the approach was encouraging.

Table 1. Discussion Forum software characteristics

Software	Functionalities	Disadvantages	Addressed to
WebCT, phpBB, WebWiz	Simple statistical awareness information	No real IA indicators	All users
i-Bee	Visualized representation of user – keyword relation	Not enough facilitation addressed to moderators	Students mostly
i-Tree	Visualized representation of user activity on mobile phones	Considers few activity characteristics. Addressed only to students.	Students only
MailGroup	SNA indicators, Structure Awareness	Indicators addressed to the moderator. Adequate number of messages is required	Analysis tools, only to the Moderator
Degree	Various collaboration quality indicators & advising mechanisms	Closed system, not easy to customize, with non-transparent indicator calculation.	All users
AulaNet add-on	Visualized statistical information drawn from log files	Various diagrams, addressed only to the moderator, poor empirical research	Moderator only

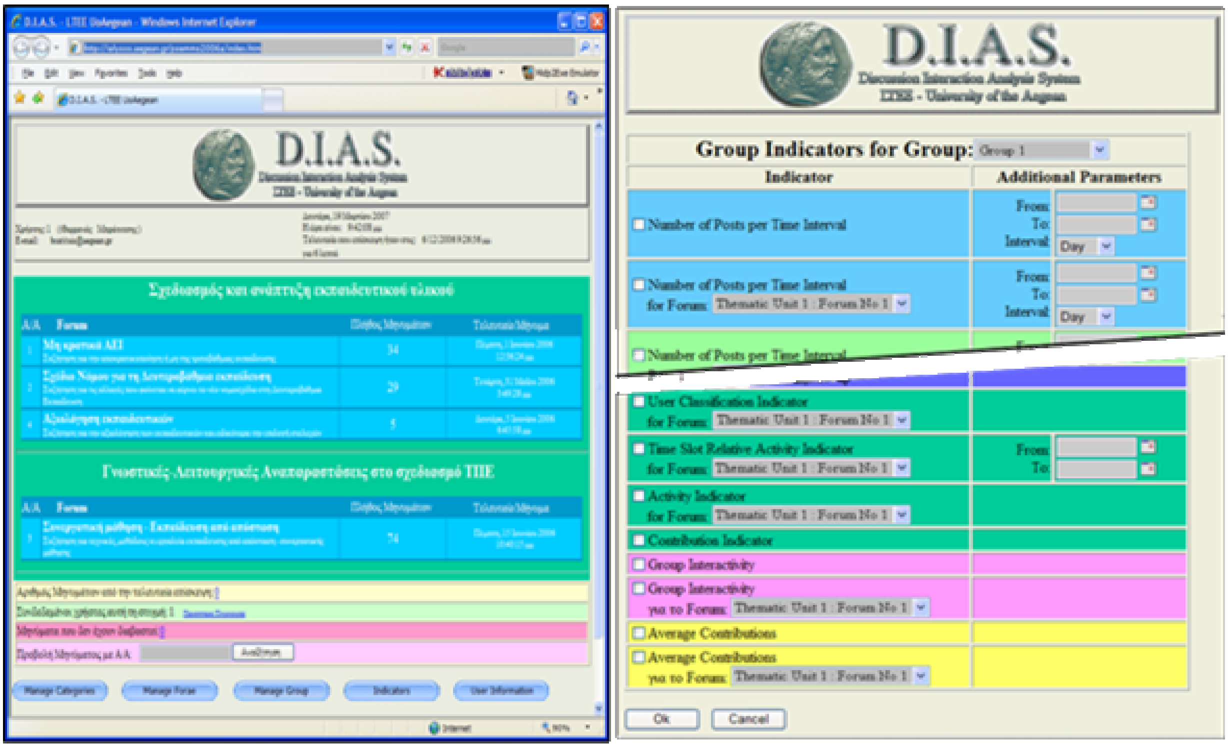
Other approaches also exist, integrating Fuzzy Logic techniques in order to assess and evaluate the collaboration level in a discussion based on several parameters (Degree system) (Barros & Verdejo, 2000) or providing a variety of visualized statistical information (add-on for the AulaNet platform) in order to help the teacher coordinate discussions and obviate undesirable situations or progress of the discussion (Gerosa et al, 2005). The latter approach is not interested mainly in the learning occurring within a discussion forum. The researchers aimed at providing a set of visualized tools for improving coordination issues related to the moderator. They imply that it is up to the moderators to rely on the system's dynamics and introduce discussion proper based activities to ensure learning outcomes.

All the approaches presented in this section, are based on quantitative analysis of activity data. They include tools addressed to students and/or moderators, facilitating their tasks during the learning activities, as opposed to in depth analyses, mentioned in section 2, which are applied after the completion of the learning activity. The Degree system proposes indicators, attempting to evaluate a single student's performance, as well as the collaboration of a group. Nevertheless, the evaluative method is not transparent. On the other hand, the other systems evaluate the individual performance. The visualization in the i-Tree system is based on the individual performance, but it focuses on the motivation of the student, rather than attempting to evaluate his/her performance. Even for that matter, not all the constituent of a student's activity are considered during the conducted analysis. Finally, similar approach is used in the i-Bee system, which mainly addresses the motivation issue in order to help student orient within a discussion. Concluding, several systems integrating IA methods exist, but almost none addresses the issue of individual assessment and evaluation. Only the Degree system tries to meet this goal, but the analysis method is rather non-transparent.

4. The DIAS system

The DIAS system (Discussion Interaction Analysis System) has been developed by the LTEE laboratory of the University of the Aegean. It is a fully functional discussion forum platform, with an underlying database management system for data recording. Several functionalities are implemented for facilitating user participation and the moderators' alternative discussion strategy planning. Additionally about sixty five (65) visualized indicators (including all possible variations) are produced, varying from simple statistical awareness information to complex cognitive and metacognitive indicators. Different sets are addressed to the teacher or moderator and the students - users, along with the corresponding interpretation schema for various discussion strategies or usage scenarios.

Our main goal is to offer direct assistance to users, supporting them in the level of awareness of their actions, as well as their collaborators, in order to activate their metacognitive processes, thus allowing them to self-regulate their activities. In parallel, we aim in supporting the discussion moderators (e.g. teachers) in order to 'identify' problematic situations and difficulties that require regulative interventions. More information about the implementation of DIAS can be reviewed in (Bratitsis & Dimitracopoulou, 2005; 2006a; 2006b).



a) DIAS Discussions & Tools main Interface b) Group Indicators' Selection Interface

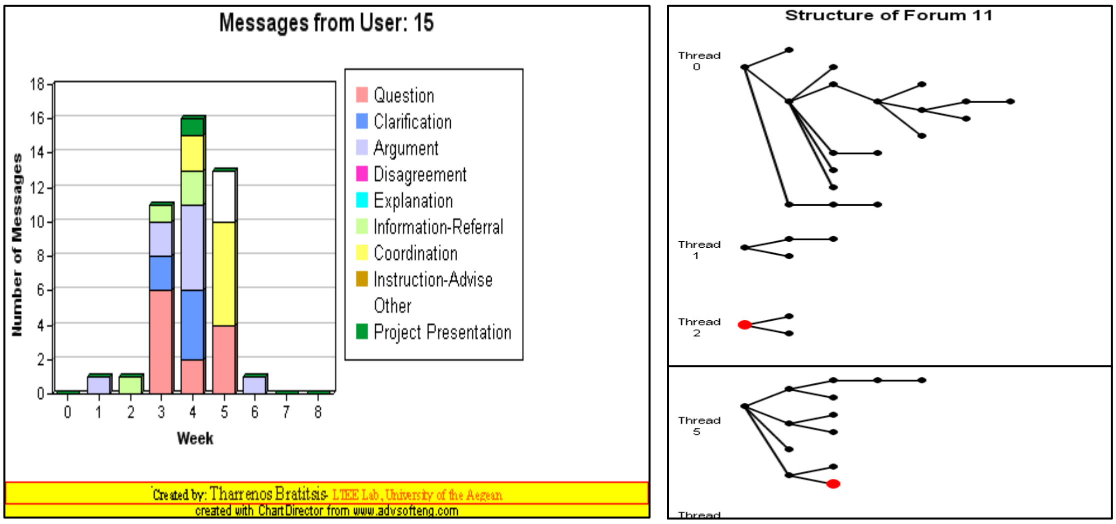
Fig. 1. Screenshots from the DIAS system

The main screen of the system is shown in figure 1a. Some useful information (time and length of the previous connection, date time and user-id) for the logged in user is displayed on top of the screen, under the logo image. The ongoing discussions are listed bellow (blue area) and some awareness information (unread and new messages, currently online users). Several buttons are available, on the bottom part of the screen, used for manipulation of user groups, access rights, message types, discussions and discussion categories. One of them, labeled Indicators, leads to indicator selection forms, such as the one displayed in figure 1b, which contains a list of all the group related indicators. A user has to select the desired indicators by clicking on the corresponding check box and fill in the appropriate additional parameters (e.g. starting and ending date). Following, by pressing the Ok button, the requested indicators are dynamically calculated and displayed. Especially for the implemented case studies, the indicators displayed to the participating students were pre-selected, depending on the instructional design.

4.1 DIAS Interaction Analysis indicators

The indicators produced by the DIAS system may reveal different information to different types of users or roles. They can be divided into 4 main categories, depending on the perspective they describe. *Individual point of view* indicators present information related to the actions or the product by an individual user (figure 2a, 2b). For example, bar-charts showing number and/or types of messages per selected time slot and period, pie-charts showing activity distribution among various forae. Indicators presenting information regarding the actions or the product by a group of users, without distinction among the individual activity of each member, constitute the *Undifferentiated Group point of view* category. Such indicators are mainly activity diagrams in bar-chart format. On the other hand, in *Differentiated Group point of view* indicators, the individual's activity can be distinguished. This category includes indicators showing comparative information regarding the actions of all the members of a group, such as the ones presented in figures 3a, 3b and 3c. Finally, indicators presenting information regarding total user and group activity within the discussion forum constitute the *Community point of view* category (e.g. *Community Type Messages* indicator, a bar chart exactly as the one displayed in figure 2a, but presenting the number of messages produced by all the system's participants).

All the indicators are produced by measuring quantitative activity data, such as number and size of messages written and read, by whom, etc. Their plethora results in having charts varying from low (presenting very simple and understandable information) to high interpretative value (providing several aspects of information, which can be different, depending on the type of user who is reading the indicator). Some of them are addressed to individual users (e.g. individual activity reports), some others to groups. Teachers–moderators or researchers–observers have increased information needs, due to higher complexity of responsibilities within a discussion forum (they want to monitor, assess and evaluate). Thus, several indicators are addressed only to them (figures 2a and 2b).

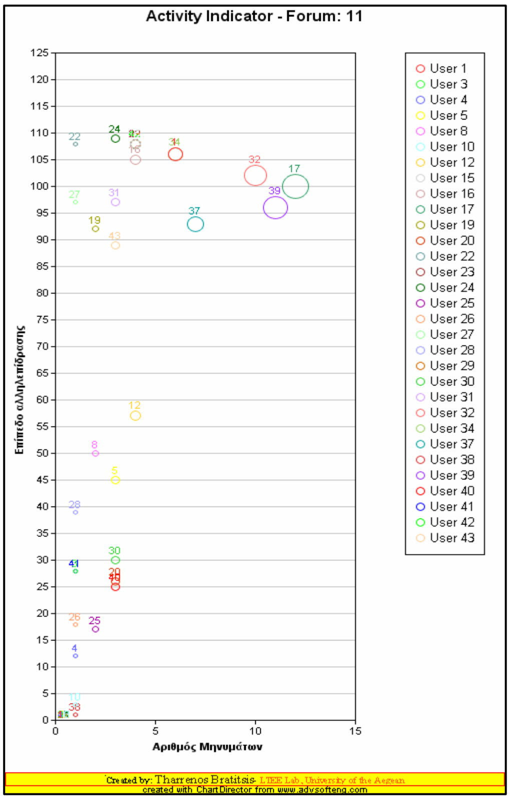


a) User Type Messages per week

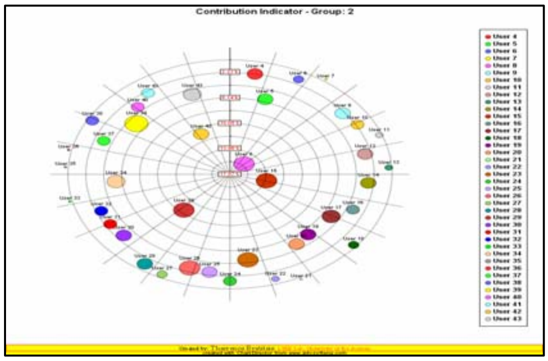
b) Tree Structure

Fig. 2. Indicators addressed to individual users

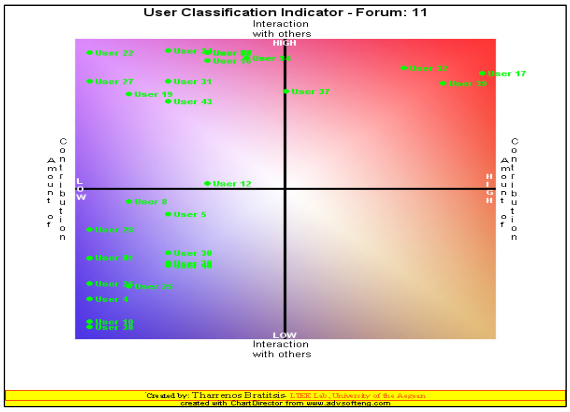
The indicator in figure 2a is an example containing low level information, easy to interpret. It shows the number of messages written by the corresponding user per week, in a stacked bar format. The colors constituting the bars represent the number of each type of message, the user has used during the corresponding time period. An example also addressed to a single user, but bearing a higher interpretative value is the *Tree Structure* indicator (figure 1b). It presents the threads constituting a discussion forum, in a tree-structure format. Messages are represented by vortices, and line segments depict their relations (which message is written as an answer to another). All the messages written by the corresponding user are colored red, giving a quick overview of his/her participation within the discussion forum. Applying a higher explanatory level, this diagram indicates the user's general attitude, by depicting whether he/she takes initiative, starting conversations, or acts more passively by joining conversations on latter phases. Finally the user's participation ratio (threads per forum) can also be calculated, thus giving an overall image of the user's behavior.



a) Activity Indicator



b) Contribution Indicator



c) Classification Indicator

Fig. 3. Indicators addressed to various user profiles

In figure 3, three indicators addressed to different types of users are shown. Students, as well as moderators – observers may review these indicators, extracting different conclusions. The *Activity Indicator*, shown in figure 3a, is a XY scattered chart, with the X-Axis representing the number of messages written and the Y-Axis representing the number of messages read by a user. A circle corresponds to each user, growing proportionally to the number of types of messages used and the number of forae, the designated user participates in. The *Contribution Indicator*, shown in figure 3b, is a polar chart, in which each user is represented by a circle. The distance of the circle from the circumference of the diagram is proportional to the activity of the corresponding user, as a percentage of the total number of messages. Discussion initiations are subsidized. The size of the circle depends on the number of message types used. Finally, the *User Classification Indicator*, shown in figure 3c is a XY scattered chart with the X-Axis representing the amount of contribution (messages written as a percentage of the total number of messages) and the Y-Axis representing the amount of Interaction (messages read as a percentage of the available number of messages) by a user. Both Axes are scaled from Low to High. By inspecting each one of the aforementioned indicators, a user may examine his/her activity in comparison with the collaborating users and thus obtaining a picture of the overall activity and his/her individual progress accordingly.

On the other hand, a moderator may also see if all users have extreme or balanced behavior (Arrogant users: write many messages but don't read other users' messages. Passive: read many messages, but don't write enough). All three indicators present similar information, but with significant differences. Comparative overview is easier using the *Classification Indicator*, with the mean values for each activity constituent viewable (corresponding to the axes). *Activity Indicator* presents the absolute values, thus depicting the actual gap between the users. *Contribution Indicator*, on the other hand contains activity information only about message writing, with even easier comparison among the users, due to the appearance of the chart. Depending on the teaching strategy followed and the activity design, important information may be drawn from these indicators, regarding user behavior meeting the expected goals.

4.2 Interpretative Schemas

Apart from reviewing diagrams with significant explanatory power, one may combine information from several indicators using an *Interpretation Schema*, in order to extract more concrete and precise conclusions. An *Interpretation Schema* is a set of instructions, explaining the manner and order of combining information from different indicators, in order to extract additional, qualitative information. In the remainder of this section, we will examine a set of indicators addressed to the teacher-moderator, which may help him/her evaluate the quality of a student's participation (henceforth called User X). These indicators are: *Classification Indicator* which has already been presented, *SNA Answers Indicator*, *SNA Reads Indicator*, *User Time Reads Indicator* and several statistical Bar Charts.

By inspecting the *Classification Indicator*, the moderator may see how active (writing and reading messages) User X is, in comparison with the other users and the mean values of each activity constituent (represented by the two Axes' position). The first conclusion is whether User X has extreme or balanced behavior. The second conclusion is whether User X's performance is far ahead from the mean values in any of the two activity constituents. Similar information may be extracted using the *Activity Indicator*, but the comparisons, especially with the mean activity values would harder, due to the appearance of the diagrams. Only absolute values may be additionally examined using the *Activity Indicator*, if desired.

The next step would be to examine the two SNA diagrams shown in figures 4. For the *SNA Answers Indicator* (figure 4a), the system produces a social matrix, according to Ucinet DL format and Agna matrix format for further processing. For N users, the Answers social matrix is an NxN matrix. The number placed in the cell designated by line A and column B is equal to the number of messages written by user A as answers to messages of user B. If the value of the cell is a positive integer, an arrow connects the vortices corresponding to User A and User B in the SNA diagram, pointing to User B. By quickly inspecting the SNA diagram deriving from the social matrix, the moderator can see whether User X is isolated or holds a central position within the discussion. Furthermore, if User X seems active in message writing (conclusion drawn from the Classification Indicator), this diagram can show if he/she is exchanging information with other users or not, by posting answers to and receiving answers from them. The number of users collaborating with User X can be detected, revealing interesting information. For example a very active user (Classification Indicator) may be isolated in this diagram, thus not contributing to the quality of the discussion and the overall collaboration (no one is posting answers to him/her). This could indicate low argumentative value of this user's messages, off topic writing, arrogant behavior or lack of knowledge regarding the topic. In any of these cases, the moderator may diagnose a problematic situation and act accordingly.

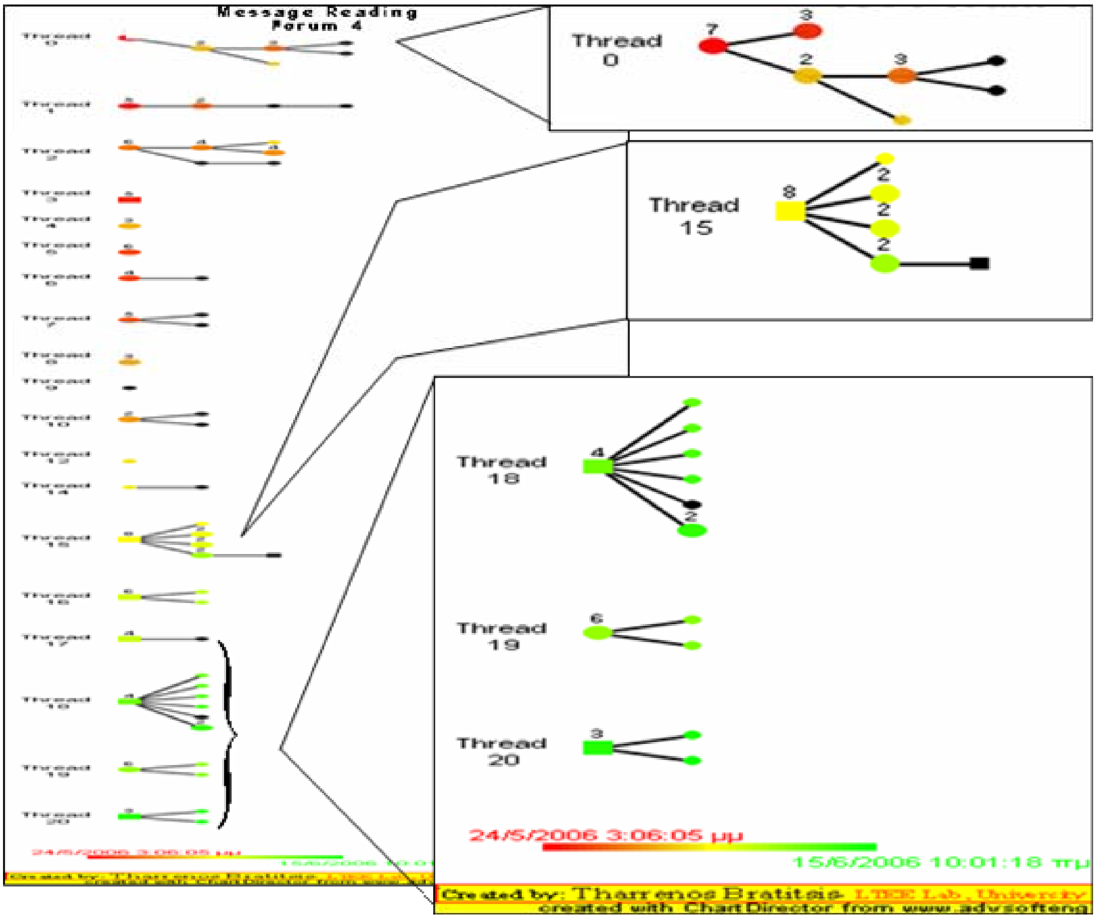


Fig. 4. Indicators combined to produce an Interpretative Schema

For the *SNA Reads Indicator* (figure 4b), the numeric value in the cell of the corresponding social matrix designates the number of messages written by user B, that user A has read, correspondingly. This diagram indicates the amount of other students whose messages User X reads and consequently his/her involvement in the collaborative discussion activity. While the Classification Indicator shows the amount of messages read, this diagram additionally shows the dissemination of these messages to the according amount of authors. In combination with the Answers SNA diagrams, the moderator can see whether User X is participating in a closed user group, interacting heavily inter se and lightly with the rest of the users. This may designate undesired behavior regarding the collaborative activity. Furthermore, this diagram reveals the amount of users who have read messages posted by User X. If he/she holds a relatively central position within this diagram but appears to be isolated or obscure in the Answers SNA diagram, then he/she writes messages which are read by many other users, but not answered to. Consequently User X could be a discussion coordinator or possibly face a participation problem that needs further attention by the discussion moderator.

Finally, a more sophisticated version of the previously presented *Tree Structure Indicator* (figure 2b) which is addressed only to the moderator, called *User Time Reads Indicator* (figure 4c) should be examined. Here, the vortices representing messages are colored, according to the time User X has read the corresponding message. Unread messages are colored black, whereas messages written by User X are represented by small rectangles. If User X has read a message more than once, then the corresponding vortex or rectangle is bigger, with the number of readings adjacent to it. On the lower end of the diagram, a gradient color line shows the time period correspondence. This indicator shows in detail a user's extend of embroilment with the discussion forum and whether User X is active mostly in earlier or later phases of the discussion activity. This could be the case of a user who simply agrees or disagrees with other users' arguments but doesn't contribute with new information and ideas, which may be confirmed by further inspecting his/her messages.

More detailed information may be extracted by reviewing simple statistical indicators in bar chart format, such as the one shown in figure 2a. Many variations are available, giving the moderator the opportunity to retrieve the exact requested information. This indicator set constitutes an example of indicator information utilization and is graphically represented in figure 5. Many combinations may be formed with various indicators, forming various interpretative schemas.

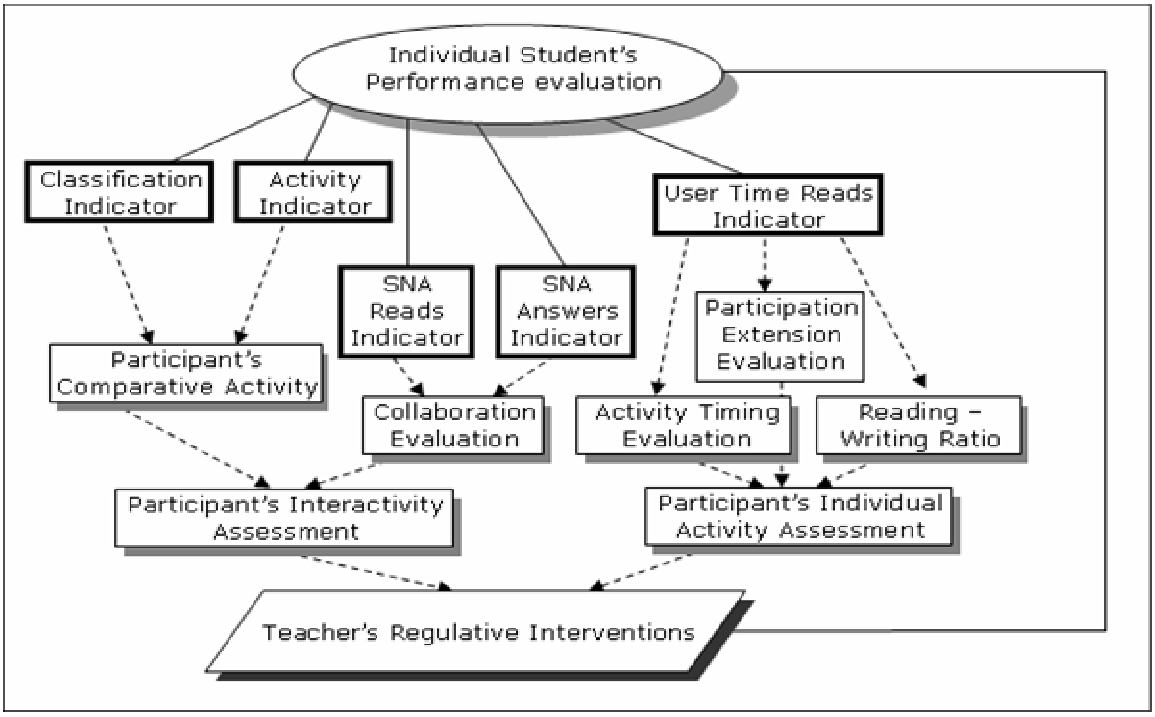


Fig. 5. Interpretative Schema for Individual Student's Performance Evaluation

Summarizing, we may distinguish two levels of interpretation, regarding the IA indicators. The first level includes single diagrams and is further resolved into two categories, one being the decoding of quantitative information from a diagram and the other being the further utilization of this information in behalf of the learning process, based on the activity settings. This results in adding explanatory value to the indicators. For example, the *Tree Structure* indicator does not only indicate the amount of messages written by a user and their placement within a discussion forum, but may reveal aspects of the user's overall behavior, designating his/her initiative status (does the user initiate discussions or participates more passively, in latter phases?). Another example is simple bar charts, showing the number of every type of messages per day. Apart from their statistical, awareness value, they can also be used to monitor users' productivity (as individuals or in groups), thus comparing it with the expected values, deriving from the activity planning. The second level consists in applying *Interpretative Schemas*, combining information from different indicators, in order to reach more insightful and concrete conclusions. The terms "*explanatory*" and "*interpretative*" will be used for the first and second level of interpretation accordingly, throughout this paper.

5. Case studies

Four case studies implementing a different learning approach have been designed *in situ*, constituting the main teaching method for the corresponding semester courses. In the initial pilot study, the three moderators' intervention was reduced only to the definition of sub-discussion topics, whenever that seemed to be necessary. Students, forming one group, discussed topics related to the course material and their semester assignments. Indicators were revealed to them gradually, during the duration of the discussion; from simple indicators after the first week, to more complex ones towards the end. In the second case study, the teacher introduced the topic for each discussion, along with some initial studying references. Two groups were formed, working in parallel discussions, one of which (experimental group) was able to review indicators, as opposed to the other (control group). For the remaining of the discussion, he tried to monitor the activity and remind the students of the time schedule and the final goal, whenever needed. In the third study, the teacher presented an initial text, containing keywords, which were assigned to students for further studying and concepts' clarification through literature research and were presented - discussed through the forum for a few days. The teacher intervened in order to help dissolve concepts' confusions, remind the time schedule, trigger discussion using appropriate comments or questions, offer assistance when requested. Finally he summarized the ongoing discussion, linking the results with the next phase's text. During six consecutive phases, students presented theoretical backgrounds, summarized research papers and presented their own case study ideas involving asynchronous discussions applied in collaborative learning context. Two groups were formed and working in parallel in this case too, acting as experimental and control groups in matters of being able to review indicators. Finally groups joined in a concluding discussion, where all the students were able to review indicators, in an attempt to monitor any possible changes in student behavior. In the fourth and last case study, the teacher presented a problem with two possible solutions for the students to choose, thus forming two groups. Each group argued in favor of their choice, designating the other choice's disadvantages. Reports were exchanged and discussed further in a joined discussion. The teacher's interventions were limited to reminding the time schedule, triggering activity in order to fulfill the goals. In this case too, one of the groups was the experimental and the other the control group.

Table 2. Implemented Case Studies

Study	Population	Duration
1 *(pilot)*	40 postgraduate students in one group – 3 teachers	6 weeks
2 *(experimental)*	14 postgraduate students in two groups – 1 teacher	7 weeks
3 *(experimental)*	14 postgraduate students in two groups – 1 teacher	7 weeks
4 *(experimental)*	30 undergraduate students in two groups – 1 teacher	7 weeks

As aforementioned, in this paper we are mainly focusing in the teacher's perspective. Following each study, semi-structured interviews took place with the teachers. Especially in the initial study, we used a participatory design approach, in order to receive valuable feedback from the users (especially the teachers) in a very early stage of the system's implementation. For that matter, they were asked to *evaluate the system and assess their overall experience*. While intending to *examine the transparency of the produced indicators and the proposed interpretative schemas* (or even construct new ones), *evaluate the indicators' contribution to the facilitation of the moderator's, coordinator's or observer's work*, we reviewed all the corresponding information and discussed it with the teachers, during the interviews. Additionally, we intended to identify *ways of evaluation and assessment of a discussion* bypassing the need of thoroughly reading all the messages or using time-consuming methods, such as content analysis, by examining message content and analyzing user participation and behavior data, using the actual IA indicators of the system. Finally, utilizing the fact that all the postgraduate students in case studies 2 and 3 were school teachers, we asked them to fill a questionnaire (both as teachers and as learners), grading the usefulness of the indicators for each one of the presented teaching strategies, two months after the conclusion of the course.

Summarizing, our objectives through these studies were to initially investigate the effect of the IA indicators to the students' behavior and the learning process at extension. We aimed at researching the potentiality of sustaining collaboration by triggering the students' metacognitive skills, leading them to selfregulation of their activities. From the teacher's perspective, especially as a moderator, *this could result to the facilitation of his/her tasks, by transferring part of the collaboration management and the learning locus of control to the students, relieving the moderating work/load*. Additionally, we wanted to study *whether these indicators can assist the moderator's monitoring and decision making tasks*. Finally, *using the IA indicators as an evaluation and assessment tool is part of our objectives*. Underlying steps towards these objectives were first of all to explore the transparency of the proposed IA indicators, substantiating the intentions of the system's design and then to identify and record the emerging needs of the teachers as well as their preferences in order to detect any unsatisfied requests and improve the system.

In fact, in this paper we focus mainly on the teacher's – moderator's perspective, attempting to *investigate the various ways of facilitating his/her tasks* and *the impact of appropriate IA Indicators' Interpretation to this process*.

6. Results

In this section research results will be presented in three different subsections, depending on their origin: *Interviews*, *Discussion Activity Analysis* and *Questionnaires*. In the first part, we present information extracted from the semi-structured interviews attempting to address the questions of: a) evaluating the system while trying to address all the participants' (students and teachers) requests, b) examining the transparency of the produced indicators, c) recording further information needs expressed by the teachers, d) investigating the teachers' appreciation of the notion of Interpretative Schemas, and e) examining if the IA indicators can support the moderator's tasks and in what way. Following, in the second part, we apply a specific Interpretative Schema and thoroughly examine the behavior of an individual student, in order to substantiate our claim that such Schemas may facilitate the teacher's moderating tasks, as well as his/her evaluating tasks. Furthermore, by pointing out observed attempts of indicators' manipulation by some students, while trying to appear more productive and effective, this example shows how the monitoring and decision taking tasks of the teacher can be facilitated. Finally, in the third part, we present the results of a questionnaire addressed to the students of case studies 2 and 3. As aforementioned, all of them were educators (mostly secondary level teachers), participating as student in postgraduate level courses. Thus they were asked to evaluate the indicators' usability as teachers and as students, having experience in both perspectives.

6.1 Interviews' results

Regarding the *system's evaluation*, comments made by the teachers were acknowledged, in order to improve the functionality of the system. We claim that our main intension, of building an independent, flexible and customizable platform for asynchronous discussions was fulfilled, after some minor adjustments in the process (Bratitsis & Dimitracopoulou 2005; 2006a). All the users were asked (teachers and students) to report any unsatisfied needs during the interviews, but they did not request any additional elements and functionalities. Overall, teachers *assessed their experience* positively, even though half of them had no significant prior experience, using asynchronous discussions for teaching purposes. They did not face any major problems while using the DIAS system or adjusting their teaching strategy, in order to include dialogic learning activities. Moreover, they were very interested in studying the provided information through the IA indicators.

While examining the *transparency of the proposed indicators*, explanatory discussions with the teachers occurred, before and after the case studies' implementation. All the comments related to the appearance of the diagrams were carefully considered, in order to improve the indicators. The first concrete conclusion is that although the indicators are considered to be generally transparent (all the diagrams were understandable and clear), interpretation instructions, should have been provided in advance. These instructions should not only include information for reading the indicators, but also ways of utilizing the presented information to the teachers' benefit, in various manners. This ensures that information deriving from the system's indicators will not be accidentally disregarded. For example, it is relatively easy for someone to understand that the *Tree Structure* indicator (figure 2b) distinguishes the messages written by an individual user and their propagation throughout the discussion threads. Additionally, it designates the general attitude of the user, by depicting whether he/she takes initiative, starting conversations, or acts more passively by joining conversations on latter phases. This refined information seems to lack many users' attention when reviewing this indicator for the first time and should be underlined in advance in order to be better utilized. Likewise, *Interpretative Schemas* should have also been provided in advance, as it is difficult for everybody to individually imagine such ways of combining information, thus drawing more concrete conclusions. Once validated and correlated with real teaching settings, these *Schemas* can be considered valuable aids for the teacher (see section 6.2).

Furthermore, some of the teachers' comments related to their specific needs for IA information. An example of data indicated as missing, during the initial study, is the size of messages in matters of words. It was requested, because it was considered to provide a quality aspect of a user's participatory behavior, as also indicated in the literature (Benbunan-Fich & Hiltz, 1999), in combination with simple quantitative information (such as number of messages). This process of ideas' exchange and needs' recording, led us to the design of various, new indicators such as the *User Time Reads* indicator shown in figure 2c, which presents user activity more insightfully.

The initial study was designed mainly for researching the students' reactions to the use of the IA indicators. As aforementioned, we chose to implement an open discussion, where students could voluntarily exchange ideas, resources and comments. Teachers introduced the initial topic, dividing it further in order to facilitate discussions and monitored the process. Having no hard moderating tasks to perform, *Interpretative Schemas* were not introduced to them. While examining all the IA indicators, during the interviews, their need for such schemas arose. It was justified by the plethora of indicators and the details of the discussion depicted by them. As one teacher stated, "it is the quantity of information provided that makes me hesitate to even attempt to distinguish the most useful indicators for my needs. You should provide instructions for combining the diagrams according to the desired task, such as evaluating an individual user's performance". This validated our initial intention to create and test Interpretative Schemas, which we tested during the following three studies. Such an example is analyzed in the next section (6.2).

6.2 Results from discussion activity analysis – Interpretation Schema application

As stated in section 5, the *support of the moderator's task, using the IA indicators* was an important objective of our research. In general, throughout all the interviews with the teachers, we found that some of the indicators are more helpful than others, but the overall impression is rather positive (see section 6.1). To give a representative example, we will use a part of the Interpretative Schema presented earlier in this paper to examine the activity of an individual student. She participated in study No 1, with 39 more postgraduate students. All of them wrote 533 messages in total. Examining the *Contribution Indicator* (figure 3b), this student was the most active one, having written almost 10% (52 out of 533) of the total messages, having used all the available message types (size of the corresponding circle). This can be validated by the *Classification Indicator*, in which she appears on the right edge of the diagram, with a significant distance from the following students. Examining her vertical position on the chart, she was found to be right above the horizontal axis, which corresponds to a value slightly above the mean value of the amount of messages read. Up to this point, by examining simple quantitative information, this student's participation seems exceptional. This impression is validated by the *Activity Indicator*, where she appears to be on the right edge of the chart. Furthermore, 18 out of 40 students appear in a higher vertical position on the diagram, having read more messages than her. The vertical gaps between them were not big, enhancing the "ideal" participating image of this student. Examining this student's interactions with her collaborators, we found that she posted answers to 14 (35%) of them, which can be considered a satisfying ratio. She answered to all the students, whose messages she had read, thus appearing to highly contribute to the evolvement of the discussion.

On the other hand, interesting information is revealed, when examining the time factor. The duration of the discussion activity was 6 weeks. Out of 52 total messages, this student wrote 24 (46%) during the last week and totally 43 (83%) during the last 2 weeks. Considering that closer to the end overall activity was normally decreasing, we decided to examined the amount of students who read these last messages. We found that 31% (8 out of 26) were read by 4 or less of her collaborators, indicating that the content of her last messages was not properly distributed within the collaborating team. Additionally, she read 332 messages, of which 51% (170) during the last 2 weeks. Having written most of her messages during the same period, we may conclude that her contribution to the overall discussion is not as high as it initially appeared to be, due to the timing of her activity.

For further analysis, we decided to examine this student's messages further. Careful reading revealed that surprisingly, the content of the messages was rather interesting, well written and documented. During her interview, she was asked to comment this delayed activation of hers. She stated that it was mostly due to lack of time during the early stages of the discussion activity, in order to fully commit to it. On the other hand, she admitted that the indicators motivated her highly, in order to work harder. She characterized her initial motivation as "contemptible", trying to precede a certain student, who happened to have an outstanding performance. Nevertheless, the results proved that her potential in contributing to the discussion was very high. Consequently this student could have contributed much more in the discussion, if she had participated in a more timely fashion. Close *monitoring* of the activity, *using the indicators*, could have revealed this student's low performance during the first half of the activity, thus giving the moderator the chance to intervene accordingly. This would have resulted in behalf of the overall learning activity.

On the contrary, a small minority of the other students tried to improve their status by writing some small, insignificant messages towards the end. This could have made them appear as more efficient and active, if only activity diagrams were examined, such as the *Activity* (figure 3a) and the *Contribution* (figure 3b) indicators. For that matter, several students admitted trying to interpret the relevance of the size of the corresponding circles in these indicators, in order to act accordingly. Even in the *Classification* indicator (figure 3c), this would improve only their horizontal positioning on the diagram. Thus an asymmetry in their behavior (writing many and reading fewer messages) would have been noticed. Even if they tried to further game the system by faking the reading of messages, adding the time dimension in a statistical chart (e.g. figure 2a), students appearing passive during most parts of the discussion and showing an unusual increase of their productivity towards the end can be easily detected. Graphically, this can be easily observed using the *Tree Structure* indicator.

Finally, other indicators measuring the message sizes in words are available, showing the distribution of words in all the messages written by a user. Nevertheless, students admitted that they were able to detect their “cheating” collaborators, although they were not able to review word counting indicators. A review of the available indicators and simple collation with the actual activity within the discussions was enough for them, thus indicating which contributions they should pay attention to. Concluding, it is rather unlikely for a student to game the system by manipulating all the measured variables at the same time. Besides, users’ attempt to falsify and manipulate system’s reports in order to improve their status is a well known issue in collaborative settings (Sun & Vassileva, 2006).

This examples show how IA indicators can be utilized by applying an *Interpretative Schema*, for supporting the monitoring and evaluative tasks of the moderator. It is obvious that by combining indicators, the conclusions are significantly different than the ones extracted by each indicator individually. Thus, interpretation of the indicators is a very important factor when applying IA techniques to monitor user activity. This also designates the need for more complex indicators, which can present significant aspects of users’ action in a more compact form. One example is the *User Time Reads Indicator* (figure 4c), which contains information regarding the amount of messages written and read, as well as the time factor of an individual users’ actions, at a glance.

More indicators have been implemented in order to facilitate moderating tasks, such as the *Thread Propagation* and *Thread Propagation Word* indicators, presented in Bratitsis & Dimitracopoulou (2006a). They distinguish the most important threads within a forum, for the moderator or an observer to review. Additionally, under specific teaching settings these two indicators provide a more *qualitative assessment* of a discussion. As described in Bratitsis & Dimitracopoulou (2007b), examination of the indicators’ values ratio leads to conclusions regarding the discussion content. Specifically, it is proportional to the quantity of unique ideas negotiated in a discussion thread, in the context of collaboratively building justification arguments, in order to support a selected viewpoint. Thus the required effort to assess a discussion decreases, which is very convenient when large groups are interacting. Even the previously described example demonstrates how the moderator can evaluate the students' individual activity, distinguishing the assiduous from the negligent ones. Similarly, preliminary assessment of individual or even group activity and/or performance can occur.

More, very interesting ideas were mentioned by the actual users during the interviews, adding explanatory value to existing indicators. For example, in a discussion activity with a summarizing phase, the moderator can review the *Classification Indicator*, in order to assign the task to the appropriate user. This could be the most active user, who probably has a better image of the overall discussion or one of the less active users, thus motivating him/her to participate more. During a coordinative phase, the *Tree Structure Indicator* may be used to quickly inspect the number of answers posted to a coordinating message, designating the appropriate time for advancing to the next phase of the activity.

6.3 Questionnaires' results

Having discussed these explanatory and interpretation issues and ideas with the students in case studies 2 and 3, we asked them to fill a questionnaire, two months after the conclusion of the course. This time period was considered adequate for them to better assimilate the application of IA techniques in asynchronous discussions, designed for learning purposes. Eight possible discussion collaboration scripts which could be applied to discourse activities were presented and explained to them. An example of such a discussion script is the one used in study No 4, incorporating opinion conflict and negotiation of meanings and arguments in the context of a learning discourse activity. Being experienced high school teachers and having participated in a discussion learning activity as students, they were asked to answer both from the teachers' and the students' perspective. The questionnaire included two tables, with the available indicators as rows and the collaboration scripts as columns, one for each perspective. They had to fill the cells with the appropriate grade, providing their opinion for using the corresponding indicator with the corresponding collaboration script. The grading scale was from 1 (Not Useful) to 5 (Necessary).

The results revealed a preference to complex indicators with high explanatory value. We calculated the mean value of all the grades, for all the discussion scripts. The designated as more useful indicators were *Tread Propagation* (grade 4.21) and *Tread Propagation Word* (grade 4.16) indicators (Bratitsis & Dimitracopoulou, 2006b). Three more indicators assigned a mean grade over 4 (very useful). These were the *User Performance Indicator* (grade 4.14), which presents comparative information regarding the amount of messages written by all the users and their sizes in matters of words, the *Activity Indicator* (grade 4.07) shown in figure 3a and the *User Time Reads Indicator* (grade 4.05), shown in figure 4c. All the indicators were graded over 3 (useful), whereas the lowest grades were assigned to indicators with low explanatory value. The latter were statistical bar charts, showing the number of answers to a single user's messages (grade 3.29), the number of messages by a group per time interval (grade 3.33), the number of users posting answers to an individual user (grade 3.37) and the number of users receiving answers from an individual user (grade 3.37).

Although the effect of the IA indicators on the students' behavior is out of the scope of this paper, a short reference is considered necessary. Overall, the appearance of the indicators was positively accepted. They functioned as a very powerful motive for increasing contribution. In all cases, the experimental groups appeared more active, producing over 30% more messages. Further refinement of their behavior was noticed. For example, students familiar with SNA diagrams were tighter connected with their collaborators. The participation pattern of most of the experimental groups' students was much more widely spread within the discussion threads, justified by them having reviewed the *Tree Structure* indicator. More information on the results from the students' perspective can be found in Bratitsis & Dimitracopoulou (2007a).

7. Discussion – Future Work

Through our studies with the DIAS system in real settings, we concluded that *IA tools can significantly facilitate the tasks of a teacher,* a moderator or even an observer, external to the activity. The importance of such quantitative information has been highlighted in the literature (Gerosa et al, 2005; Mazza & Milani, 2003; Reffay & Chanier, 2003). The element differentiating our approach is our attempt to go one step further from just presenting statistical information, by adding explanatory values and applying Interpretation Schemas.

Our experience showed that this can be a perpetual process. New needs constantly arise, leading to the design of new, more complex indicators. Of course the production rate of new indicators decreases with time, but we were surprised to hear some new ideas after conducting four studies and implementing more than 65 indicators. Consequently, it would be legitimate to say that providing a set of explanatory values or a few Interpretative Schemas is not enough. A repository of ideas for indicators' utilization should be built, which will be enriched in the future. It is not very easy to estimate the number of case studies needed to reach a saturation level for that matter, due to the variety of discussion scripts, educational settings and learning contexts.

Overall, the IA approach was positively accepted by all the participants. This conclusion is further validated by the final questionnaire's answers, in which all the indicators where graded from useful (grade 3) to necessary (grade 5). Users preferred more, indicators containing complex information, which may be interpreted in various ways. One explanation for this is that simpler information can be more or less monitored subconsciously, during participation (for example number of messages written by an individual user).

Consequently, simple statistical indicators function more as confirmatory tools for the users' obtained impressions. On the contrary, more complex indicators represent information in an automated manner, which would demand considerable effort and time to extract manually.

Considering *users' selfregulation within a learning activity as an additional facilitation to the moderating tasks of a teacher*, we intended to also examine the influence of the IA indicators to the discussion activity evolvement, focusing on students' behavior. The main conclusion is that the indicators act as an additional motive for user's activity, thus providing means for increased interaction between the students (Bratitsis & Dimitracopoulou, 2006b). Evidence of improvement in the students' behavior during dialogic activities has also been collected (Bratitsis & Dimitracopoulou, 2007a). It relies upon the teacher to manage this aspect of the tool to his/her benefit, by providing an appropriate set of indicators to forum participants so as to selfregulate their own activity. We have found that different indicators affect users' behavior in a different way. We are working towards the definition of sets of indicators, appropriate for different discourse learning activities. This, of course, demands many case studies to be implemented, in order to further research the effects of the indicators on the users' behavior, as individuals and as groups. Thus, the moderator would have the opportunity to select the indicators more suitable to the designed activity, further decreasing his/her work load, by transferring a portion of the regulative tasks to the users.

Moreover, the moderator can utilize *Interpretative Schemas*, in order to make decisions and then motivate students in an appropriate way to improve their participation quality. As explained in the example presented in the previous section, the corresponding student was cognitively capable of contributing more to the discussion's quality. It was the timing of her actions that reduced the effectiveness of her messages. Hence, closer monitoring of her activity through the indicators, could lead the moderator to intervene, in order to trigger her motivation status at an earlier stage of the discussion. Consequently, this student, her collaborators and the dialogic activity overall could have gained more, through this process, at a cognitive level.

Basic student monitoring is possible using only a small set of indicators. For example the *Activity*, *Contribution* and *Classification* indicators, in combination with the two SNA diagrams, presented in this paper are enough in most of the cases, provided that they are reviewed in regular basis, in order to provide an overview of the status shifting through time. They depict the current situation for all the students at the same time, whereas individual indicators, such as the *Tree Structure* or the *User Time Reads* indicator could be examined rarely, when needed. In fact, a challenging idea for future work would be to combine the metrics from these indicators in a much more complex algorithm, in order to produce alerts for the moderator, designating undesired student behavior (cheaters, delayed participants etc). Consequently the moderator should be able to thorough examine the problem, by reviewing more detailed information, by various indicators.

The core objective of this paper was to explore the impact of proper *Interpretation* in the overall learning process through asynchronous discussions and the facilitation of the teacher's - moderator's tasks in particular. The first step for that matter would be to explore the transparency of the proposed IA indicators, substantiating the intentions of the system's design. At a next level, recording of the emerging needs of the teachers was attempted, in order to detect any unsatisfied requests, which led to the implementation of additional, more complex indicators (Bratitsis & Dimitracopoulou, 2006b), thus implementing a more complete system. Overall, the results were promising, with the users appearing very enthusiastic in using such tools. Correlating the produced information and the constructed *Interpretative Schemas* with the actual evolvement and outcome of the discussions, interesting conclusions were drawn. As presented in section 6, applying a different angle in the indicators' examination, underlying information may emerge, such as the exposure of the actual intentions of a user. The example of the individual student, or even the detection of students trying to manipulate the participation variables, proves this point. After all, as the *Information Visualization* theory supports, the goal is to combine raw data in visual forms, providing different perspectives of them (Card et al, 1999). An additional conclusion is that detailed instructions are better provided in advance, in order to further utilize the produced information. Concluding, we claim that *Interpretation* is a very important issue in visualizing information, which needs to be further researched.

Furthermore, we explore the needs of moderators, in asynchronous discussion forae other than for learning purposes (e.g. in the CSCW spectrum: such as open-audience discussions forae within corporative networks, scientific networks, etc). A complementary, overall goal is to associate activities and identifiable user action patterns, easily inspected through the visualized IA indicators.

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