Interaction Analysis in Asynchronous Discussions: Lessons learned on the learners' perspective, using the DIAS system

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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 Interaction Analysis (IA) indicators jointly used in various situations, to all discussion forae users (individual user/students, groups, moderators/teachers or even researchers/observers), appropriate for their various roles in different activities. In this paper we present an overview of the research questions and results regarding the students as IA tool users, deriving from four conducted studies, in educational contexts.

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 (Corich et al, 2004). The latest quinquennium 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 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 Interaction Analysis techniques, taking into account quantitative data. We have developed a discussion forum platform with integrated Computer Based Interaction Analysis (IA) tools called D.I.A.S. (Discussion Interaction Analysis System). We are aiming at supporting all users (moderators, learners, researchers, etc) and facilitating discussion learning activities (Bratitsis & Dimitracopoulou, 2005; 2006a; 2006b), by implementing a wide range of IA indicators. In the current paper, we will present a general overview of the research questions and results emerging from our research approach and a number of case studies, focusing on one of the perspectives: this of adult learners (students) as .IA indicators' users.

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 analysis of a discussion 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 in discussion forae as an ideal reflective process. Literature points out that intensive discussion and social interaction may lead to multiple knowledge construction phases (Schellens & Valcke, 2005). Besides, the importance of a critical mass of users in order to sustain a learning community has been highlighted (Pallof & Pratt, 1999). According to Weinberger & Fischer (2006), knowledge construction through argumentation is based on the assumption that learners are involved in dialogic activities and the frequency of participation is proportional to knowledge construction.

Several categories have been proposed for differentiating approaches attempting to detect 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 (Suthers, 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) or thread depth (for distinguishing important threads). Simoff & Maher (2000), proposed a visualization method for evaluating collaboration intensity and extension, through a set of nested rectangles, depicting the depth and the levels of a thread, along with their width (number of messages per level), while attempting to identify collaboration patterns within various threads. They stated that "The collaboration is closer when there are large thread widths and lengths". The mean number of words has also been suggested by Benbunan-Fich & Hiltz (1999) for measuring collaboration extend. They suggest that well connected, technology supported groups produce longer products, in matter of words, than individuals or loosely connected groups. By validating their hypotheses, they indicated that longer products correspond in higher discussion quality. According to Hewitt (2003), extended online dialogue should ideally be the norm, proposing thread depth as an indication of intense and hopefully fruitful collaboration. 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 analysing the message content by applying proper coding schemes. They introduce certain analysis dimensions, including user participation, cognitive, metacognitive and interactive behaviour, but they are consider to be time consuming (Henri, 1992; Gunawardena et al, 1997; Garisson et al, 2001). A review of the literature also reveal a lot of 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 (Reimann, 2003; Pallof & Pratt, 1999; Salmon, 2000).

Several issues arise during discourse activities, which need to be attended in order to sustain discussions and facilitate knowledge construction. Reduced user participation, off topic argumentation, untimely confrontation of arising problems and problematic user behaviors are some of them. 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. 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 collaboration on an adequate level (Jerman et al, 2001; Barros & Verdejo, 2000). 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). Furthermore, the lack of usual social structures, which exist in face to face communication, should be substituted by corresponding support tools for the learners.

Summarizing, our main research axis is peer support in asynchronous discussion learning activities, in order to trigger metacognition, leading to selfregulation and facilitate the moderator's tasks. It can be placed between the earlier, purely quantitative and the latter, in depth approaches. Our intention is to build tools by applying Interaction Analysis techniques in discussions' activity data, visualizing quantitative information. Computer based IA provides mainly information directly to technology based activities' participants, in order to self assess their activity (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, in order to analyse 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.

Related Work

While examining Forum and Forum type software, we found 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 (No of messages posted and read), few statistical indicators (most-least busy day), online users, number of messages per day or unread messages, etc. We consider this as minimal information, which supports forum usage only as a subsidiary tool of a Learning System (Bratitsis & Dimitracopoulou, 2005).

Several new and promising approaches that implement 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 orientate within a discussion. i-Tree is another system using visualisations via metaphors by presenting the discussion status on mobile phones using a tree representation. The tree corresponds to a single user, whose activities designate the tree's appearance. Thereby the tree's log and branches are relevant to the number of messages, the leaves' range and colour are relevant to message reading, the fruits are relevant to 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 researcher reported increase in the tendency of the users only to read messages and replies, but 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. Mailgroup is a Forum Type tool with integrated analysis tools emerging from the Social Network Analysis field. It implements an alternative method of representing the message sequence in an asynchronous discussion, taking into account both chronological and logical constituents (Reyes & Tchounikine, 2005). SNA was used in order to examine the effect of their representation method in the communication itself, concluding that it was an encouraging approach. 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 visualised 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 activity (Gerosa et al, 2005).

The aforementioned approaches constitute a representative specimen of asynchronous discussion software, used for learning purposes. All of them provide tools and functionalities for supporting and facilitating user activity in various levels. Nevertheless a closer examination leads us to the conclusion that they can only be used under specific usage settings. Some of their disadvantages are described in Table 1.

Table 1: Discussion Forum software characteristics

SOFTWARE	FUNCTIONALITIES	DISADVANTAGES
WebCT, phpBB, WebWiz	Simple statistical awareness information	No real IA indicators
i-Bee	Visualized representation of user – keyword relation	No empirical research about learning utilization of this feature
i-Tree	Visualized representation of user activity on mobile phones	Considers few activity characteristics. Seems to encourage message reading only
MailGroup	SNA indicators, Structure Awareness	Indicators addressed to the moderator. Adequate number of messages is required
Degree	Various collaboration quality indicators & advising mechanisms	Closed system, not easy to customize, with non-transparent indicator calculation.
AulaNet add-on	Visualized statistical information drawn from log files	Various diagrams, addressed only to the moderator, poor empirical research

The Discussion Interaction Analysis System (DIAS)

Design principles – General Overview

The DIAS 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 Data Based Management System for data recording. Several functionalities are implemented for facilitating user participation and the moderators' alternative discussion strategy planning. About 65 visualized indicators (including all possible variations) are produced, varying from simple statistical awareness information to complex cognitive and metacognitive indicators. Our main goal is to offer direct assistance to users, supporting them in the level of awareness of their actions, as well as those of 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 (eg teachers) in order to 'identify' problematic situations and difficulties that require regulative interventions. The design of the system is based on three core design principles (Bratitsis & Dimitracopoulou, 2005; 2006a):

1. Take into account the totality of the users involved in a 'learning activity', as well as the cognitive systems they may form, such as, students as individuals (in various roles), teachers in different roles according the category of learning activity, but also as members of one or more groups or even communities, etc.
2. Provide a rich range of IA indicators for the various user profiles and points of view of the activity process, its quality, as well as its product. Different sets of indicators should be addressed to the teacher or moderator and the students - users, along with the corresponding interpretation schema for various discussion strategies or usage scenarios.
3. Create an independent, flexible, customizable and interoperable system. Forae are tools that can be used in a variety of contexts and activity categories. Furthermore forum participants take various roles and have different needs according to their discussion subjects, the available time etc. Thus, customization and flexibility are crucial characteristics.

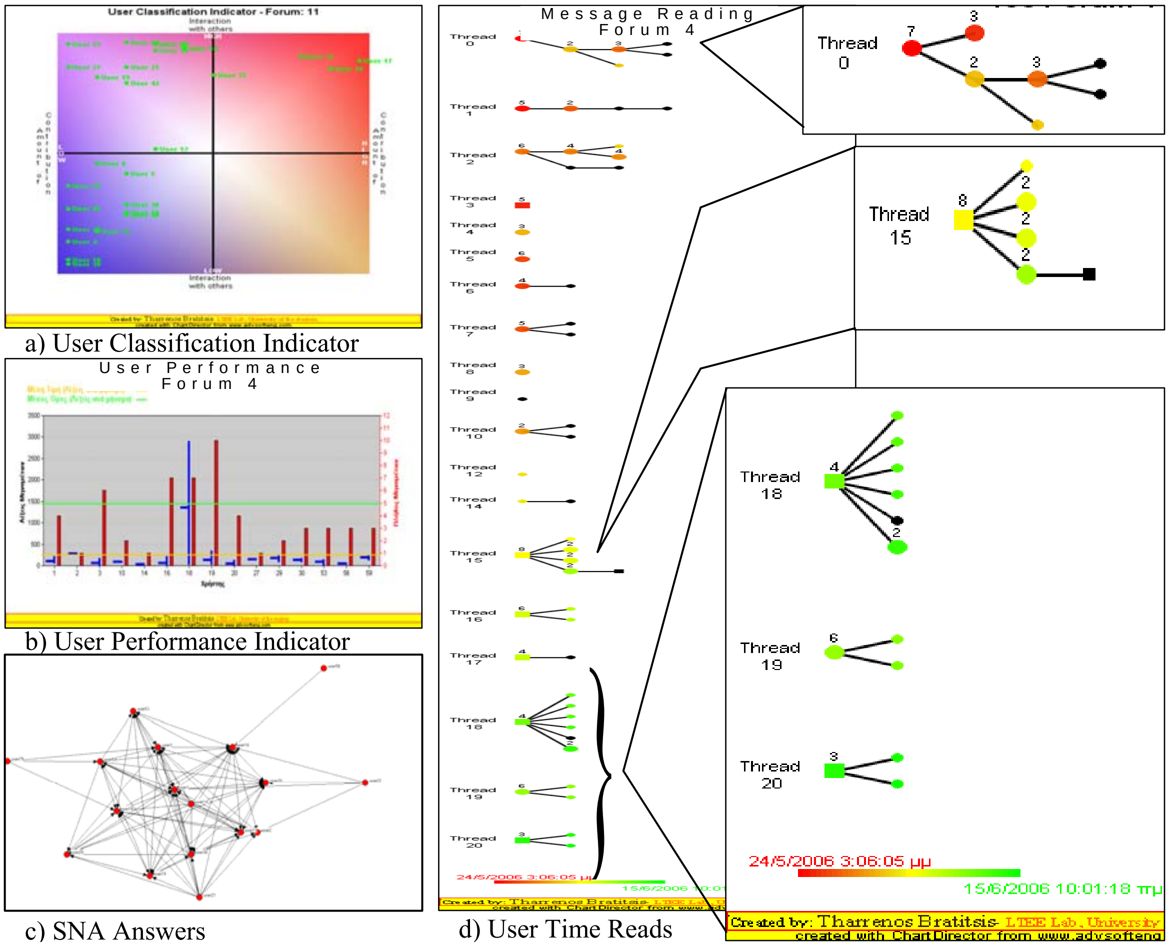
DIAS Interaction Analysis Indicators and their Interpretation Schemas

The indicators produced by the DIAS system may reveal different information to different types of users or users' 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. 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 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 1a, 1b, 1c. Finally, indicators presenting information regarding total user and group activity within the discussion forum constitute the *Community point of view* category.

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 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 (e.g. the indicator in figure 1d). 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. For example, simple bar charts present individual activity information. In combination with charts containing answer exchanging and the actual positioning of messages within the discussion threads, provide more insightful information about a single user's activity. In all the indicators, users appear using a numerical code, hiding true identity, respecting ethics matters. The four examples presented in the current paper (figure 1) constitute a very small fragment of the indicators produced by the DIAS system. More related information can be found in Bratitsis & Dimitracopoulou (2005; 2006a; 2006b).

User Classification Indicator (Figure 1a): It is a XY scattered chart. The X-Axis represents the contribution amount (messages written as a percentage of the total messages' number). The Y-Axis represents interaction amount (messages read as a percentage of the available messages) by a user. Both Axes are scaled from Low to High. By inspecting this indicator, one may see how active (writing and reading messages) users are, compared to each other and the mean values of activity (represented by the two Axes' position). Additionally the moderator (in particular) can see whether a certain user has extreme or balanced behaviour (Arrogant: writes many messages but doesn't read other users' messages. Passive: reads many messages, but doesn't write enough).

User Performance Indicator (Figure 1b): It is a combined bar chart, presenting the performance of all the users in matters of productivity. To each user appearing on the X-Axis, correspond 2 bars. The red bar indicates the number of messages the user has written and the blue bar indicates the extension of messages' size in words. The lower end corresponds to the number of words in the smaller message, whereas the higher end corresponds to the number of words in the larger message. The mean number of words per message is distinguished by a small blue horizontal bar, intersecting the vertical one. Additionally, a green and a yellow horizontal line indicate the average ($(max_{value}+min_{value})/2$) and mean ($total_{Words}/total_{Messages}$) values of message sizes correspondingly. This indicator is addressed to the moderator, presenting at glance comparative information about users' total activity. Useful conclusions can be extracted on whether users perform as expected, according to their assigned role.



a) User Classification Indicator

b) User Performance Indicator

c) SNA Answers

d) User Time Reads

Figure 1: DIAS system indicators' samples

SNA Answers Indicator (Figure 1c): The system produces social matrices according to Ucinet DL format and Agna format for further processing. For N users, the Answers social matrix's dimensions are NxN. The number 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. By quickly inspecting the SNA diagram deriving from this matrix, a moderator can distinguish isolated or central users within the discussion. Furthermore, this diagram reveals the number of cooperators a user is interacting with (writing answers to and receiving answers by them). In combination with other indicators, such as the Classification Indicator, more insightful information is revealed. A highly active user, as seen in the Classification Indicator, who is isolated or loosely connected to others in the SNA diagram, may be the case of a user in need of help by the moderator. Similar diagrams regarding message reading are also constructed.

User Time Reads Indicator (Figure 1d): It is a complex indicator, which reveals many details regarding a single user's activity. All the threads constituting a forum are displayed in a tree-structure format. Vortices represent messages and lines represent their connections. The vortices are hued, according to the time the user has read the corresponding message. Unread messages are hued black, whereas messages written by that user are represented by small rectangles. If the user 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 colour line, shows the time period correspondence. This indicator shows in detail a user's extend of embroilment with the discussion forum. A simpler version of this indicator, where no information regarding time is included and the vortices are black (messages written by other users) and red (messages written by the user) is available for the learners to review.

Research Methodology

Following a methodological triangulation approach, four case studies implementing a different educational activity approach (see Table 2) have been designed *in situ*, constituting the core teaching method for the corresponding semester courses. Similar data collection and analysis methods were used. In the initial pilot study, students were gradually provided with more complex indicators, in order to monitor alterations in their participation behavior. During the 4th week they filled a questionnaire, in order to capture their initial reactions to the indicators' appearance. They were not given any kind of interpretative instruction, as we wanted to examine the transparency of the indicators. In case studies 2, 3 and 4 only one group (experimental group) was allowed to review and study selected indicators, which were available throughout the activity, in order to identify total behavior differences with the control group. The majority of the students had no previous experience of participating in asynchronous discussion forae. Therefore a 3 hour exhibition seminar was conducted at the beginning of each course.

Table 2: Implemented Case Studies

Study	Population	Duration	Teaching Strategy
1 (Pilot)	40 postgraduate students in one group	6 weeks	Free conversations, relevant to the course syllabus and students' obligatory assignments. 8 topics of discussion in order to exchange ideas, arguments and information
2	14 postgraduate students in two groups	7 weeks	3 topics of free discussion, relevant to the course syllabus. One student per group summarized each conversation and coordinated a presentation at the end of the semester.
3	14 postgraduate students in two groups	7 weeks	Students chose keywords from an initial text to present and explicate through the forum. After 2-3 days of explanatory discussion, the moderator summarized and linked to the next phase's (total 6 phases). Students presented theoretical backgrounds, summarized research papers and presented their own case study ideas. Finally groups joined in a concluding discussion.
4	30 undergraduate students in two groups	7 weeks	Students chose 1 of 2 possible problem answers, forming 2 groups. Each group argued on their choice, designating the other choice's disadvantages. Reports were exchanged and discussed further.

Following each study, 30 minute semi-structured interviews took place with each one of the participants. They were asked to evaluate the system and their overall experience with the corresponding teaching approach. Among the questions asked were: (a) *Which indicators do you review more/less and why*?, (b) *Was your behavior altered due to the indicators' presence and how*? (c) *Did you notice a difference in your collaborators' behavior and what kind*?, (d) *How often did you review the indicators*?, and (e) *Which data did you review more, about yourself or your collaborators*? During interviews, *all the available indicators* (even the ones not provided during the corresponding activity) were reviewed and discuss upon, in order to examine their transparency. Additionally we intended to record utilization ideas and initial reactions to the indicators' information – "*What do you understand by observing this diagram*?", "*Would this affect you and in what way*?", "*Do you think this information is important and why*?". Utilizing the fact that all the postgraduate students in two case studies 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.

Data were collected through semi-structured questionnaires and interviews, along with observation of activity, using the actual produced indicators and raw data. Statistical processing of questionnaires' answers, qualitative analysis of the open ended questions and evaluation of user participation was used to cross examine and validate results. The most powerful indicators in matters of explanatory value were correlated with the discussions' actual content, in order to examine possible relations. Furthermore, qualitative analysis methods by other researchers have been applied, in order to examine relevance of results.

Results

Regarding the main question, "*do IA indicators affect users?*", our studies lead us to the concrete conclusion that indeed they do, operating as a very powerful motive for users to increase activity. In the pilot study, messages' production rate was gradually doubled, whereas in the next three studies the experimental group wrote significantly more messages than the control group (60-40 in the 2nd, 68-43 in the 3rd and 128-57 in the 4th study). Almost all the users admitted being very much interested in and affected by the indicators. Very few cases (less than 3%, overall) supported that they would have behaved the same under any circumstances. Users seemed to be positively surprised by the dynamics of the presented information and very eager to utilize it. As stated by a student, "the indicators assist you in evaluating your participation behavior and reveal whether you respect the ongoing discussion or not". This regards to message writing and reading. Students appeared very enthusiastic about using the IA indicators during the discussion activity (94 out of 98 agree). These findings seem to agree with approaches supporting the power of visualization (Gerosa et al, 2005; Vassileva et al, 2005)) and the results of studies within the same research area (Nakahara et al, 2005; Mochizuki et al, 2005).

Examining "*how often users reviewed the indicators?*", we found that the majority acted so very often. In the pilot study, during the first half of the activity, 60% reviewed indicators once a week or more, which was altered to 90% acting likewise almost every time they connected to the system, during the second half. This was due to the more complex and interesting indicators appearing in the second period. In studies 2 and 3, all the users reviewed indicators almost every time they connected. In study 4 the corresponding percentage was 60%, whereas 80% reviewed indicators at least 2-3 times per week. Researching the "*kind of information they were interested in*", 70% of the users wanted to see comparative information, in order to assess their actions in regard to those of their collaborators. Individual indicators were less reviewed (50% of the users), mostly to confirm their impression about their individual activity. The latter percentages were similar to all the studies. A very interesting observation during the pilot study was that students initially believed that receiving many answers to their messages designates their acceptance by their collaborators and their assimilation within the group. Gradually they seemed to alter this consideration, valuing the number of collaborators reading their messages as a more significant indication for that matter. This perspective is validated by observing users to review the diagram showing the number of users posting answers to their messages more than the one showing the number of reads of their messages at the beginning of each course (95% and 55% mean values correspondingly), whereas these percentages appear reversed towards the end.

A very significant issue of the IA research field is "*how users decode visualized information?*". It appears that most of the indicators were transparent. Using simple, widely diagram formats, such as bar-charts, XY-charts and scattered charts facilitates understanding, since everybody is familiar with them through school physics and science lessons. A careful choice of colors may be an additional facility. For example, the gradient transition from blue to red color in the background of the Classification indicator presented in the current paper, indicated the desired area for a user to be placed upon; "The red, hot area is hot and the blue is cold. So it is good for me to be closer to the red area, right?". The pilot study, in which no instructions were given to the users, revealed that great caution and decoding instructions are necessary when using more complex diagram formats, such as mixed charts and SNA diagrams. By discussing with the participants (in all 4 studies), we decided that detailed instructions are necessary in order to better utilize the IA indicators, regardless of the complexity of the diagrams. In many cases, users understood the main concept of a diagram, but were unable to "read between the lines". For example, is very easy to understand that the simpler version of the User Time Reads indicator (called Tree Structure indicator), presented in the current paper, distinguishes the messages written by the corresponding user, and his/her participation propagation in the various 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 the indicator for the first time and should be underlined in advance in order to better utilize it (as described thereinafter). Furthermore, the combinations of information from different indicators, in the form of an Interpretative Schemas, is better to be also provided in advance, as it is difficult for a single user to think of all the possibilities, regardless of his/her role.

Another, equally significant issue of research is "*how the indicators affect the users and the learning process at extension. Do they help users to develop their own regulation process? Do they help to monitor and assess such activities?*" As aforementioned, they function as a very strong motive for increasing participation, but *is that enough? If students understand that the teacher is observing their actions in that detail, it is only reasonable for them to increase their activity.* For better answering this question, we had to further analyze users' actions. The results were very encouraging. For example, all the postgraduate students, in all the studies, who knew how to read

SNA diagrams seemed to be tighter connected with their collaborators, than just increasing the number of messages they read and wrote (in some cases at the expense of content quality). They tried to interact with more collaborators, which resulted in more profitable conversations. Many of the undergraduate (almost 90%) students in study No 4 agreed that they would have acted likewise if they were provided with SNA diagrams and knew how to decode them. Another example is the effect of the Tree Structure indicator in the 4th study, which was explained in detail at the beginning of the activity to the students. The result was that in a total of 15 threads in the experimental group: 1 student participated in 12, 2 students in 11, 2 students in 9 and 3 students in 5 threads. This means that 33% of the users participated in 60% or more of the threads and 53% of the users participated in more than 1/3 of the threads. On the contrary, in the control group only one student participated in 40% of the threads and 4 in total participated in 25% of the threads or more. These very simple examples lead us to the conclusion that IA indicators *do affect users and the learning process at extension*. The users' effort to improve their interaction status within the discussion activity consequently increased the prerequisites for high order thinking and learning, as described earlier in the current document. Higher interaction facilitates critical thinking and sustains effective discussions (Pallof & Pratt, 1999; Garisson et al, 2001; Schellens & Valcke, 2005; Weinberger & Fischer, 2006).

In matters of "*facilitating understanding and assessment of discussions activities' goals*", the indicators helped students to evaluate their participation and see if they respect the discussion and the collaborative process, as aforementioned. In a multiple phase activities (studies No 3 & 4), some students admitted that various group indicators, such as the Relative Activity Indicator presented in Bratitsis & Dimitracopoulou (2005), assisted them in better noticing increased activity periods in the discussion forum, designating beginning or ending of the distinct phases. Thus these indicators assisted them in better understanding the activity planning and indicated how and when they should act. During coordination and discussion summarizing phases, where students were obliged to decide on how to proceed, information from specific indicators was used. As stated during the interviews (in studies No 3 & 4), some users preferred to review a diagram showing the number of users answering to their messages or the *Tree Structure indicator*, counting the answers to a coordinating message. Thus they could decide if the number of answers was adequate in order to review them and proceed to the next step or if they had to wait some more. In another case, a student assigned the task of summarizing a discussion in order to present the group decisions (study No 4), mentioned that she would "see from the Classification Indicator who are the most active collaborators (in matters of reading and writing messages) in that discussion and thus have a better perspective of the whole activity. She would then contact them requesting their assistance in order to produce a better summary". These are some examples of ideas generated by students (while using the indicators on their behalf) clearly showing that specific indicators improve monitoring of the process and better assessment of the current situation. Especially indicators showing the structure of the threads, such as the *Tree Structure indicator*, were more than welcomed by the users – "This shows exactly what I did in the forum". It is clear that common visualization approaches in discussion forae are not adequate for users to fully understand the structure and evolvement of the discussion, as also distinguished by Reyes & Tchounikine (2005).

Although the results related to moderators' and researchers' perspective is out of the scope of the present paper, we could mention that for these IA users, more complex indicators and interpretative schemas are needed. One example is the *User Time Reads* and the *User Performance indicators*, presented in the current paper. Teachers participating in our case studies expressed very positive attitudes towards the proposed utilization ideas. Some of them were generated through interviews with the teachers, while trying to record their specific needs. This seems to be a perpetual process, as our experience revealed that interpretation and utilization ideas may be produced at any time. The User Performance indicator, for example, was generated when a teacher expressed the need to have a clear picture of the messages' sizes, apart from their number, in order to evaluate user participation. In the pilot study, several students tended to write many small-sized messages, in order to appear more active in the simple indicators. Likewise, the User Time Reads indicator's concept was generated after noticing users attempting to increase their status within the indicators, towards the end of the activity, thus attempting to "trick" the system. Furthermore, additional explanatory ideas were generated through the process of the interviews. For example, the aforementioned idea of a student about utilizing the *Classification indicator* generated the idea that likewise the moderator can assign a summarization task to the optimum student for better results or to one of the more passive students in order to further activate him/her. Finally, the "*possibility of preliminary discussions' qualitative evaluation*" appeared to be possible. One of our goals was to explore the possibility of analyzing and evaluating discussions, without having to review all the messages or apply content analysis methods. Both approaches result in a great amount of work, which in the case of real settings teaching, with 40 or more participating students seems rather impossible to accomplish. For that matter, some indicators were built by combining and expanding existing analysis approaches

(Bratitsis & Dimitracopoulou, 2006b). The results were positive and the ideas were welcomed by the teachers. In some cases, we were even able to connect indicators' values to the actual content of a discussion thread.

Discussion – Future Work

Our main conclusion is that the use of IA indicators in asynchronous discussions is an encouraging and efficient approach. The overall impression was very positive by the majority of the participants in our case studies. We were able to observe shifting in users' behavior through activity data. Users appeared to be more active and productive. Several indicators seem to be more preferable than others, regardless of the teaching settings, such as the *Classification indicator*, which was the most preferred indicator by the users, in all the conducted studies. Some of them are better utilized under specific context and activity settings. For example *SNA diagrams* seem more appropriate when heavy interaction among smaller groups is pursued, whereas *Activity Indicators* (Bratitsis & Dimitracopoulou, 2005; 2006a) seem more appropriate in cases of open ended discussions with a large number of participants. The use of questionnaires assisted us in our effort to designate the appropriate set of indicators for various teaching contexts and settings. On the other hand, we consider that a large number of case studies is necessary in order to extract concrete results for that matter. The complexity of the IA process evaluation and the variety of the produced diagrams, indicate that this method is useful for medium and large-sized groups of students. For groups with less than 5 or 6 people, it seems easier to review the actual messages in order to draw conclusions. In general, our findings seem to agree with those of other research approaches mentioned in the current paper, which indicate improvements in user behavior. It is the variety of indicators and the dimensions that we measure, which mainly differentiates our work, having focused on collecting data regarding participants' opinions and needs related to IA indicators, given that a previous analysis had revealed a corresponding lack (Dimitracopoulou et al., 2005).

Having produced several Interpretative Schemas, which were positively evaluated by the participants (Bratitsis & Dimitracopoulou, 2006a), we were very surprised to see that users came up with new ideas for utilizing indicators. New indicators were built in the process, as new needs were expressed. As aforementioned, this seems to be a perpetual process, which may lead to the creation of an "Idea Repository". Detailed instructions are required, if we wish users to exploit the indicators. Otherwise, the amount of diagrams produced would give them the impression of additional workload, with no clear meaning. Consequently, they would avoid reviewing the indicators.

Our future plans include the conduction of additional case studies, in order to explore further aspects of the IA process. Results found under specific learning settings, may be tested for validity under different settings (for example using a different collaborative learning strategy). Furthermore, new questions arose. Does age influence the users' perception and decoding of visualized information? Do indicators presenting similar information with different visualizations affect users in a different way? If yes, when should each approach be used? For example, some indicators present comparative activity information (e.g. number of messages read or written) using absolute values and other use percentages. As a result, the gaps between user visualizations are larger in the first case. Could this (large gap) be a reluctant factor for a less active user, considering that the effort needed to improve his/her position is too much? On the other hand, could this affect likewise more active users, leading them to reduce participation? What could be the difference in motivation when using visualizations with smaller gaps? Another question regards the quality of the effect on the users. While activity indicators seem to motivate user to increase participation, SNA diagrams seem to motivate them to interact with more collaborators. The latter is not necessarily proportional to total activity. For example in large groups, it is possible to see a more active user to be more loosely connected with collaborators in the SNA diagram, than a less active user. When using only one of these indicators, what would the result be in user activity and in the learning process? Which are the optimum combinations? The variety of new questions is quite big. All these questions relate to a more refined research of the indicators' effect on the users individually, as a group or a community and the learning process. The overall conclusion that applying IA methods for building tools to support the participants of an asynchronous discussion activity is one step at the right direction, should be the main lesson learned from this approach.

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