# Computer based Interaction Analysis Supporting Self-regulation: Achievements and Prospects of an Emerging Research Direction

ANGELIQUE DIMITRACOPOULOU*

*Learning Technology and Educational Engineering Laboratory, University of the Aegean, Greece*
*1, Av. Democratias, 85100, Rhodes, Greece*

*Computer based Interaction Analysis (IA) for the support of the participants' self-regulation in technology based learning activities (individualised or social) is a new direction of research that has emerged during the last years. Its main purpose is to offer a cognitive and metacognitive support to learning environment participants (e.g. students, moderators, teachers) as well as to observers of those activities (e.g. teachers, researchers), who need to analyze and understand the complex cognitive and social phenomena that may occur. The core aim is to offer directly to human actors the means (usually via visualized representations of appropriate IA indicators) so as to be aware of and regulate their behaviour, either as individuals or as cognitive groups. The paper introduces this research direction, presenting its achievements via the features of IA tools, a synthesis of their actual usages, as well as a brief research roadmap regarding the design of these tools. Finally, a discussion on the perspectives of IA for self-regulation concludes the paper.*

Keywords: *Interaction Analysis, technology-based learning environments, selfregulation, design, tools, cases studies*

## INTRODUCTION

Computer-based Interaction Analysis (IA) for selfregulation support can be defined as the automatic or semi-automatic processes that aim at understanding the computer mediated activity,

* adimitr@aegean.gr ; www.ltee.gr/adimitr

drawing on data obtained from the participants' activities. This understanding can serve in order to support the human or artificial actors to take part in the control of the activity, contributing to awareness, self-assessment or even regulation and selfregulation.

The IA process consists of recording, filtering and processing data regarding system usage and user activity variables, in order to produce the analysis indicators. These indicators (presented usually in a visualized form) may concern: a) 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 interaction analysis results that are presented to the participants of the learning activities’ (students, moderators, or teachers) as well as the observers (teachers, administrators or researchers) must be displayed in an appropriate format (which will usually be graphical, but also numerical or literal). These results should be interpretable by them.

The core aim is to offer the means directly to the human actors, so as to be aware of and regulate their behaviour, either as individuals or as cognitive groups. In fact, the corresponding interaction analysis tools support the users in three major levels: awareness, metacognition and evaluation. The objective is the optimization of the learning activity through: (a) refined participation by the students through reflection, self-assessment and self-regulation, (b) better activity design, regulation, coordination and evaluation by the teachers.

The need to support participants’ awareness and metacognition is driven by the intensive interest to use technology based learning environments and especially highly interactive ones in particular in every day educational practice, where there is a need to (self)/evaluate in an operational way, both the learning processes and the quality of activity. When students work, for instance, with exploratory learning environments, a variety of interactions among students and system take place. Moreover, during technology based social activities very complex interactions occur, between two or even more individuals collaborating in a group, as well as among students and an eventual moderator. Subsequently, on the one hand, students seem to need information on their own actions, as well as on their collaborators. On the other hand, teachers, especially in real class contexts, need some structured information on what happens, that could allow them to have more appropriate synchronous or aposteriori interventions, related to the quality of the activity outcome (content) and/or the quality of the collaboration itself.

Thus, actually, most of the existing learning systems present limitations when used by students in educational settings. Some of the limitations are attributed to the fact that students have difficulties to develop metacognition on their own actions and processes, or to participate in the interaction with their partners, while teachers who are in charge of several students, fail to interpret, the enormous number of complex interactions that take place simultaneously; this leads to scenarios in which teachers are not able to detect, for instance, collaboration breakdowns that could produce frustrating experiences and even the abandon of these new learning experiences in favour of more traditional methods.

Acknowledging these limitations, during the last years, researchers have started to work on addressing this problem. Tools or simplest functions that aggregate the interaction data of logfiles into a set of high-level indicators which are presented to the learners or to the teacher have been developed [Dillenbourg et al. 2002; Reimann 2003; Petrou & Dimitracopoulou, 2003; Fesakis et al. 2004; Jermann 2004; Vassileva et al. 2004; Gerosa et al. 2005; Mochizuki et al. 2005, Nakahara et al. 2005, Reyes & Tchounikine 2005; Bratitsis & Dimitracopoulou 2006, Hlapanis & Dimitracopoulou, 2007; Teplovs et al. 2007; Kay et al. 2007]. Thus, it has emerged a new research direction related to the design of technology based learning environments: the one that I call “computer based Interaction Analysis supporting self-regulation” [Dimitracopoulou, et al. 2005; Dimitracopoulou & Bruillard, 2006; Dimitracopoulou, 2008].

Finally, nowadays, the automated analysis of participants’ interactions is taken into account by three main directions that are distinguished but also complementary ones. The two first well known directions correspond to those that the system, based on the output of interactions analysis, takes into account the profiles and the cognitive processes of individuals or collaborating groups, in order to adapt the learning environment to their own needs and preferences, or even to provide appropriate guiding messages guiding (applying typical techniques of Artificial Intelligence). The third new direction provides information directly to the human actors, based on the automated interaction analysis, so as to self-regulate their decisions, actions and behaviours, supporting them in a level of awareness and metacognition (Dimitracopoulou & Bruillard 2006). If we want to depict two main differences, we could say that: (a) In the two first directions, it is the system that makes the decisions (leading to the so-called Adaptive Systems or even to the Intelligent Tutoring Systems), while in the third one the locus of control is on the human actors' side; (b) Given that the output of interaction analysis is to be interpreted by humans, the nature of the presenting information as well as the corresponding visualisation plays a critical role, in the case of IA.

In the following part of the paper, an overview of this new research direction is presented, in particular via the features of IA tools as well as the synthesis of their actual usages. Then, the main aspects of a research roadmap highlight its achievements, while they draw the underlying objectives and perspectives that could enforce this research direction. At the end, the prospects on the design of enriched learning environments are discussed.

## INTERACTION ANALYSIS TOOLS

### Interaction Analysis Tool Processes and Indicators

The IA tools produce IA indicators that constitute variables indicating 'something' related to the mode or the 'quality' of individual activity (e.g. modelling approach, quality of hypothesis testing, etc.), the mode or the quality of the collaboration (e.g. division of labour, categories of specific contributions), the process or the quality of the collaborative product.

Let us briefly present the main 'phases' involved in the 'interaction analysis process' of a generic IA tool. Students interact in a technology-based learning environment. In different moments of the learning activity, they can interact with the environment in an individualised (stand alone) mode, or in group(s), forming various cognitive systems. Additionally, a teacher may intervene or just supervise the whole activity.

In order to analyze participants' interactions, a number of processes occur that are presented briefly in the following:

First of all, data are selected (*data selection or data filtering*) by an automated mode, from the available data sources. Two kinds of data could be collected: (a) the interaction *product* (its final form and eventually a number of its intermediary instances); (b) student(s) and/or teacher actions registered into the environment logfile.

The selected data are aggregated by different *data processing methods*. Often, *preprocessing methods* are also needed (e.g. transformations of available databases in suitable shapes or intermediary calculations), in order to prepare the data in an appropriate way (e.g. needed for specific algorithms).

The application of 'data processing methods' produces usually one or more basic '*indicators*' (usually low level indicators), as well as one or more *composite*, *derived* ones (high level indicators).

In the *interface of the IA tool*, the IA tool user can observe or even handle the output values of IA indicators. Concerning the presentation of the indicators' values to the users of interaction analysis: (a) The values of these indicators could be announced directly to the users via a specific interface. The *presentation of the values* usually takes an appropriate form: textual, numerical, or diagrammatic- visualized. (b) In some cases, the systems incorporate an assessment of the values of indicators (via a mechanism of '*calibration*' according to specific *norms*), specified into the specific context of interaction (e.g. presenting a range of 'positive" and 'negative values"). (c) In other cases, systems interpret the meaning of the indicators values, comparing them with an *internal model* suitable or even ideal *(desired interaction state)*, and therefore proceeds to the production of explicit messages advising students what to do. In the latter case, a guiding system is produced (addressed usually to students).

In case that the *IA tool* is *customizable* by its users (e.g. teachers or adults students), it may allow them, via the IA tool Interface, to insert appropriate values for: (i) the desired indicators to be observed, (ii) the norms of some indicators, (iii) the desired model if needed (e.g. in the previous third case).

Finally, it is to be noted that the output of an IA tool, can be visualised even in the *Interface of the Learning environment*, in case that it is considered useful during the interaction (e.g. indicators supporting workspace awareness in social software).

The whole 'system' that selects the required data and aggregates them via data processing methods, producing indicators and even developing appropriate forms of messages could constitute a distinct *interaction analysis tool*, or just a piece of interaction analysis software/code, internal to the learning environment.

Besides the exact processes executed by an IA tool, each one of them is marked by the IA indicators, which produces. There is a number of attributes and properties that characterises the IA indicators. For their detailed presentation and discussion the reader can consult other publications (Dimitracopoulou et al. 2005; Dimitracopoulou & Bruillard 2006, Dimitracopoulou, 2008). Among the totality of IA indicators attributes, we can mention four central ones and in particularly, the IA Indicator : (a) *Nature* (cognitive, social, affective); (b) *Status*, that is related to the status of the values of the indicators, namely if they correspond to clear values, values calibrated according to a norm, or even values that offer a direct evaluation; (c) *Point of View* on the interaction data, corresponding to an Individual point of view, a Point of view of Group (differentiated or undifferentiated), a community or society point of view; (d) *Visualisation mode*, where we can distinguish three main general categories (the typical visualisation of an indicator in function of the time, the co-variation between two indicators, and the simultaneous visualisation of multiple indicators).

## The features of IA tools

An IA tool presents three main features: (i) The *intended users* of an IA tool, according to its designers; (ii) the *status of the IA tool* in relation to the technology based learning environment; (iii) the *model of interaction* which is finally produced. Other features of these tools that could be mentioned here are the type of data that can be received as entries or their validity field. Subsequently, we will present briefly these three main features of IA tools.

### *The users of IA tools*

Generally speaking, three different categories of users can benefit by the outputs of an IA tool: the participants of the learning activity, the observers of this activity; the system itself (the learning environment).

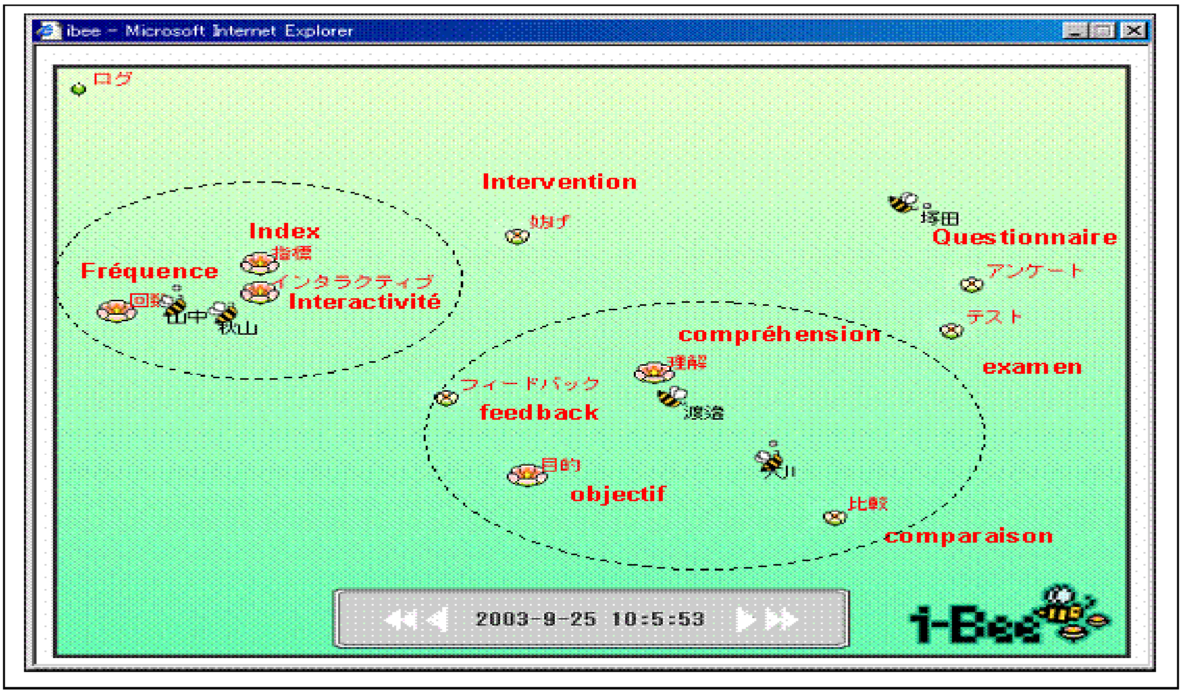
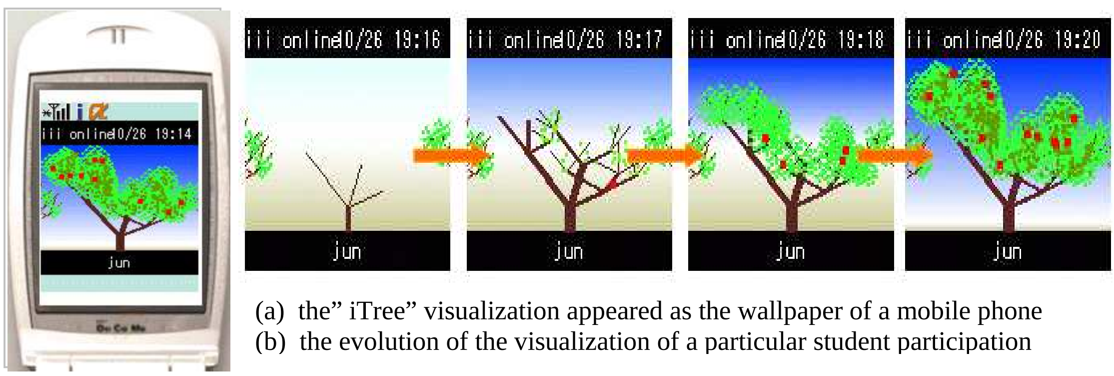



**Figure 1.** *«i-Bee »: Example of IA tool addressed to students (Mochizuki et al., 2005)*

(a) *The participants in a technology based learning activity*. It is useful to distinguish two sub-categories:

(a1) The *students:* For instance, the IA tool « *i-Bee* » (Mochizuki et al., 2005) (Figure 1) is addressed to students discussing via a forum of asynchronous discussion. *i-Bee* produces as the analysis output a visualisation incorporating four IA indicators visualised by metaphors: «the popularity of each discussion topic/keyword » (represented by a flower with values: bud of flower, flowering, full bloom), «the activity degree of every participant » (represented by a bee with values: sleeping, active, very active), «the main topic of discussion per participant » (represented by the distance between bees and flowers) and “keywords used by participant” (represented by the head direction of bees). Similarly, the tool « *iTree* » (Nakahara et al., 2005) represents four indicators, which can be visualised in the screen (as a wallpaper) of the mobile phones of the students studying on a university campus and intented to participate in an online BBS forum (Figure 2); the participation variables are the “number of posts” (visualised by the growth of tree’s trunk), the “Number of times posts are read” (number and color of leaves), “Number of replies to posts” (red nuts), and “Ratio of total forum posts to replies” (color of sky).

.




(a) the” iTree” visualization appeared as the wallpaper of a mobile phone
(b) the evolution of the visualization of a particular student participation

**Figure 2.** *“iTree”: Example of IA tool addressed to students (Nakahara et al. 2005)*

(a2) The *teachers, moderators, tutors, trainers,* etc. For instance the IA tool « *Analytic Tool* » (Figure 3) is a set of IA sub-tools linked to the environment of asynchronous collaboration ‘*Knowledge Forum*’ (Teplovs *et al.,* 2007). It offers to the teachers a set of indicators (e.g. regarding the “evolution of vocabulary » or the « semantic field of students’ discussion topics», Figure 3a and 3b respectively). Another tool, which is addressed to teachers, is « *ARGUNAUT* » (de Groot *et al.*, 2007), which also offers to the moderator some functionalities of intervention towards the students.

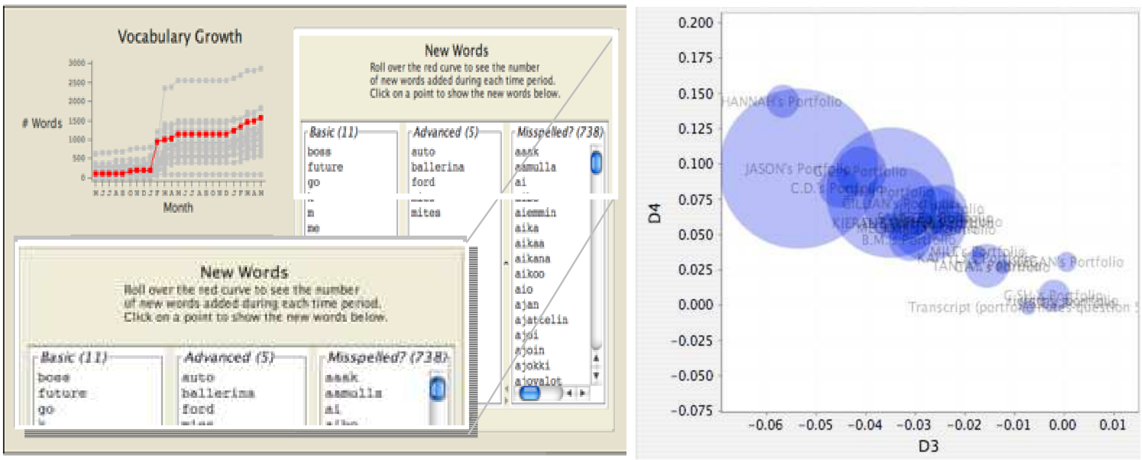
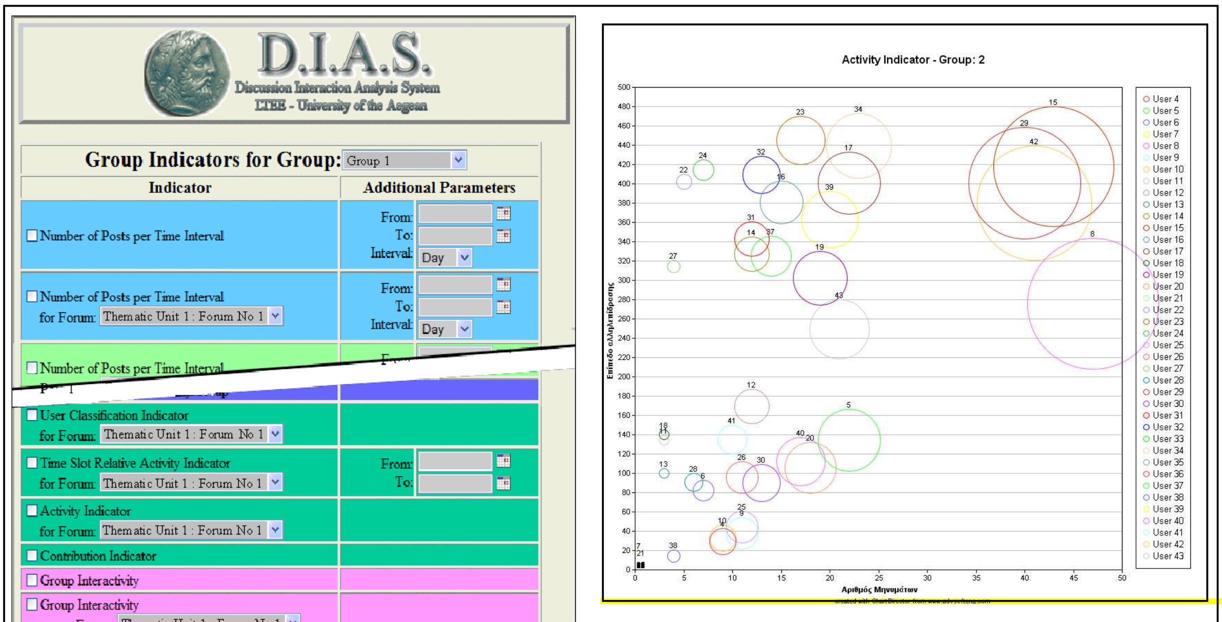



**Figure 3**. *« Analytic Tools»: IA sub-tools linked to the learning environment « Knowledge Forum » addressed to teachers (Teplovs et al., 2007)*

(b) There are different profiles of *observers of the technology based learning activity* that might want, for instance: to estimate the quality of interaction among the participants, such as the *teachers*, or the *moderators* which are not directly involved in the activity; to validate the technical functioning, like, for example, the *administrators* of a web-based environment; or even to analyse the events and the interactions like, for example, a *researcher*.

(c) The *system* itself, adopts equally a role of *observer*, when it takes into account the analysis results so as to produce automatically messages towards students or even to adapt the learning environment, offering an alternative, enriched interface or adapted resources. This last case, of an enriched interface corresponds to a specific forum developed by Reyes & Tchounikine, 2005, which offers a complementary and alternative interface (superposing a chronological vision with a vision by trees), taking into account the interactions taken place.

Besides these three basic distinctions of the IA tools' users, it is important to mention a related recent and promising tendency. Researchers have indicated the importance (Dimitracopoulou et al. 2005; Marcos *et al.*, 2004) of designing IA tools addressed to *multiple human users*, taking into account their *different profiles* (students, teachers, researchers), or even their *different roles*. For instance the IA tool 'DIAS' (Bratitsis & Dimitracopoulou 2006, 2008) (figure 4) offer an important number of IA indicators (about eighty), so as to support students, moderators of an asynchronous discussion forum, as well as administrators and researchers. This is possible, by the design of a customisable and optional IA tool allowing experienced users to: (a) choose the sets of indicators that are appropriate for a specific context and learning scenario; (b) adjust them, defining appropriate values norms or visualisation modes. Similarly, another promising idea is to create diversified sets of indicators, according to the roles of the participants (pre-established or emerging during the learning activity) (Marcos *et al.*, 2004).




(a) Main Menu of Indicators activation,

(b) Example of Indicator: Relative Activity Indicator: positioning each user in the space of two dimensions: ‘Level of interaction’ and ‘Number of Messages’

**Figure 4.** *IA tool ‘DIAS’ for forums (Bratitsis & Dimitracopoulou 2006)*

*The status of IA tools*

The actual IA tools can be distinguished in three categories of their attributed *status*, regarding their relation to the learning environment of which the interaction data are analysed. They can constitute an ‘integrated component’ to the learning environment, a ‘component linked’ to it, or even an ‘independent IA tool’.

(a) *A component integrated* to the learning environment that often can be very limited, offering just a simple functionality (e.g. *PHPbb* that offers some indicators such as « number of participants per day") or a little bit more elaborate.

(b) *A component linked* to the learning environment that often constitutes an elaborated IA component. It is the case of « *Analytic tools* » (Teplovs *et al.*, 2007) (Figure 3) linked to the system of asynchronous collaboration 'Knowledge Forum', or the separate component, called « *Activity Analysis* »[1] (Petrou, 2005) linked to the « *MODELLINGSPACE* » (Dimitracopoulou & Komis, 2005) (a modelling environment for individual use as well as for synchronous collaborative use) (Figure 5).

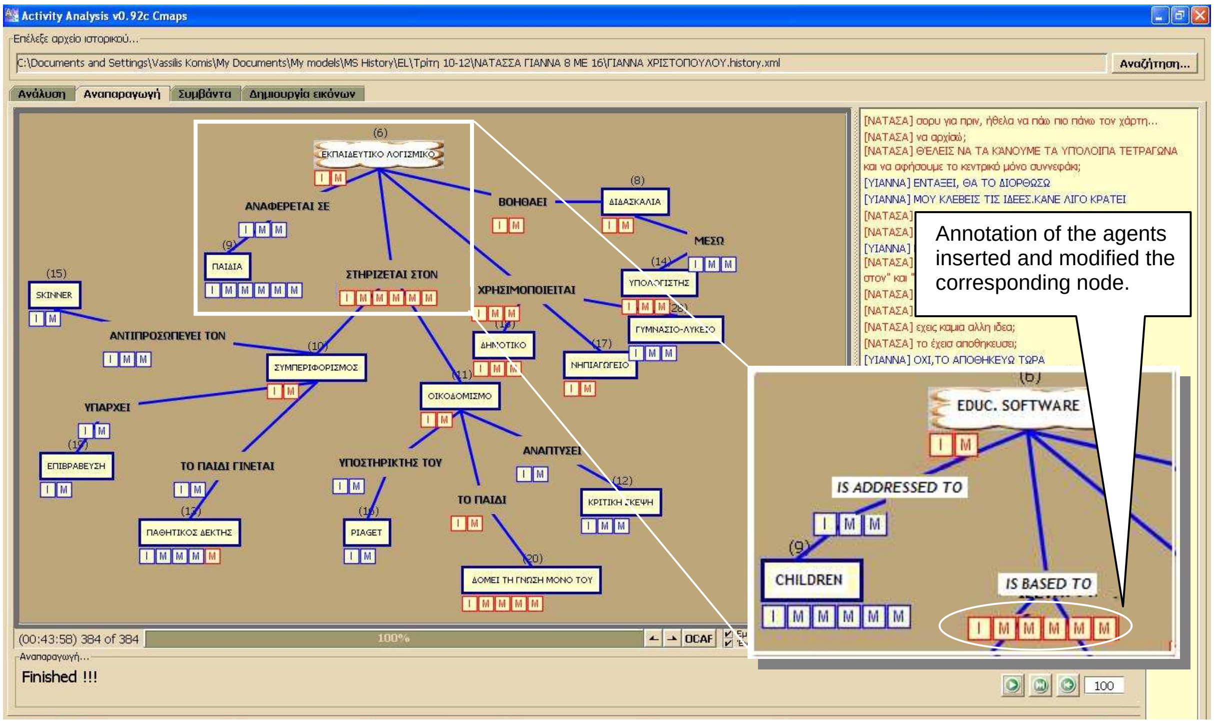



**Figure 5.** *"Activity Analysis" IA component of "MODELLINGSPACE": Snapshot of "Annotated Playback" sub-tool (Dimitracopoulou & Komis, 2005)*

(c) *An independent IA tool*, in principle, is able to exchange data with different technology learning environments usually of the same category (e.g. modelling systems, forums, etc).

[1] The IA tool "Activity Analysis"/MODELLINGSPACE includes IA subtools for offline use as well as some functions for online use. Among those for offline use, the "Statistics overview" offers simple quantitative indicators regarding the participation of each collaborator, while the "Annotated Playback" (see Figure 5), offer the possibility to watch in a video-like mode at the whole synchronous collaborative session, while the annotation of the authors acting in the learning environment (who had the initiative to insert an entity, who has modified it, who has deleted it etc) is inserted,

It is the case of IA independent tool “*DIAS*” (Bratitsis & Dimitracopoulou, 2006, 2008) (Figure 4) that can be connected to different forums of asynchronous discussion. The interaction analysis output (the values of calculated indicators) are displayed in a specific space, different to the learning environment interface.

*The model of interaction produced by the IA tool*

The main general aim of an IA tool, regarding the activities in a learning environment, is to produce an overview ‘figure’, but also a detailed one, of the interactions taken place, so as to support participants reflection and regulation or selfregulation of their actions. This figure, more or less complete, can constitute a kind of model of interaction. We can distinguish three levels of « *expressiveness* » of the models produced by the IA tools.

(a) *Low level*: the corresponding tools produce a limited number of indicators not connected between them. It is often the case of the integrated components of IA, included in specific learning environments.

(b) *Intermediary level*: these tools offer a coherent but often partial set of indicators. Usually, they analyse just an aspect of interaction. A characteristic example of this model expressiveness level  is the analysis resulted by the IA tool included in the learning environment *Degree* (Barros & Verdejo, 2000), which produces a coherent set related to the quality of collaboration, represented by the composite indicator “collaboration” (Figure 6).

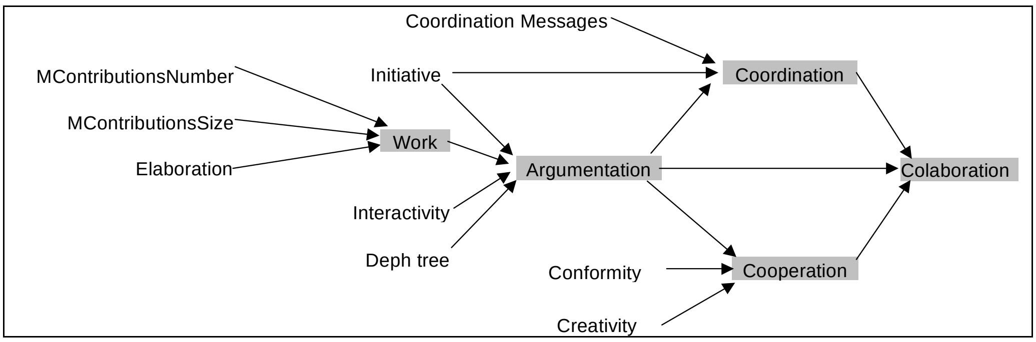



**Figure 6.** *Model of intermediary level of expressiveness produced by the incorporated interaction analysis component of the system ‘Degree’ (Barros & Verdejo, 2000)*

(c) *High level*: corresponding to models that integrate sets of coherent indicators, for a series of different aspects of interactions (e.g. cognitive, social, affective aspects) as well as activity products.

This categorisation represent the actual state of research direction that is still in emerging process, and where there are not yet IA tools able to produce a complete figure of interaction, and so to feature a high level of expressiveness of the produced interaction model.

Besides the « expressiveness » of the models produced by the IA tools, another qualification that we could define is the « *power* » of these models. The power of IA output models is related to the interpretative value of the indicators. Most of the actual IA tools produce indicators of low interpretative value (percentage of participation, percentage of answers to messages, etc). A few tools propose indicators of a high interpretation value (e.g. the indicator «collaboration quality», Figure 6; Barros &Verdejo, 2000).

## THE USE OF IA TOOLS

However, what are the actual usages of these IA tools? How do the users profit from them and what is the effect of their usages?

The kind of usages may differ according to the users' profiles and roles into a learning situation, the objectives, the features and the structure of the learning activity, as well as the activity context. However, we could present some indicative examples of decision making by the users of IA tools that are present in the actual related literature. Laying aside the specific usages of IA tools by the administrators and the researchers, as well as those of the artificial agent systems, we will refer to the usages of direct or indirect human participants of technology based learning environments, namely the students and the teachers or moderators, in an educational context.

Regarding students, one of the main reasons of the use of IA tools, is to support them to be aware of their own functioning, as well as the functioning of others collaborators or participants (of a group, groups or community) in a social context. It is about to reflect on the visualised 'model', taking also into account their own representations formed during interaction and then activate meta-cognitive operations, so as make decisions and estimations, and if it is necessary to adjust their behaviour or to accomplish new, different actions and activities, in order to selfregulate their own functioning and/or to influence the regulation of the group or the whole community. Regarding teachers or moderators, one of the main reasons of their use, is to become able to create an overview 'figure' of the interactions among their students, and some detailed underlying aspects, allowing him/her to regulate their eventual interventions or to estimate students' evaluation (as individuals or as groups), as well as to support them to be aware of their own functioning, when they participate or intervene in a learning situation.

Even if there are not yet an important number of profound research studies, able to identify the instances of observation of IA tools outputs, or even better to capture the indices of 'awareness' and the regulative or selfregulative decision making users' actions, however, a spectrum of different usages and corresponding regulative actions has already been reported. Based on references related to IA tools that report an experimentation of an IA tool with real users, we can present an overview of these.

(I) *IA tools usages by students and decision making effects*:

(a) Regulation of their actions related to: (a.1) the degree and mode of participation; (a.2.) the orientation of the activity

(b) Regulation of the activity process

(II) *IA tools usages by teachers or moderators and decision making effects*:

(a) Decisions on the moderation tactics to undertake

(b) Evaluation of students

(c) Selfregulation of moderation strategies.

It is to be mentioned that the reported usages:

(i) are registered regarding *IA tools of various status*: for instance, a simple IA tool integrated to a distance learning platform, a component linked to a modelling environment, an independent IA tool, connected to a forum of asynchronous discussion, etc.;

(ii) seem to enrich *a variety of learning environments* (simulation game, modelling environment, forum, asynchronous collaboration, synchronous collaboration, file exchange system, platform of distance education etc.)

(iii) concern *different populations* (students of primary school, secondary school, or university; teachers of secondary education, professors in university, moderators in a community, etc) *and context of usages*. In just a few cases, studies are reported concerning the usage of the same IA tool by both students and teachers/moderators.

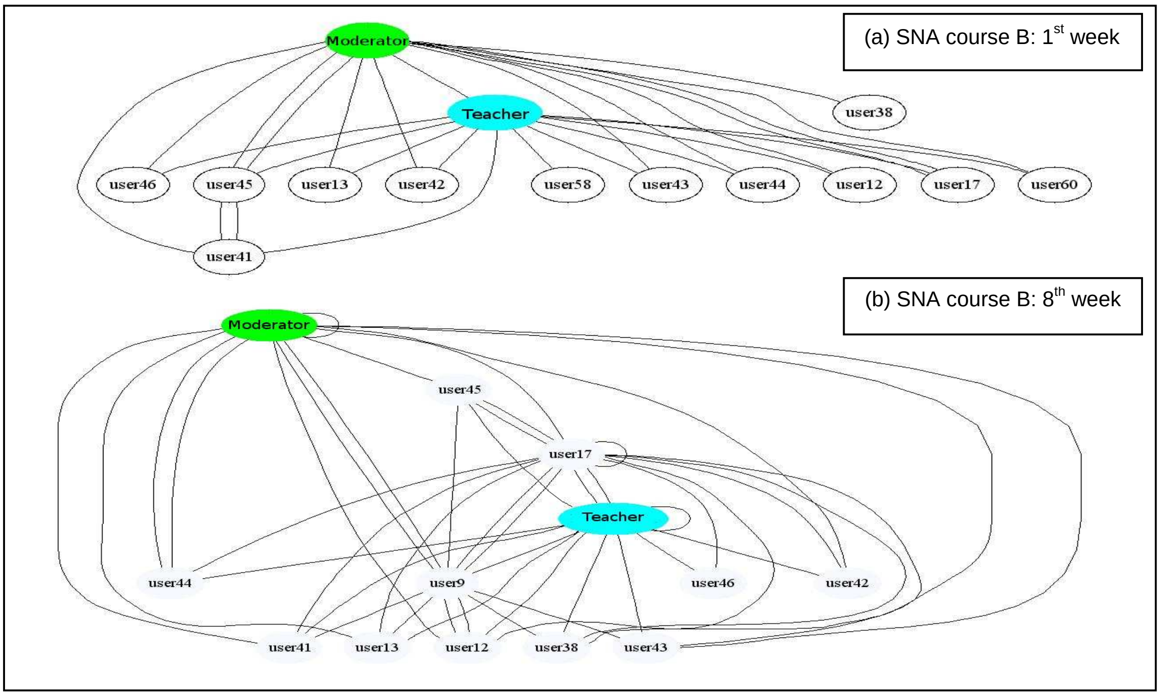



**Figure 7.** *Social Network Analysis diagrams of a group (Hlapanis & Dimitracopoulou, 2007)*

*(I) IA tools usages by students and decision making effects:*

(a) Regulation of their actions

(a.1) *Regulation of their own actions regarding the degree and mode of participation (socio-cognitive aspects);* Most of the published cases studies report that in situations of regular usage of IA tools, when the students ascertain that their own level of participation (in social environments) is low in comparison to other participants, they tend to increase their corresponding percentages, by acting more (e.g. by inserting entities in a shared space, posting messages in a forum, writing in a chat), Nakahara et al. 2005; Vassileva et al. 2004; Bratitis &

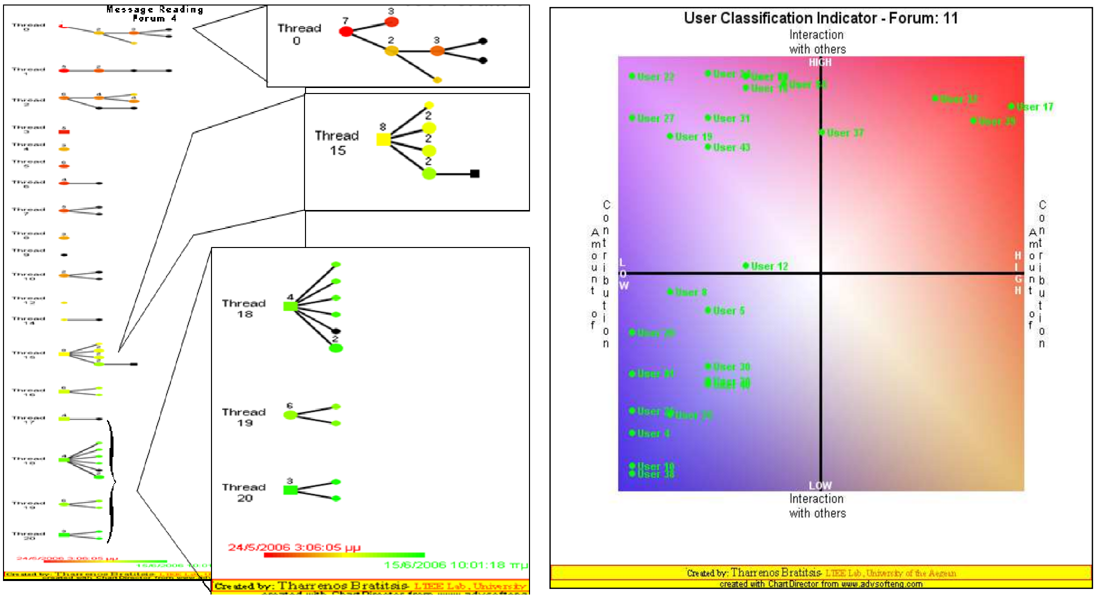
Dimitracopoulou, 2006. Similarly, in the case of a distance learning training program for in service teachers, where the 'students' had access every week to the Social Network Analysis (SNA) diagram[2] (Figure 7) representing e-mail interactions in the frame of their course group (Hlapanis & Dimitracopoulou, 2007), most of these students had increased their participation in being reactive in e-mail messages, as well as sending more messages to their mates (and not only to their 'teacher'). The same students have also confirmed their changes in behaviour via questionnaires, as well as during interviews. It is to be noted that some researchers report also that an increase of the participation may appear without an improvement of the quality of interaction (Cheng & Vassileva 2005, Bratitsis and Dimitracopoulou 2006, Zumbach et al. 2005); this finding provides implications for the need to produce and visualise a number of complementary indicators (both on the quantity and the quality of participation), so as to avoid this kind of phenomena.

*(a2) Regulation in the orientation of the activity, regarding its content (cognitive aspects)*: There are very few cases involving indicators with underlying content analysis (mostly due to the embryonic state of automated content analysis), however, it is possible to report a case, concerning the tool "*i-Bee*" (Mochizuki et al. 2005), where the corresponding indicators are calculated via keywords. The researchers report cases where the students had identified common points of discussion (in a forum) into messages posted by other students, something that incited them to identify, read and re-read the corresponding messages in order to communicate with these students having common interests or points of view. Another case, of the same sample has pointed out instances where the students regulate their discussion on topics that merited to be continued even if they had been dropped out without concluding.

(b) *Regulation of the process of the activity:* In cases of learning activities structured in a number of phases, it is often needed to organise and manage the process of such an activity. University students, in a context of forum discussion during three months, reported that some indicators (e.g. the "Relative Activity indicator", -Figure 5.b-, or the "Time Read

[2] The SNA diagram is based on two indicators "Network Density" and "Centralisation"; however a common user can easily distinguish by the corresponding graph (see Figure 7) for instance: the members of a group that are isolated, from the members that interact with others, undertaking even a central role in the network.

Indicator" -Figure 8.a-Bratitsis & Dimitracopoulou 2006) helped them to identify periods of a participation peak, while in other cases to identify the end and/or the beginning of effective phases; instances that could lead them to decide when and how to act




(a) Indicator « Time Read messages »    (b) Indicator «User Classification»

**Figure 8[3].** *IA tool « DIAS »: Examples of composite indicators (Bratitsis & Dimitracopoulou, 2006 ; 2008)*

(II) *IA tools usages by teachers or moderators and decision making effects*

*(a) Decisions on the moderation tactics to undertake.*

Forum moderators inspect regularly the indicators related to the 'branches' of the discussion trees, so as to intervene if necessary in order to assure a minimum number of discussion depth for some discussion questions, in a case of distance course in university (Gerosa et al. 2005) (Figure 9). In a similar way, when in the example of forum moderation, the categorisation of

[3] (a) "*Time Read Messages*" indicator of DIAS IA tool: 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.

(b) "*User Classification*" indicator of DIAS IA tool: the X-Axis represent the amount of contribution (messages written as a percentage of the total number of messages) and the Y-Axis represent 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.

types of messages is activated, the corresponding indicators seem to help the moderator to have a quick look at the process of discussion. For example, if a discussion ‘branch’ include only “argumentation” messages without ‘confrontation’ ones (situation not favourable in the practice of argumentation process), he/she intervenes (Bratitsis & Dimitracopoulou, 2008)..

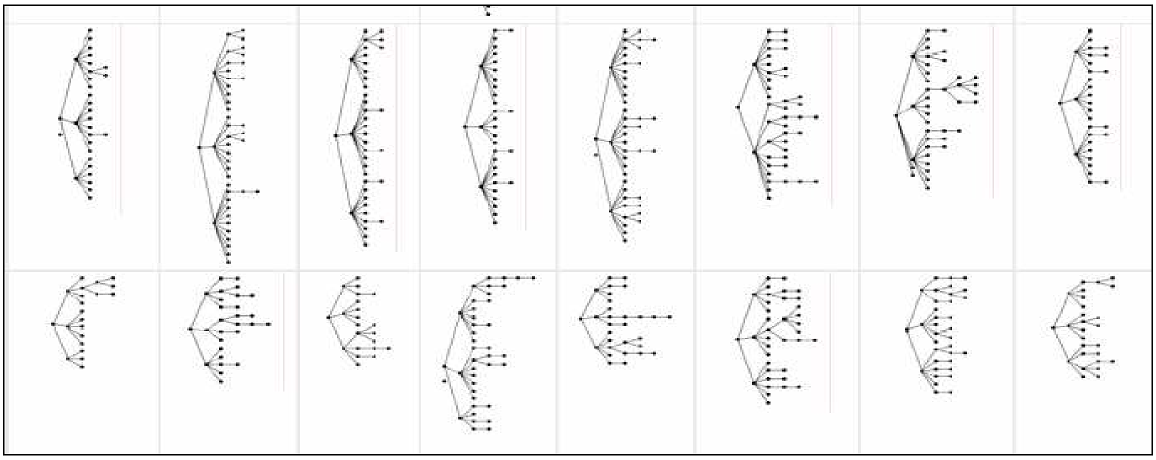


**Figure 9.** *The indicator « Discussion Depth» represented by discussion branches in different periods of time, related to a forum of a distance university course (Gerosa et al., 2005)*

A set of complementary indicators seem to help the moderators to identify individuals that try to appear active or very active without a significant contribution; in fact trying to cheat the IA tool (Chen & Vassileva, 2003; Bratitsis & Dimitracopoulou, 2006). Similarly, the moderator can identify students that act only at the end, without being active during the whole process (Gerosa et al. 2005), (Bratitsis & Dimitracopoulou, 2008) (for instance via the “Time Read” Indicator, Figure 8.a). Furthermore, moderators are usually involved in managing the process of activity, including the group formation, the coordination, etc. So, inspecting quickly the indicators, they can also identify students who take initiatives and have high quality of participation, so as to designate them for undertaking the role of coordinator during a phase (for instance to prepare and propose a summary, or a synthesis of points of views) using among others high interpretative value indicators such as “User Classification Indicator” (Figure 8.b) (Bratitsis, & Dimitracopoulou, 2006).

*(b) Evaluation of their students*

The evaluation, in principle, could be applied either in individual or group level. Concerning the summative individual evaluation there are not yet tools that could support it completely, while researchers work intensively towards this direction (Hamilton & Hurford, 2007). Partial support we can see in the context of a distance university (Gerosa et al. 2004). Another example of partial evaluation (regarding collaboration quality of an individual) we can see in the work of Barros & Verdejo, 2000), provided by a high level indicator called "collaboration quality". In fact, the main actual purpose of IA tools is to provide to teachers synthetic view(s) of the interaction and the activity, where they can get, at a glance, an appreciation of the situation of an individual or of a whole group.

*(c) Selfregulation of teachers or moderators strategies and tactics*

Concerning the self-regulation of teachers/moderators strategies or tactics, it is useful to distinguish two situations. The selfregulation that may occur during the evolution of the learning activity (in fact on-line) and the one that could evolve afterwards (e.g. offline). For instance, in the case of synchronous collaboration, where a moderator or teacher intervenes, the available indicators seem to help him/her to supervise the activity and in the same time to choose an alternative intervention, when observed that the previous one was unsuccessful (e.g. leading in an impasse), (Petrou, 2005) After an activity phase (of a session or even a week), research has captured instances where teachers have identified that their mode of intervention was for instance very directive, or in contrary, that there was a lack of intervention and so to reflect and express the need to regulate it, in a next phase.

## RESEARCH ROADMAP

During the last three decades, while the field of Information and Communication Technologies in Education made significant progress, the corresponding scientific community has focused on the design, the evaluation and the implementation of technology based learning environments as well as on the understanding of the learning processes. The new research direction on IA for the support of selfregulation, proposes that the design of learning environments should not be limited to the basic means of action and communication. It should also include the means of analysis of very complex interaction that occur, when the students act in individualised (stand alone) or in a social mode. These means of analysis and the corresponding new functions are necessary, for allowing the participants to regain partly the control of the activity, while being supported in their mental operations of metacognitive processes, regarding the evaluation and selfregulation of their own activity. On the other hand, observers of these activities should attain the means for observing, understanding and interpreting the processes that take place.

The consequences of this new research direction and the innovation that is introduced require that the designers of technology based learning environments conceive from the outset of design process, the appropriate functionalities, the IA components or even better, the related independent IA tools, able to offer the necessary support.

It should be noted that the direction of research on IA support for selfregulation is actually in an emerging state. In order to reach its promises, the researchers working on this area, as well as the new researchers attracted by the presenting interest, have to work on a series of underlying research dimensions: (a) The Design of IA Indicators and IA tools; (b) the Development of IA tools, (c) The Investigation around the usage of these tools by the users and the effects that may be brought about. Subsequently, the main aspects of the underlying research will be indicated and discussed in regard to these three main dimensions.

*(A) Design of IA tools*

A central feature of an IA tool is the IA indicators that it produces and their *power* regarding their interpretation value. There is a need to produce appropriate and significant IA indicators, and in order for this to take place, researchers have to work in a profound way on the underlying aspects.

First of all, there is a lot to do, in order to produce: cognitive indicators that analyse in a sophisticated way both the process and the products of the activity (the last one need to progress in the area of automatic content analysis); indicators of social nature, where researchers have to work more so as to make emerge and represent the aspects of group cognition processes; indicators of affective nature that must be explored in a more systematic way, during the next years (Dimitracopoulou, 2008). Moreover, it is important to bear in mind that there might be a significant difference, among the indicators that we calculate, with respect to those that have a pedagogical or psychological significance, and to those that are in fact capable of activating metacognitive processes to the participants in technology based learning activities. These three perspectives are not necessarily identical.

Finally, a determinant aspect is that of visualisations. When these visualisations simultaneously incorporate a number of indicators, could allow perceiving at a glance a global figure of the interaction. In addition, the usage of metaphors for representing the values of indicators can offer a significant frame for the simultaneous representation of calibrated values of multiple indicators.

Concluding, the conception of tools offering a model of interaction of a significant level of ‘expressiveness’ is imperative. This entails that models should be appropriate for activating metacognitive processes. The indicators involved should, at the same time, correspond to multiple points of view on the interaction data (regarding various individuals and groups). They should also be calibrated (according to the specific learning situation, pupils, and context) and visualised in a powerful mode.

*(B) IA tools Development*

According to the previous discussion regarding the ‘status’ of the current IA tools, actually, there are mainly some basic functions of automated interaction analysis included into the learning environments, as well as some components linked to specific learning environments. An idea that could help to diffuse rapidly the usage of IA tools for the support of selfregulation, could be to develop IA tools independent from specific learning environments. In fact, we could turn our attention to the design and development of IA tools, that are appropriate to the various categories of learning environments (e.g. for forum, modelling environments, simulations, etc). However these independent IA tools, would have to satisfy, simultaneously, two requirements: (a) *be interoperable,* which means that they would be connected to a wide range of learning environments; (b) *be customisable,* which means that they will allow their users to choose the sets of IA indicators, most appropriate to a specific learning situation.

With the aim of developing interoperable tools, groups of researchers have started to define formats of standardised data, for different collaborative and social environments (Harrer et al. 2007; Harrer, Martinez-Mones, Dimitracopoulou, in press).

*(C) Investigations oriented to the Users of IA tools*

It deserves to be stressed that not only the design and development, but also the usage of IA tools is actually recorded and can be announced. However, it is obvious that researchers have to work, as has already pointed out, on a more sophisticated level. We should also study the effects of these new functionalities offered by the automated IA. After the first period of superficial experimentations, we should now distinguish between two central axes of investigation focusing on the users of these IA tools, which need to address the following: (a) The identification of the 'requirements', specified by the users themselves, on the design of IA tools; (b) The study of the effects of the usage of IA tools by the various intended users. What follows is a brief discussion of these two axes.

(a) The *identification of the users' specifications, on the design of IA tools*: it is about knowing and taking into account the users of the IA tools, and studying the visibility and the readability of the included visualisations.

⇨ First of all, what is needed is to *better know and take into account the users*: Identify their needs and interests (i.e. which IA indicators they need, which types of usage they wish to have during the various learning situations and settings). Taking into account the profile and the role of each user, the type of activity as well as the application context, different sets of indicators or different visualisation modalities of the same indicators could be less or even more appropriate, to those users.

⇨ There is also a need to know *how the users decode the visualisations produced by the IA tools*. There are very few studies that have identified whether and how the users decode the information underlying the diagrams of indicators' variation. *Are the users able to decode the information that the designer had in mind? Do they decode all the information or just a part of it? Moreover, what is the meaning of the indicator concept according to the users?* What is needed in particular is the identification of eventual gaps between the intentions of the designers and the interpretations of the users themselves.

b) *The study of the effects of IA tools usages*: There is a series of underlying investigation questions:

⇨ *How do the users use the IA tools? When do they use them?* We need to have more data from natural contexts of usage, taking also into account the dominant culture. *Is there a culture propitious for self-evaluation? Is there a culture propitious for the respect of common deontological and ethical rules, assuring an appropriate (and not disguised) usage of IA tools?*

⇨ *What are the effects of the usages of IA tools? Do they affect the learning process? Do they affect the process of monitoring or teaching? Do they actually support the process of reflection and self-evaluation? Do they actually help the users to develop self-regulation competences?* What is needed is to study in a more profound way the modes by which the IA indicators influence the reasoning and the behaviour of the users (for instance, via direct observations, as well as interviews during or just after the functioning). These effects have also to be studied in longitudinal way and not only in one or two sessions.

## CONCLUDING STATEMENTS

In this paper we argue that *the design of a technology based learning Environment must concern not only the components and the functions determining how to act, but also those supporting how to manage the actions and the interactions; thus, insight into how to empower participants to control, regulate and self-regulate their own activity*, designing and developing in this way enriched learning environments. Finally, what is proposed is that *every high interactive learning environment has to be linked with an IA component or tool*.

The IA for self-regulation research direction is still at an early phase of development, nevertheless presents an impressively intensive growth. Its potential is attributed to the fact that even simple IA tools could be effective.

It is to be noted that these new requirements can be taken into account by the designers in a complementary mode with the two other pre-existing automated interaction analysis approaches: the one of adaptation of the learning environment itself (*see adaptive systems*) and that of students or even teachers' guidance by the system, via the application of artificial intelligent techniques. In fact, researchers could design future systems, where the IA tools could be addressed, simultaneously, to *multiple human and artificial users*: We could imagine more complete learning environments, where the IA tool could be used in the same time, by the student, the teacher, as well as the system. The human and artificial users of IA tool could take up complementary roles, while the control of the activity is distributed to all the involved actors. For instance, the students are supported by awareness functions, able to activate metacognitive and selfregulating operations; the teachers being supported by supervision and moderation functions; while the system is supported by functions of intelligent help and adaptation (figure 10).

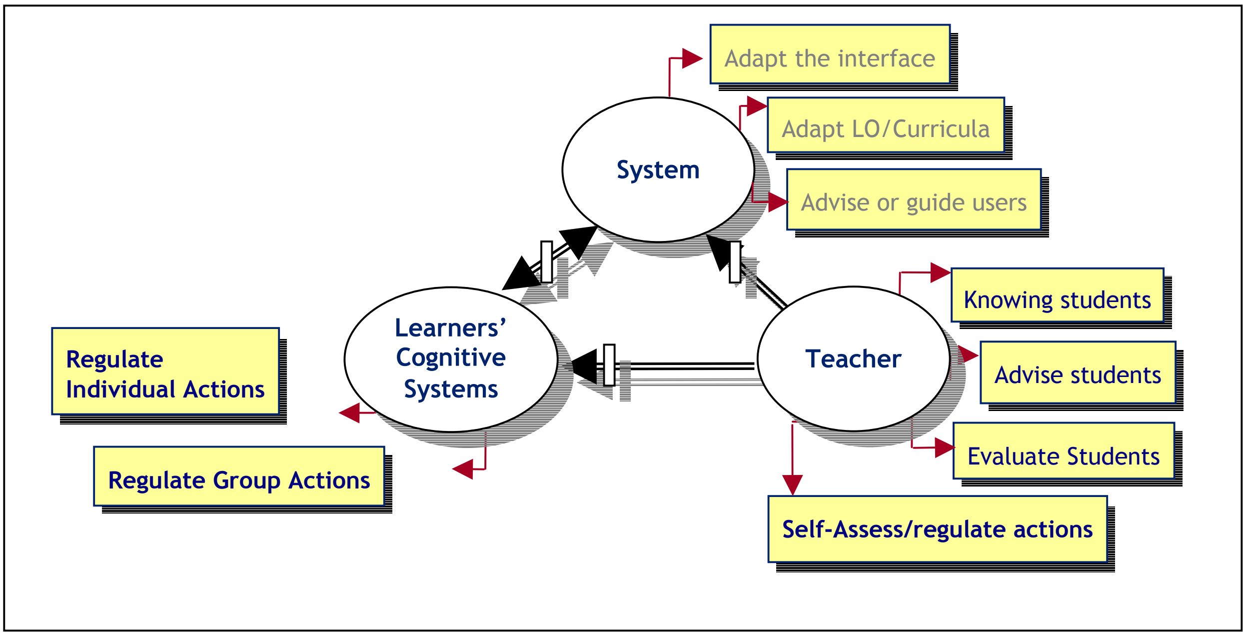



**Figure 10**. *Vision of locus of activity control distributed to all actors (humans and artificials)*

**REFERENCES**

Barros B., & Verdejo F. M. (2000). Analyzing student interaction processes in order to improve collaboration. The DEGREE approach, *International Journal of Artificial Intelligence in Education*, 11, 221-241.

Bratitsis T. & Dimitracopoulou A. (2006). Indicators for measuring quality in asynchronous discussion forums. International Conference on *Cognition and Exploratory Learning in Digital Era* (CELDA2006), IADIS (International Association for Development of the Information Society) 8-10 December, 2006, Barcelona, Spain.

Bratitsis T. & Dimitracopoulou A. (2008). Monitoring and Analysing Group Interactions in Asynchronous Discussions with DIAS system, Special Issue, *International Journal of e-Collaboration ( IJeC).* Vol. 4, No 1. January-March 2008. IGI Publishing. pp.20-40.

Cheng R., Vassileva J. (2005). Adaptive rewarding mechanism for sustainable online learning community. *Artificial Intelligence in Education.* 2005, C.-K. Looi et al. (Eds). IOS Press.

De Groot, R., Drachman, R., Hever, R., Schwarz, B., Hoppe, U., Harrer A., De Laat, A. Wegerif, R., McLaren, B., and Baurens, B. (2007). Computer Supported Moderation of E-Discussions: the ARGUNAUT Approach. In C. Chinn, G. Erkens, S. Puntambekar, (Eds). Proceedings of the *International Congress CSCL 2007: Computer Supported Collaborative Learning, Mice, Minds and Society*, July 21-26, 2007, Rutgers, The State University of New Jersey, USA. ISLS Inc. pp. 165-167

Dillenbourg P., Ott D., Wehrle T., Bourquin Y., Jermann P., Corti D., Salo P. (2002). The socio-cognitive functions of community mirrors. In F. Fluckiger, C. Jutz, P. Schulz and L. Cantoni (eds). *Proceedings of the 4th International Conference on New Educational Environments*. Lugano, May 8-11, 2002.

Dimitracopoulou A. (2008). Analyse Automatique des Interactions pour le Support a l'Auto-régulation des Participants dans des Activités Mediées. In J-C Marty & A. Mille (Eds). *Observer pour Personnaliser les Environnements Informatiques pour l'Apprentissage Humaine*. Editions Hermes.

Dimitracopoulou, A. Bruillard, É. (2006). Enrichir les interfaces de forums par la visualisation d'analyses automatiques des interactions et du contenu, *Revue STICEF*, Volume 13, 2006, ISSN : 1764-7223.

Dimitracopoulou A. *et al.* (2005). *State of the Art on Interaction Analysis for Metacognitive Support and Diagnosis.* Report JEIRP. D.31.1.1, Kaleidoscope Network of Excellence, Retrieved April 2008, www.noe-kaleidoscope.org. p. 6-62.

Dimitracopoulou, A. & Komis, V. (2005). 'Design principles for an open environment supporting education actors during modelling, collaboration and learning' In C. Constantinou, Z. Zacharias & P. Kommers (Guest Editors), Special Issue on the "Role of Information and Communication Technologies in Science Teaching and Learning. *Int. J. Continuing Engineering Education and Lifelong Learning, Vol, 15, No 1-2, 2005, pp.35-55*

Hamilton & Hurford, (2007). Assessment of Group and Individual Learning through Intelligent Visualisation. Workshop Proceedings, *13th International Conference of Artificial Intelligence in Education.*, Martina del Rey, CA. USA, July 2007.

Fesakis G., Petrou A., Dimitracopoulou A., (2004). Collaboration Activity Function: An interaction analysis tool for Computer Supported Collaborative Learning activities, In *4th IEEE International Conference on Advanced Learning Technologies* (ICALT 2004), August 30 - Sept 1, 2004, Joensuu, Finland.

Gerosa M. A., Pimentel M. G., Fuks H., Lucena C. (2004). Analyzing Discourse Structure to Coordinate Educational Forums. Intelligent Tutoring Systems. *7th International Conference, ITS 2004*. Berlin Heilderberg: Springer, p. 262-272.

Gerosa M. A., Pimentel M. G., Fuks H., Lucena C. (2005). No need to read messages right now: helping mediators to steer educational forums using statistical and visual information. In T.

Koschmann, D. Suthers, T.-W.Chan (eds), Proceedings of *Computer Supported Collaborative Learning 2005: The Next Ten Years!* Taipei, May 30-June 4, 2005, Taiwan, ISLS.

Harrer, A., Zeini S., Kahrimanis G., Avouris N., Marcos J.A. Martinez-Mones A., Maier A., Rummel N., Spada H. (2007). Towards a flexible model for computer based analysis and visualisation of collaborative learning activities. In C. Chinn, G. Erkens, S. Puntambekar, (Eds). Proceedings of the International Congress CSCL 2007: Computer Supported Collaborative Learning, Mice, Minds and Society, July 21-26, 2007, Rutgers, The State University of New Jersey, USA. ISLS Inc. pp. 280-282

Harrer, A., Martinez-Mones A., Dimitracopoulou A. (2008). Users' Data : Collaborative and Social Analysis. T. De Jong, N. Balacheff, S., Ludvigsen, S.Barnes, Lazonder A. (Eds). *Technology Enhanced Learning*, Kaleidoscope NoE., Springer

Hlapanis, G., Dimitracopoulou A. (2007) A School-Teachers' Learning Community: Matters of Communication Analysis, (Guest Editors) P. Kirschner & K.-W. Lai, Special Issue on Online Communities of Practice in Education, *Journal of Technology, Pedagogy, and Education*, Volume 16, Issue 1.

Jermann P. (2004). *Computer Support for Interaction Regulation in Collaborative Problem Solving*, PhD Thesis, University of Geneva.

Kay J., Yacef K., & Reimann P. (2007). Visualisations for Team Learning: Small Teams Working on Long-term Projects, In C. Chinn, G. Erkens, S. Puntambekar, (Eds). Proceedings of the International Congress CSCL 2007: Computer Supported Collaborative Learning, Mice, Minds and Society, July 21-26, 2007, Rutgers, The State University of New Jersey, USA. ISLS Inc. pp. 351-353

Marcos J.A., Martinez-Mones A., Dimitriadis Y. (2004). The role of roles in the analysis of interactions on collaborative environments, *European Conference on Artificial Intelligence (ECAI 2004),* Workshop on Artificial Intelligence in Computer Supported Collaborative Learning, Valencia, Agosto.

Mochizuki T., Kato H., Hisamatsu S., Yaehashi K., Fuzitani S., Nagata T., Nakahara J., Nishomori T., Suzuki M. (2005). Promotion of Self-Assessment for Learners in Online Discussion Using the Visualization Software. In T. Koschmann, D. Suthers, T.-W.Chan (eds), Proceedings of *Computer Supported Collaborative Learning 2005: The Next Ten Years!* Taipei, May 30-June 4, 2005, Taiwan, ISLS.

Nakahara J., Kazaru Y., Shinichi H., Yamauchi Y. (2005). iTree: Does the mobile phone encourage learners to be more involved in collaborative learning? In (Eds) T. Koschmann, D. Suthers, T.-W.Chan, Proceedings of *Computer Supported Collaborative Learning 2005: The Next Ten Years!* Taipei, May 30-June 4, 2005, Taiwan, ISLS.

Petrou A. & Dimitracopoulou A. (2003). Is synchronous computer mediated collaborative problem solving 'justified' only when by distance? Teachers' point of views and interventions with co-located groups during every day class activities. In B.Wasson, S.Ludvigsen, & U. Hoppe (eds), Proceedings of *Computer Supported Collaborative Learning 2003: Designing for Change in Networked Learning Environments,* 2003. Kluwer Academic Publishers.

Petrou, A. (2005). *Teachers' roles and strategies during educational exploitation of collaborative learning, being supported by appropriate computational environments*. PhD Thesis, School of Humanities, University of the Aegean, Greece.

Reimann P. (2003). How to support groups in learning: More than problem solving. (keynote talk) in Aleven et al. (ed.), *Artificial Intelligence in Education (AIED 2003).* Supplementary Proceedings Sydney: University of Sydney, p. 3-16.

Reyes P., Tchounikine P. (2005). Mining learning groups' activities in Forum-type tools. In T. Koschmann, D. Suthers, T.-W.Chan (eds), Proceedings of *Computer Supported Collaborative Learning 2005: The Next Ten Years!* May 30-June 4, 2005, Taiwan, ISLS.

Teplovs, C., Donoahue, Z., Scardamalia, M., & Philip D. (2007). Tools for Concurrent, Embedded, and Transformative Assessment of Knowledge Building Processes and Progress In C. Chinn, G. Erkens, S. Puntambekar, (Eds). *Proceedings of the International Congress CSCL 2007:*

*Computer Supported Collaborative Learning, Mice, Minds and Society*, July 21-26, 2007, Rutgers, The State University of New Jersey, USA. ISLS Inc. pp.720-722

Vassileva J., Cheng R., Sun L., Han W. (2004). Designing Mechanisms to Stimulate Contributions in Collaborative Systems for Sharing Course-Related Materials, *ITS 2004, Workshop on Computational Models of Collaborative Learning.* Maceio, Alagoas, Brazil, August 30 - September 3, 2004.

Zumbach J., Schonemann J., Reimann P. (2005). Analyzing and Supporting Collaboration in Cooperative Computer-Mediated Communication. In T. Koschmann, D. Suthers, & T. W. Chan (Eds.), *Computer Supported Collaborative Learning 2005: The Next 10 Years!* (pp. 758-767). Mahwah, NJ: Lawrence Erlbaum.