Logging of fingertip actions is not enough for analysis of learning activities

Nikolaos AVOURIS, Vassilis KOMIS, Georgios FIOTAKIS,
Meletis MARGARITIS and Eleni VOYIATZAKI
Human-Computer Interaction Group, E&CE Dept.,
University of Patras, GR-26500 Rio Patras, Greece

Abstract. In this paper we discuss key requirements for collecting behavioral data concerning technology supported learning activities. It is argued that the common practice of collecting machine generated logfiles of user actions is not enough for building a thorough view of the activity. Instead more contextual information is needed to be captured in heterogeneous media like video, audio files, snapshots, etc in order to re-construct the learning process. A software environment (Collaborative Analysis Tool ColAT) that supports inter-relation of such resources in order to analyse the collected evidence and produce interpretative views of the activity is described.

1. Introduction

Collection of usage data by registering users' operations in the form of logfiles has become mundane during technology supported learning activities these days. Many researchers assume that cognitive processes can, in principle, be inferred from studying and comparing this recorded behavior. Logfile analysis can be used when the purpose is to infer the cognitive processes of persons who interact with learning tools. Subsequent analysis can then be performed in a number of ways, for example by examining the frequency with which different operations are carried out or by focusing on the sequence in which operations occur [1]. Analysis of a learning activity is important for understanding the complex process involved, improve effectiveness of collaborative learning approaches and can be used as a reflection-support mechanism for the actors involved.

Tools to support interaction and collaboration analysis have been proposed in the field of learning technology design and human-computer interaction [2]. In the education field, analysis of collaboration and interaction between the actors (students, tutors etc.), the artefacts and the environment is a process that can support understanding of learning, evaluate the educational result and support design of effective technology [3].

In this paper we describe first the typical characteristics of Synergo, a tool that records users' operations and then supports their analysis during the activity and off line. In the second part of the paper, we argue further that while this approach is useful, more contextual information is needed to be interrelated to the logfiles. So an innovative analysis tool (ColAT) is presented that can be used for effective analysis of interrelated data that may be collected during technology supported learning activities.

2. Logfile-based analysis of learning activities

In this section, we describe the functionality of a typical environment for analysis of group learning, called Synergo (www.synergo.gr), associated to a synchronous collaboration-support environment, which permits direct communication and problem solving activity of a group of distant students, manipulating a shared graphical representation [4]. Synergo incorporates tools for analysis of usage logfiles. Through them the researcher can playback the recorded activity off-line and annotate the produced solution, while various indices and views of the logfiles can be produced.

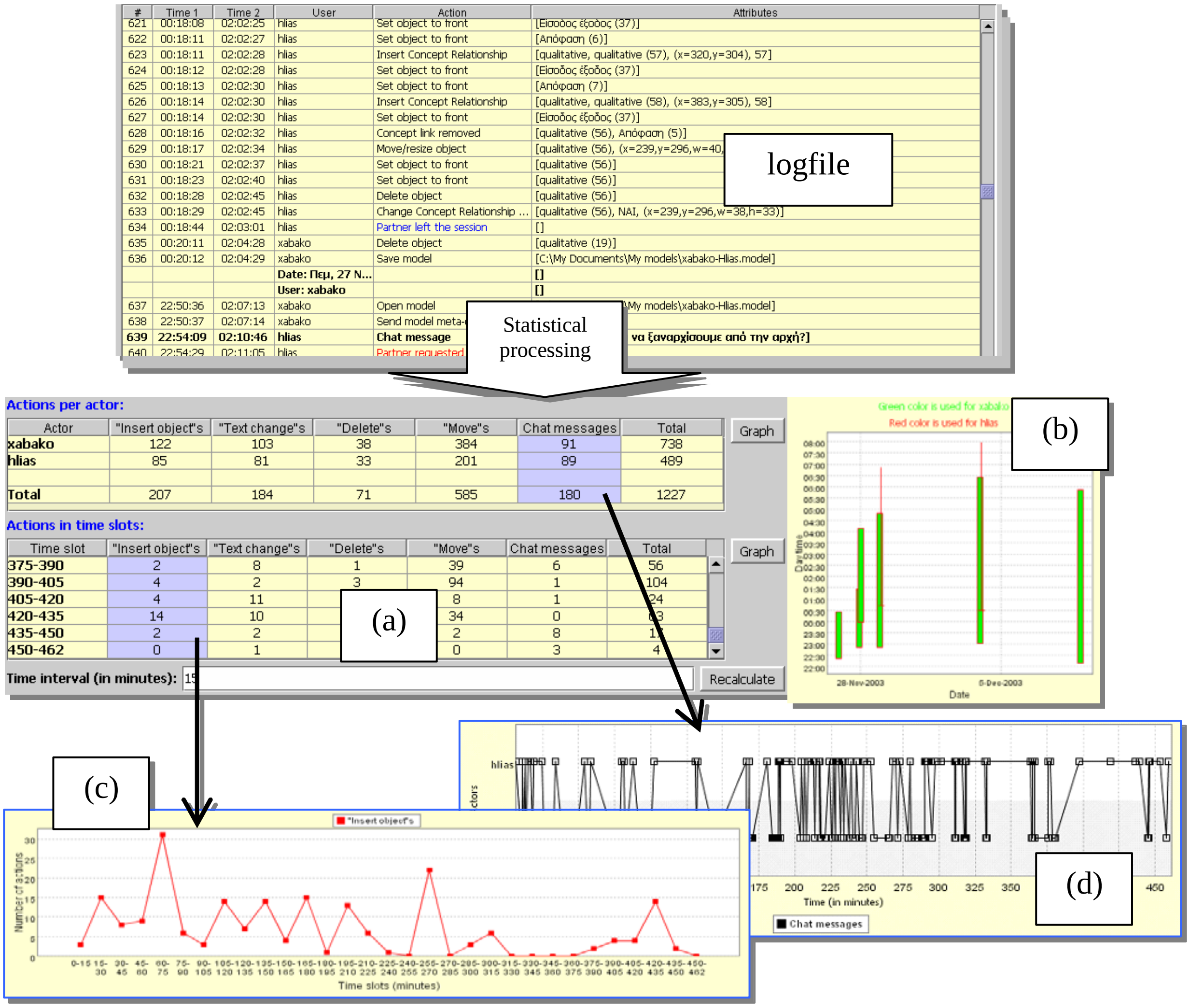

Figure 1. Snapshots from the Synergo analysis environment: The logfile (top of the picture) is used for producing statistical measures across various dimensions (type of event, time slot, actor), shown in (a). Also the extended of group sessions over time are shown in (b), while in (c) and (d) the statistical measures of (a) are drawn vs time.

In a typical synchronous collaborative learning situation in which Synergo is used, two or more actors, supported by networked equipment, collaborate at a distance by communicating directly and by acting in a shared activity board. A graphic representation of a solution to a given problem may appear in this shared board. This activity is typically monitored through logging of the main events of the actors in the shared activity board and of the dialogue events in text form. The Synergo analysis tool is used for presentation and processing mainly of the logfiles, produced during collaborative learning activities. These logfiles (see an example at the top of fig.1) contain time-stamped events, which concern actions and exchanged text messages of partners engaged in the activity, in sequential order. These events have the typical structure <time-stamp>, <actor>, <event-type>, <attributes>, <comments>.

The <event type> attribute categorizes the recorded event. This categorization can be done by interpreting one by one the logfile events manually. The Synergo environment facilitates this tedious process, by allowing association of the events, automatically generated by the software, to classes of annotations. So for instance, all the events of type "Modification of textual description of concepts" in a concept-mapping tool are associated to the "*Modification*" type. So statistics and visual views concerning the activity can be automatically generated. For instance in figure 1 some of the views automatically generated by the Synergo analysis environment can be seen. This is an extract from a logfile that was generated by a pair of two students of a distance learning course who interacted for over 7 hours (462 minutes of interaction spread in 8 sessions). In fig. 1(a) the recorded events are grouped by user and type of event in the top table and by time interval and type of event in the second. The analyst can observe the value of various indexes, like the number of events of type "insert new object in the activity space" per time interval, shown in fig 1(c), or an interaction diagram indicating the activity per partner of a specific type of event, like chat messages between two partners in fig 1(d). Finally other views relate to length of sessions in fig 1(b). These representations can have some value for a trained analyst or teacher, or they can be used as self-awareness mechanisms for students as they can be presented to them during collaborative activities.

Not all recorded events however can be automatically annotated in this way, while important events are not captured at all by the logfile as they do not occur as a result of user-tool interaction (i.e. user fingertips activity). For instance, face to face dialogues have to be captured through other media, and interpreted by the analyst and after establishing their meaning and intention of the interlocutor, to be annotated accordingly. There are various ways of interaction, for instance, a suggestion of a student on modification of part of the solution can be done either through verbal interaction or through direct manipulation of the objects concerned in the shared activity board. Additional more complex indices may be generated, like the graph of evolution of the Collaboration Factor (CF), discussed in [4], the Collaboration Activity Factor suggested in [5], etc.

3. Interrelation of the logfile to other observational data

It should be observed that a typical logfile, like the one discussed in section 2, takes usually the form of an ordered list of events occurred at the user interface of a software tool. It contains a record of the activity of one or more learning actors, from the rather restrictive point of view of their fingertip actions. However a lot of contextual information relating to the activity, as well as results of the activity in print or other forms, dialogues among the actors, etc., are not captured through this medium. So in this section we present an analysis environment that permits integration of multiple media collected during learning activities. In section 3.1 we present examples of studies in which crucial role was played by these additional media.

The *Collaboration Analysis Tool (ColAT)* is the environment that is used for building an interpretative model of the activity in the form of a multilevel structure, following an Activity Theory approach [6], incorporating pointers and viewers of various media. ColAT permits fusion of multiple data by interrelating them through the concept of universal activity time. The analysis process during this phase, involves interpretation and annotation of the collected data, which takes the form of a multilevel description of the activity.

The ColAT tool, discussed in more detail in [7], uses the form of a theatre's scene, in which one can observe the activity by following the plot from various standpoints. The *Operations view* permits study of the details of action and interaction, as recorded by a logfile, while other media like most typically video and audio recordings, capture dialogues, other behavioural data of actors (posture, gestures, facial expressions etc.), while media like screen snapshots, PDF files etc record intermediate or final outcomes of the activity. The automatically generated logfile can be expanded in two ways:

- First by introducing additional events as they are found in the video and other media, and by associating comments and static files (results, screen snapshots etc.) to specific time stamped events.

- Second, more abstract interpretative views of the activity may be produced: the *Actions-view* permits study of purposeful chunks of action, while the *Activity view* studies the activity at the strategic and motivational level, where most probably decisions on collaboration and interleaving of various activities are more clearly depicted.

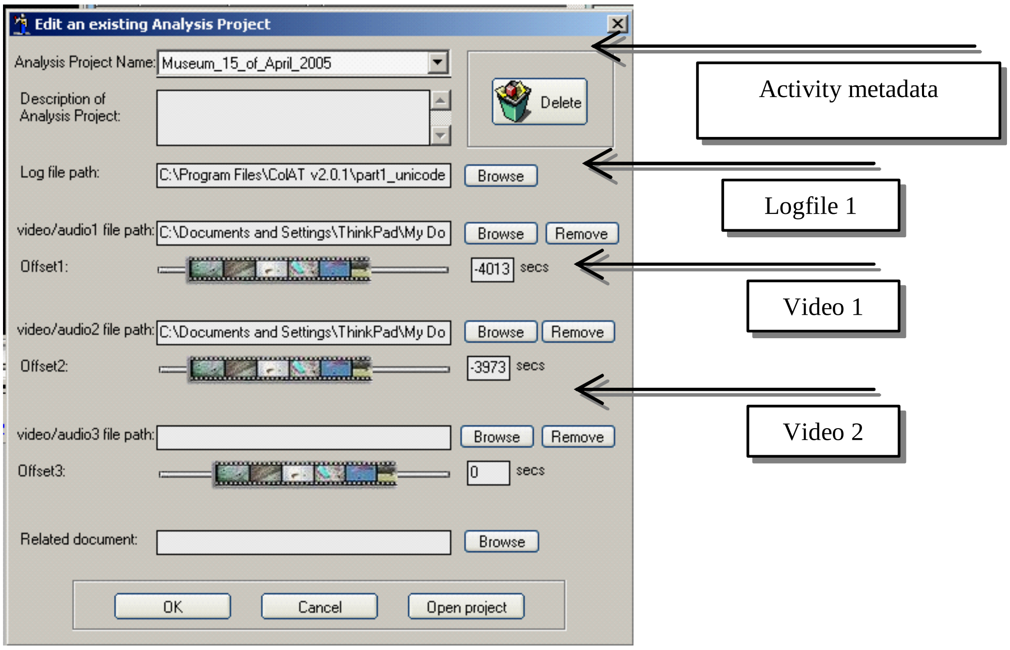

Figure 2. The ColAT environment: Project definition in which multiple logfiles and video/audio sources are synchronized by defining their corresponding offsets.

This three-level model is built gradually: the first level, the *Operations level*, is directly associated to log files of the main events, produced and annotated, and is related through the time stamps to the media like video. The second level describes *Actions* at the actor or group level, while the third level is concerned with *motives* of either individual actors or the group.
In fig. 3 the typical environment of the ColAT tool for creation and navigation of a multi-level annotation and the associated media is shown. The three-level model is shown on the right side of the screen, while the video/audio window is shown on the left-hand side. Other features shown in fig.3 include a toolbox for defining viewer filters, through which a subset of the activity can be presented, related to specific *actors*, *tools* or *types of events*.
The original sequence of events contained in the logfile is shown as level 1 (*Operations level*) of this multilevel model. The format of events of this level in XML, is that produced by Synergo, ModellingSpace, CollaborativeMuseumActivity and other tools that adhere to this data interchange format, while definition of a common format that includes requirements of other learning tools logfiles, like those generated by CoolModes [12, 13] is in progress. Thus the output of these environments can feed into ColAT, as first level structure. A number of such events can be associated to an entry at the *Actions level 2*. Such an entry can have the following structure: <ID, time-span, entry_type, actor(s), comment > where ID is a unique identity of the Action, time-span is the period of time during which the action took place, type is a classification of the entry according to a typology, defined by the researcher, followed by the actor or actors that participated in the execution, a textual comment or attributes that are relevant to this type of action entry. Examples of entries of this level are:" Actor X inserts a link ", or "Actor Y contests the statement of Actor Z".

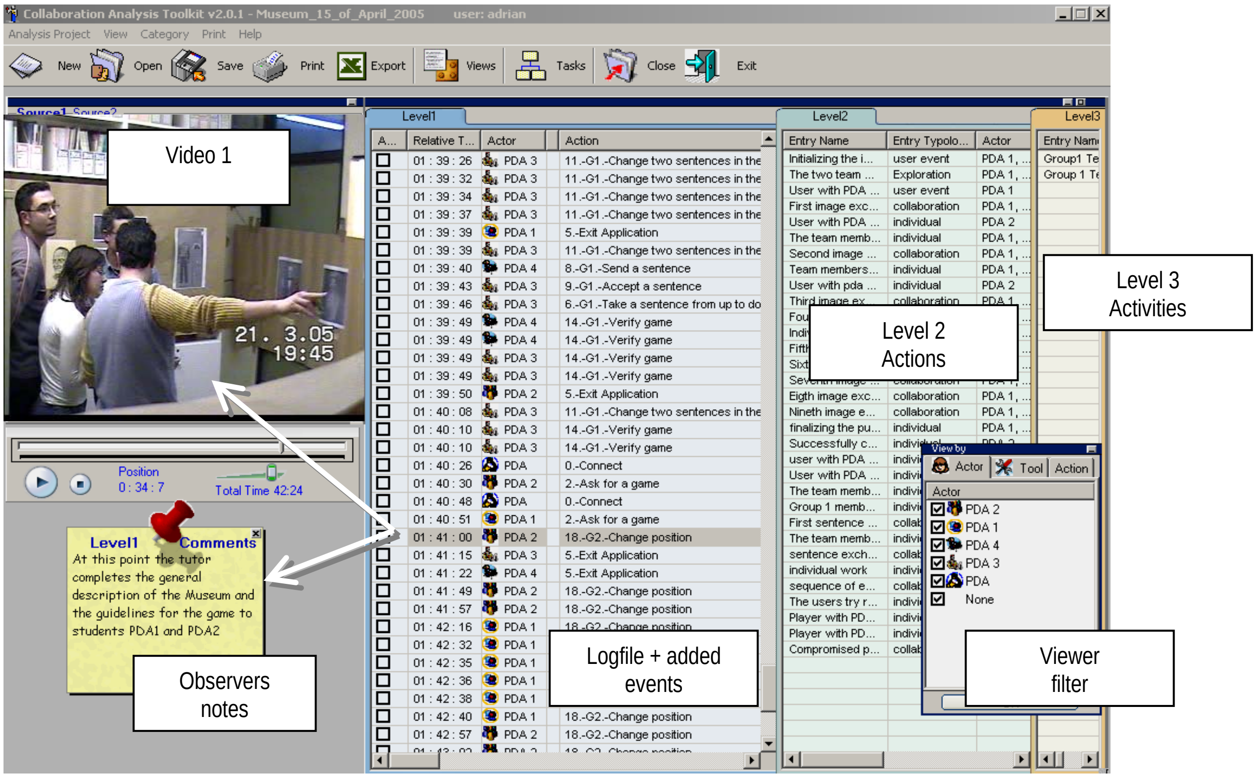

Figure 3. The ColAT environment: Multi-level view of problem solving activity

In a similar manner, the entries of the third level (*Activity level*) are also created. These are associated to entries of the previous *Actions level 2*. The entries of this level describe the activity at the strategy level as a sequence of interrelated goals of the actors involved or jointly decided. This is an appropriate level for description of plans, from which coordinated and collaborative activity patterns may emerge. In each of these three levels, a different typology for annotation of the entries may be defined. This may relate to the domain of observed activity or the analysis framework used. For entries of level 1 the OCAF typology [8] has been used, while for the action and activity level different annotations have been proposed. In figure 4 the dialogues for definition of annotation scheme for actions and identity of actors in ColAT is shown.

The various media, like video or audio, that can be associated to logged events through ColAT can be played from any level of this multi-level model of the activity. As a result, the analyst can decide to view the activity from any level of abstraction he/she wishes, i.e. to play back the activity by driving a video stream from the *operations*, *actions* or the *activity* level. This way the developed model of the activity is directly related to the observed field events, or their interpretation.

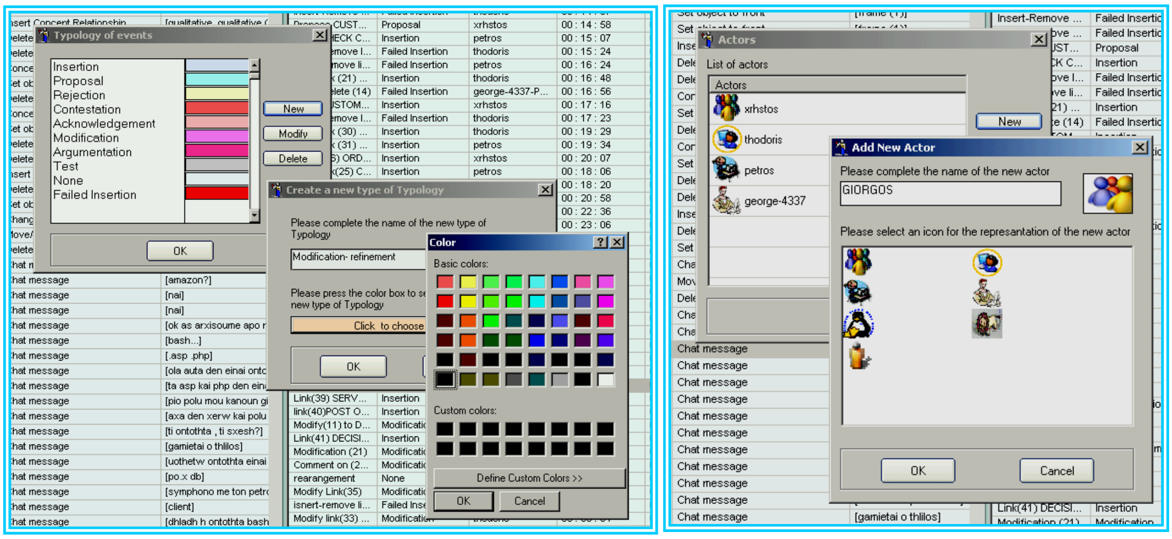

Figure 4. Definition of (a) typology of actions including the scheme that relates each type of event to a specific color code and (b) identity of actors that relates an avatar to each specific actor in ColAT

Other media, like still snapshots of the activity or of a solution built for a given problem, may also be associated to this multilevel model. Any such image may be associated through a timestamp to a point in time, or a time interval, for which this image is valid. Any time the analyst requests playback of relevant sequence of events, the still images appear in the relative window. This facility may be used to show the environment of various distributed users during collaboration, tools and other artefacts used, etc. Also observer comments related to events can be inserted and shown in the relevant window, as shown in the SW corner of fig.3.

The possibility of viewing a process using various media (video, audio, text, logfiles, still images), from various levels of abstraction (operation, action, activity), is an innovative approach. It combines in a single environment the hierarchical analysis of a collaborative activity, as proposed by Activity Theory, to the sequential character of ethnographic data.

3.1 Validation studies

The discussed tools have been used in a number of studies that involved effective analysis of collected evidence of technology supported learning activities in various forms. For instance in the study reported in [9] data were collected of groups of students interacting through the *ModelsCreator3* environment. Interaction between distant group members was affected through a chat tool and between the group members that were located in front of the same workstation through direct conversation. The first was captured through the ModelsCreator3 logfile that conforms to the ColAT format, while the latter through audio recording. By associating the two data sources, valuable information on comparison of the content of interaction that was done through the network and the dialogues of the group members was performed.

In [10] a study is discussed of activities that took place in a computer lab of a high school, using *Synergo*. The logfiles of Synergo were analysed along with contextual information in the form of video recording of the classroom during the activity and with observers' notes. These where interrelated and through this the verbal interventions of the tutor where identified and the effect of these on the students problem solving process was studied.

In Komis et al. [11] evaluation of the effectiveness of the concept mapping environment *Representation2* in the educational process is discussed according to various dimensions, like group synthesis, task control, content of communication, roles of the students and the effect of the tools used. In these studies, various features of the presented here analysis tools have been

used. First tools have been used for playback and annotation of the activity, while statistics and estimation of the collaboration factor have been produced. Subsequently, the produced video and sequences of still images, along with the logfiles of the studies were inserted in the ColAT environment through which the goal structures of the activities were constructed and studied.
Finally recently, collaborative game playing in a Museum using PDAs has been studied [14]. A logfile of the Museum server was studied in relation to three streams of video from different angles together with the observers' notes. It was found that various events related to interaction of the students with the exhibits and verbal interactions of the students between them and with their tutor/guide were captured in the video streams and were interrelated with actions at the user interface level of the PDAs. In this particular study it was found that the additional information conveyed through the posture of the users, their spatial location etc, was important for studying and understanding the activity, while the limited size of the portable devices and the technical limitations of monitoring the PDA screens during the activity, made the video streams and interrelated logged events at the side of the server most valuable source of information.
In the four studies discussed here the common characteristic was that in order to analyse effectively the studied activities and test their hypotheses the analysts used additional evidence in various forms, mostly video and audio. This was added to logfiles generated by the tools used (chat messages exchanged, actions on concept mapping tools etc.) and interrelated to them. The analysis environment ColAT that was used in these cases facilitated and supported effectively the analysis and evaluation task.

4. Conclusions

In this paper, we outlined the main features of two tools that facilitate analysis of complex field data of technology mediated learning activities, the Synergo Analysis Tool and ColAT.
The first one, is based on logfiles of events at the user interface of the *Synergo* Collaborative Learning environment. So playback and solution annotation were used in order to re-construct the problem solution and to visualize the partners' contribution in the activity space. However it was found that often this approach is not adequate for a complete reconstruction of the learning activity.
The second approach supports building a multilevel interpretation of the solution, starting from the observable events, leading to the cognitive level. This is done by using combination of multiple media views of the activity. Through this, a more abstract description of the activity can be produced and analysed at the individual as well as the group level.
It should be observed that the two presented tools are complementary in nature, the first one, used for building annotation of the problem solving at the user interface level, while the second one leading to more interpretative structures, as it takes into account additional contextual information. The result of the first phase can feed the second one, in which case the annotated logfile is just one source of information. The two presented tools are quite independent, since their use depends on the available data. The Synergo Analysis Tool is mostly related to the Synergo synchronous problem-solving environment, while the ColAT tool is more generic and can be used for studying any kind of learning activity, which has been recorded in multiple media.
In the extracts of four studies, that were discussed in section 3.1, it was demonstrated that there are many issues, relating to analysis of interaction, that necessitate multiple perspectives. So, analysis tools, like ColAT that interrelate logfiles and contextual information in various forms are needed to support and facilitated such studies.

Acknowledgements

The research reported here has been supported by projects TELL2003-4721/001-001 EDU-ELEARN (*Towards Effective network supported coLLaborative learning activities*) funded by the European Commission and Project *Methods & Tools for CSCL* funded by the Basic research program Herakleitos of the Hellenic Ministry of Education.

References

[1] Hulshof, C. D. (2004), Log file analysis, in L.Kimberly Kempf (ed), Encyclopedia of Social Measurement. Academic Press, 2004.

[2] Dix A., Finlay J., Abowd G, Beale R., (2004), Human-Computer Interaction, 3rd ed., Prentice Hall

[3] Gassner K., Jansen M., Harrer A, Herrmann K, H.U. Hoppe, (2003), Analysis methods for collaborative models and Activities, In B. Wasson, S. Ludvigsen, U. Hoppe (eds.), Designing for Change in Networked Learning Environments, Proc. CSCL 2003, pp. 411-420, Kluwer Academic Publ., Dordrecht.

[4] Avouris N., Margaritis M., and Komis V., Modelling interaction during small-group synchronous problem-solving activities: The Synergo approach, 2nd International Workshop on Designing Computational Models of Collaborative Learning Interaction, ITS2004, 7th Conference on Intelligent Tutoring Systems, Maceio, Brasil, September 2004

[5] G. Fesakis, A. Petrou, A. Dimitracopoulou, Collaboration Activity Function: An interaction analysis tool for Computer Supported Collaborative Learning activities, Proc. ICALT 2004, Joensuu, FI, September 2004.

[6] Bertelsen O.W., Bodker S., (2003), Activity Theory, in J. M Carroll (ed.), HCI Models, Theories and Frameworks, Morgan Kaufmann, 2003.

[7] N. Avouris, V. Komis, M. Margaritis, G. Fiotakis, (2004), An environment for studying collaborative learning activities, Journal of International Forum of Educational Technology & Society, 7 (2), pp. 34-41, April 2004 .

[8] Avouris N.M., Dimitracopoulou A., Komis V., (2003a) On analysis of collaborative problem solving: An object-oriented approach, J. of Human Behavior Vol. 19, (2), pp. 147-167.

[9] Fidas C., Komis V., Tzanavaris S., Avouris N., Heterogeneity of learning material in synchronous computer-supported collaborative modelling, Computers & Education, 44 (2), pp. 135-154, February 2005.

[10] E. Voyiatzaki, Ch. Christakoudis M. Margaritis, N. Avouris, Teaching Algorithms in Secondary Education: A Collaborative Approach, Proceedings ED Media 2004, AACE publ, Lugano, June 2004, pp. 2781-2789.

[11] Komis V., Avouris N., Fidas C., (2002), Computer-Supported Collaborative Concept Mapping: Study of Synchronous Peer Interaction, Education and Information Technologies, 7:2, 169–188.

[12] L. Bollen, A. Harrer, H. U. Hoppe (2004), An Integrated Approach for Analysis-Based Report Generation, Proc. ICALT 2004, Joensuu, FI, September 2004.

[13] N. Pinkwart (2003), A Plug-In Architecture for Graph Based Collaborative Modeling Systems, Porc. AI ED 2003.

[14] A. Stoica, G. Fiotakis, J. Simarro Cabrera, H. Muñoz Frutos, N. Avouris, and Y. Dimitriadis, (2005), Usability evaluation of handheld devices, Proc. PCI 2005, Volos.