State of the art on Interaction and Collaboration Analysis

Angelique Dimitrakopoulou

▶ **To cite this version:**

Angelique Dimitrakopoulou. State of the art on Interaction and Collaboration Analysis. 2004. hal-00190145

HAL Id: hal-00190145

https://telearn.hal.science/hal-00190145

Submitted on 23 Nov 2007

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Concepts and methods for exploring the

future of learning with digital technologies

D26.1.1 (Final)

State of the art on Interaction and Collaboration Analysis

Main author : Angelique Dimitrakopoulou (UAEGEAN)

Nature of the deliverable : Report

Dissemination level : Restricted

Planned delivery date : June 2004

No part of this document may be distributed outside the consortium / EC without

written permission from the project co-ordinator

Prepared for the European Commission, DG INFSO, under contract N°. IST 507838
as a deliverable from WP26
Submitted on 27-07-2004

Summary

The document focuses on students-machine or students-students' interactions analysis that could support students & teachers, when students work in stand-alone mode or in collaborative technology based learning environments.
The document concerns the State of the art on the interaction analysis dimensions and approaches that are already applied. The appropriateness of these approaches is related to the learning environments features, the user's profile, the learning activities, and the context of use.

The document is structured as follows:
w It defines the interaction analysis research field. It specifies research dimensions that are related or underlying of the interaction analysis field.
w It presents an overview of the main interaction analysis indicators as well as of interaction analysis tools that are used or proposed by researchers. The actual version contains the indicators used by the partners of ICALTS consortium. An elaborated synthesis of the presented indicators will be presented in the next version of the present document.

History

Filename	Status	Release	Changes	Uploaded
D26-01-01-F.pdf	Final	2	-Changes into the first 30 pages.	
-new material was added into the appendix (at the end)	27/07/04			
	Draft	1	-	01/01/70

State of the Art on Interaction Analysis: "Interaction Analysis Indicators"

TABLE OF CONTENTS

1. Introduction 4
1.1. Status and content of the document 4
1.2. Why are we interested in Interaction Analysis? 4
2. Aspects of Interactions' Analysis Field 5
2.1. Identifying the Aspects of the Field: " Interaction Analysis Supporting 5
Participants Self-regulation in Technology-Based Learning Environments" 5
2.2. Research Dimensions and Questions 10
3. Interaction Analysis Indicators & Tools 12
3.1. Interaction analysis process and "main concepts" 12
3.2. Discussion on "Interaction Analysis Indicator" Concept 13
3.3. Indicators' Attributes: Indicators Presentation Templates 18
3.4. Summary on the currently applied Interactions' Analysis Indicators 22
4. References 38
5. Annex 40
An.1. Indicators: laboratory CRAFT/EPFL *41*
An.1.1. "Conversation and action balance" Indicator 41
An.1.2. Division of Labor indicator 46
An. 1.3. Activity Level Indicator 53
An.2. Indicators: laboratory COLLIDE 59
An.2.1. Action classification Indicator 59
An.2.2. Object/Relation type's ratio Indicator 62
An.1.3. Learner's ratio of participation Indicator 65
An.2.4. Social Network Analysis Features (General on SNA) 68
An.3. Indicators: laboratory LTEE/UAEGEAN 71
An.3.1. Overview 71
An.3.2. "Collaborative Action Function" Indicator 75
An.3.3. "Non Verbal Action" Indicator (NVA) 78
An.3.4. "Selected Agent Contribution" Indicator (SAC) 80
An.3.5. "Participation Percentage" Indicator (PART) 83
An.3.6. "Interactions" Indicator 85
An.3.7. "Active Agents" Indicator 87
An.3.8. COLEMON Interaction Analysis Tool 89
An.3.9. "Key possession per participant" Indicator 91
An.3.9. "Number of messages per participant" Indicator 93
An.3.10. Inserted/Deleted Objects per participant" Indicator 94
An.3.11. CoRPET Tool (an interpretation support tool) 95

An.4. Indicators laboratory UNED 97
An.4.1. Collaboration level (in the group) Indicator 97
An.5. Indicators: Laboratory Intermedia 104
An.5.1. Participation_Count Indicator 104
An.5.2. LOGIN_Time Indicator 107
An.6. Indicators: Laboratory GSIC/University of Valladolid 110
An.6.1. Network Degree Centralisation Indicator 110
An.6.2. Actors' Degree Centrality Indicator 114
An.6.3. Network Density Indicator 118
An.7. Indicators: Laboratory EDTE/University of Twente 122
An.7.1. "Heuristics use in Experimentation" Indicator 122
An.7.2.Knowledge development in discovery learning process Indicator 126
An.7.3. "Optics Computer Simulation" Indicator 132
An.7.4. Indicators related to experimental trials 135
An.8. Indicators: Laboratory COSET/University of Athens 138
An.8.1. "Self Re-Read" Indicator 138
An.8.2. "Others Re-Read" Indicator 141
An.8.3. "Group Read" Indicator 144
An.9. Interaction Analysis Tool: Laboratory ICAR-CNRS Lyon 147
An.9.1. Opinion difference visualization 147
An.9.2. Interaction Replay Tool 150

ABSTRACT

The document focuses on students-machine or students-students' interactions analysis that could support students & teachers, when students work in stand-alone mode or in collaborative one via technology based learning environments.

The document points out the main concepts and aspects underlying "interaction analysis", produced automatically by the technology based learning environments or independent tools in order to support the students, the teachers or even the researchers. For this purpose the related work of ICALTS JEIRP partners was analysed in profound.

The document is structured as follows:

- It defines the interaction analysis research field. It specifies research dimensions that are directly related or underlying of the interaction analysis field.
- Focusing on the identified central concept of Interaction Analysis Indicator, it defines and discuss this concept as well as their significant "features"
- It presents an overview and a synthesis of the main interaction analysis indicators.
- The document contains the presentation of a rich variety of indicators introduced by the partners of ICALTS consortium (see appendix)

Responsible Author -Contact:

Name: Angelique Dimitracopoulou, Associate Professor, Univ. of Aegean
Address: 1, Avenue Democratias, 85100, Rhodes, Greece
Phone Numbers: +30 2241 99127, +30 697 2880636
E-mail: adimitr@rhodes.aegean.gr

Main Authors:

Alexandra Martinez Mones & Yannis Dimitriadis

Anders Morch & Sten Ludvigsen

Andreas Harrer & Ulrich Hoppe

Beatriz Barros & Felisa Verdejo

Casper Hulshof & Ton de Jong

George Fessakis, Argyro Petrou & Angelique Dimitracopoulou

Kristine Lund & Michael Baker

Patrick Jermann & Pierre Dillenbourg

Vassilis Kollias & Stella Vosniadou

ICALTS project website: www.rhodes.aegean.gr/LTEE/Kaleidoscope-Icalts

1. Introduction

1.1. Status and content of the document

The document focuses on students' interactions analysis that could support students & teachers, when they work in stand-alone mode with technology based learning environments or in collaborative mode.

Especially, the document concerns the State of the art on the interaction analysis approaches that are already introduced by researchers, designers, or developers.

It is to be noticed that instead of presenting a literature-based state of the art, the document is prepared in order to make emerge or to define the main underlying concepts, that were mostly hidden in the actual related work. For this purpose, the related work of partners involved in ICALTS JEIRP, was taken as the base of profound analysis.

The document is structured as follows:

- It defines the interaction analysis research field. It specifies research dimensions and aspects that are related or underlying of the interaction analysis field.
- It 'proposes' the "Interaction Analysis Indicator" concept that seems to be central and fruitful in the discussion on interaction analysis field.
- It presents an overview as well as a synthesis of the main interaction analysis indicators used or proposed by researchers.
- The document contains also the presentation of a rich variety of indicators introduced by the partners of ICALTS consortium (see appendix)

1.2. Why are we interested in Interaction Analysis?

Usually work related to Interaction Analysis is carried out:

(a) by systems applying Artificial Intelligence inspired methods that compare Interaction Analysis results with an ideal case, and produce messages that guide directly students during the learning activity

(b) by researchers that collect data and analyse interactions afterwards in order to understand interaction or collaborative process.

'Interaction Analysis' that provides information directly to students and/or teachers, in order to self assess their activity, is a new direction emerged during the last years, mainly due to the very complex interactions that occur through the collaborative systems (given also that 'by definition' a collaborative activity is a reflective activity). The interaction analysis results that are shown to the participants of the learning activities' must be displayed in an appropriate format [which will usually be graphical, but also numerical or literal one], able to be interpreted by students or teachers. This could provide an "inside" on their own previous activity allowing the participants to reflect on it. This approach could produce flexible interaction analysis tools, which support teachers in their work (an aspect almost neglected), but also directly students themselves.

We propose that the design of technology based learning environments must not be limited to the basic means of action and communication, but should be extended by providing means of analysis of the very complex interactions that occur, when the participants of the learning activities work in individual or collaborative mode. These means would allow supporting both students and teachers in a metacognitive level in order to (self) regulate or to assess their activity.

It is to be noted that the need to support participants' awareness and metacognition is pushed by the intensive interest to use technology based learning environments and specially collaborative ones 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.

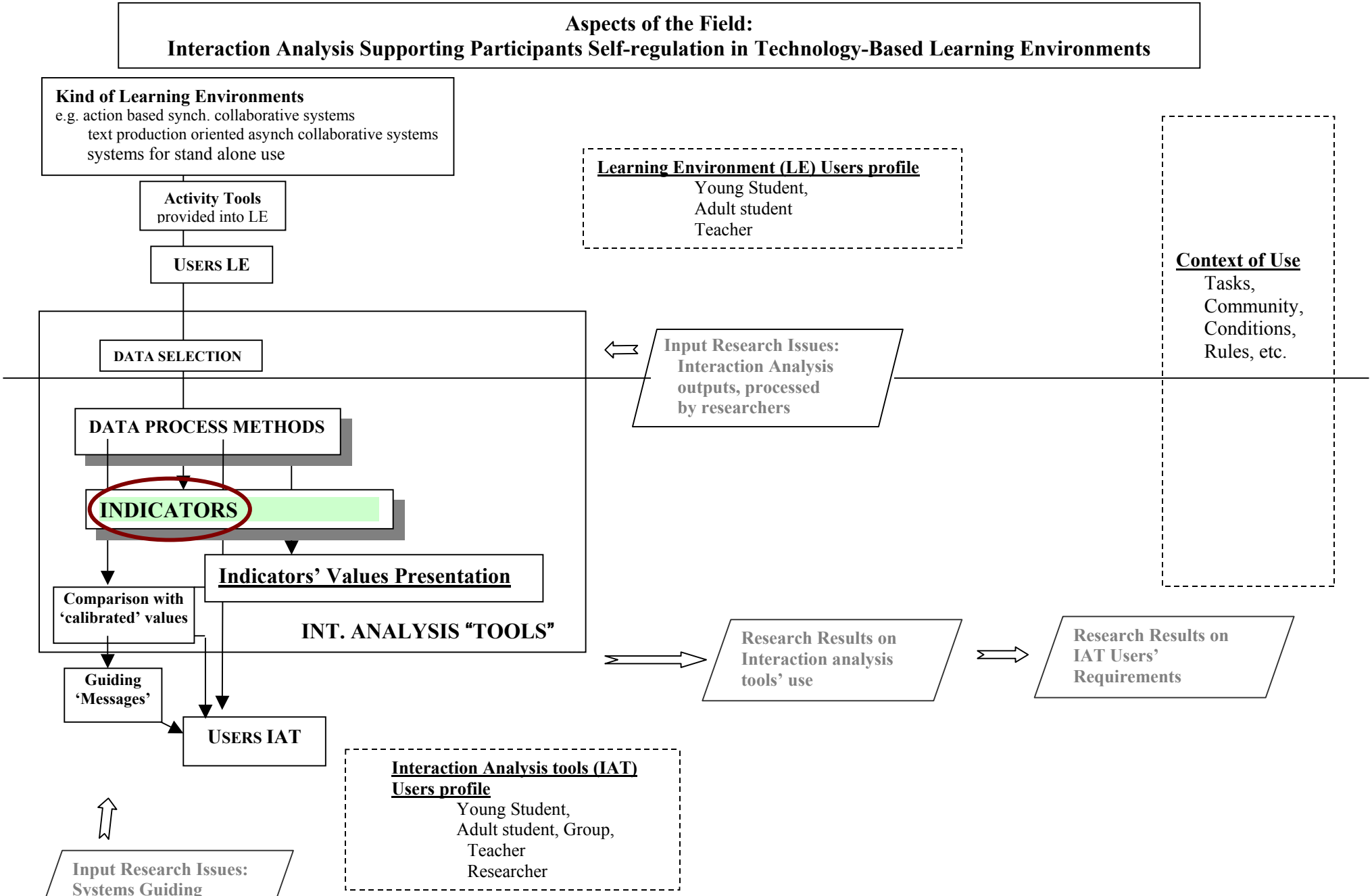
2. Aspects of Interactions' Analysis Field

2.1. Identifying the Aspects of the Field: " Interaction Analysis Supporting Participants Self-regulation in Technology-Based Learning Environments"

When students work with exploratory learning environments a variety of interactions among students and systems take place. Furthermore, during collaborative learning activities very complex interactions occur, between two or more individuals collaborating in a group, as well as among students and an eventual coach.

Systems that aggregate the interaction data of logfiles into a set of high-level indicators and present them to the learners or to the teacher have been already proposed. Additionally, there are systems that analyse students' interactions, in order to produce appropriate messages guiding them.

Figure 1, will be used to point out some of the aspects involved, as well as the core and the adjacent research areas.


Aspects of the Field:
Interaction Analysis Supporting Participants Self-regulation in Technology-Based Learning Environments
Kind of Learning Environments
e.g. action based synch. collaborative systems
text production oriented asynch collaborative systems
systems for stand alone use
Activity Tools provided into LE
USERS LE
Learning Environment (LE) Users profile
Young Student,
Adult student
Teacher
Context of Use
Tasks,
Community,
Conditions,
Rules, etc.
DATA SELECTION
Input Research Issues: Interaction Analysis outputs, processed by researchers
DATA PROCESS METHODS
INDICATORS
Indicators' Values Presentation
Comparison with 'calibrated' values
INT. ANALYSIS "TOOLS"
Guiding 'Messages'
USERS IAT
Research Results on Interaction analysis tools' use
Research Results on IAT Users' Requirements
Interaction Analysis tools (IAT) Users profile
Young Student,
Adult student, Group,
Teacher
Researcher
Input Research Issues: Systems Guiding Learners

Technology-based learning environments:

Students may work in different technology-based learning environments:

- Learning environments that allow problem solving, exploration (e.g. simulation systems), modeling, programming or even navigation in a hypermedia material, and are addressed to individual use* or side by side collaboration [*environments for stand-alone use*]
- Environments mainly addressed to a wide community of students, including a number of activity tools that often require text production and are usually used in an asynchronous interaction mode (e.g. Knowledge Forum, Active Document), [*text production oriented environments*]
- Environments mainly addressed to small groups of students, that invite to a synchronous activity in shared workspace [e.g. COLER, Cool Modes, Colab, ModellingSpace] [*action oriented environments*]

[**the use of collaborative systems still concerns only a low proportion of the time spend in technology based learning environments. Moreover, even in collaborative learning systems, users work also in individual mode, situation that often needs to be supported*].

Specific Interaction Means & Mode:

Learning environments may include one or more main *activity tools* (such as forum, chat, modeling tool, simulation tool, repository of text-based files, notebook, etc. Thus, various activity types are involved and different communication channel are available, while a variety of activity products may result.

Users may work in *individual mode with the system, or in a synchronous or asynchronous* communication mode with other participants (even into the same learning environment).

The User of the Learning Environment (LE), may have different profiles:

Young students, adult student, or even teacher. The distinction between young and adult student, is useful, given that in general, adults have already developed important metacognitive skills (e.g. Adults students could more easy be supported by interaction analysis tools that initially could be designed for researchers)

Interaction analysis process:

In order to analyse participants' interactions:

⇨ Data are selected (*data selection or data filtering*) by an electronic mode, from the available data sources [logfiles & Interaction Products].

⇨The selected data are aggregated by different *data processing methods*.

⇨ The application of 'data processing methods' produces one or more *'indicators'*, that indicate 'something' related to the 'quality' of individual activity, the mode or the quality of the collaboration, the quality of the collaborative product, or the appropriateness of its production process. These variables interpreted, taking into account, the learning activity, the profile of the participants and the context of interaction could support interaction participants on the level of awareness ,or of the (self) assessment.

The analysis may produce one or more basic indicators (usually low level indicators), as well as one or more composite ones (high level 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 students or teachers, via a specific *interface*. The *presentation of the values* usually takes an appropriate form: textual, numerical, or diagrammatic visualized form. The diagrammatic visualized form, concerns the variation of the values of the indicator in relation to an independent variable (e.g. time), or the values of another indicator.

(b) The assessment of the values of indicators is done into the specific context of interaction. An interaction analysis system can provide the learning activity participants (students, teachers) with various levels of information:, taking different degrees: (a) Indicating in an indirect mode the range of 'positive" and 'negative values", (b) Indicating by a direct mode, through specific and explicit messages advising students what to do (as was inferred by the system on the bases of the indicators values).

The whole 'system' that selects the needed data and aggregate them via data processing methods, producing indicators, or even developing appropriate forms of messages could:

(a) constitute a distinct *interaction analysis tool*,

(b) be a piece of interaction analysis software/code, internal to the Learning environment.

The *Users of Interaction Analysis* tools outputs: could be: students (young or adults), teachers. Users of interaction analysis tools could be also researchers.

Context of Interaction:

In order to analyse the main features of the interaction, it is always necessary to *take into account the context of interaction*: tasks, conditions of use, community (small, larger, wider), implicit or explicit rules applied, etc.

Similarly, it is indispensable to take into account the context of interaction, in order to (a) discuss if an interaction analysis approach or its output is appropriate or not, (b) identify the needs of learning activity participants (students, teachers), in 'information' derived from the analysis of their interaction.

2.2. Research Dimensions and Questions

Based on the above general view, we could distinguish the Main research dimensions, as well as the adjoining one.

➢ **Main research dimensions, aspects and underlying questions:**

(I) Design [of interaction analysis functions & tools, supporting users]

⇨ Indicators of the interaction:

(a) What indicators we produce?

(b) What indicators may we need?

What are the indicators used in the actual systems that support guiding or metacognition? Which of them are independent of the content?

How they are related to the kind of the learning environment?

What are the indicators that researchers could indicate as possible "candidates" for interaction analysis results presented to users?

⇨ Indicators' values presentation (output of interaction analysis): What are the appropriate forms of indicators' values output? [literal, quantitative, visualized], in function of the profile of IA user, but also the context of the situation.

⇨ Define a variety of information formats derived from interaction analysis (quantitative information, visualisations, messages, etc) that could be appropriate for specific participants' profiles: What format should the information that will be provided to each type of participant take (messages, quantitative info, visualised info)?

⇨ Indicators' values Calibration & Presentation form: How to calibrate an indicator, or how to present the covariation of indicators (in a visualized form)? How to present the 'desired values' to users'. We could say that way that values are calibrated constitute an often 'hidden aspect' in most of the applications. This hidden aspect is really significant for the interpretations

⇨ Identify-Define *design principles for interaction analysis tools* addressed to different participants' profiles (students of different ages and teachers)

(II) Development:

⇨ Interaction Data Processing Methods:

(a) What data processing methods are applied [source of data used, methods of data or indicators process in order to derive higher level indicators],

(b) What data processing methods could be applied [source of data used, methods of data or indicators process in order to derive higher level indicators]

There are two interrelated aspects:

(i) Data used and Points of view about data.

(ii) Data process Methods.

⇨ Representations of Interaction Analysis Data & Methods: Data representation types, Ontologies, etc.

⇨ Design & Development of Interaction analysis Tools

(III). Research approaches for requirements and support use:

- Take into account *empirical results* on how users (students & teachers) benefit from the provided support. What are the effects of interaction analysis tools on participants' collaborative activity regulation?

- Define *appropriate methods* of how to identify students' and teachers' needs and requirements, in order to achieve a better design of tools and functions supporting them.

➢ **Adjoining research dimensions:**

⇨ Research results derived by researchers analysis, could/may indicate important 'indicators', that could be used as metacognitive support [for students, or for teachers]

⇨ Interaction analysis methods and tools that are actually used by researchers, could eventually used in a reconverted way also for students, or teachers [e.g. SNA graphs].

3. Interaction Analysis Indicators & Tools

3.1. Interaction analysis process and "main concepts"

Let's recapitulate the main concepts implicating in the 'interaction analysis process'.

In order to analyse participants' interactions:

⇨ Data are selected (*data selection or data filtering*) by an automatic mode, from the available data sources [logfiles & Interaction Products].

⇨The selected data are aggregated by different *data processing methods*.

⇨ The application of 'data processing methods' produces one or more *'indicators'* that indicate 'something' related to the 'quality' of individual activity (e.g. variables that he/she change, order of significant actions, etc.), the mode or the quality of the collaboration (e.g. division of labor, participation rates, categories of specific contributions), the process or the quality of the collaborative product. These variables have to be interpreted, taking into account, the learning activity, the profile of the participants and the context of interaction etc.

The analysis may produce one or more basic indicators (usually low level indicators), as well as one or more composite ones (high level 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 students or teachers, via a specific *interface*. The *presentation of the values* usually takes an appropriate form: textual, numerical, or diagrammatic visualized form. The diagrammatic visualized form, often concerns the variation of the values of the indicator in relation to an independent variable (e.g. time), or the values of another indicator.

(b) The assessment of the values of indicators is done into the specific context of interaction. An interaction analysis system can provide the learning activity participants (students, teachers) with various levels of information: (a) Indicating in an indirect mode that range of 'positive" and 'negative values", (b) A direct mode, via specific and explicit messages advising students what to do.

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

In the present document we focus on the concept of indicator, its main underlying primitive concepts, their purpose and their users

The Concept of Interaction Analysis Indicators, in the frame of this document, is considered as having central importance, in all the case of interaction analysis systems: Systems that guide directly the student, with the intention to regulate their activity, or systems that support them during their metacognitive reflective activity. Similarly, indicators of interaction analysis, are central when the 'readers'/ interpreters'/users of these indicators are the teachers, or even the researchers. Furthermore, indicators seems to be the unifying concept among learning systems that are used in stand-alone mode (focusing on content), and systems used in collaborative mode.

3.2. Discussion on "Interaction Analysis Indicator" Concept

➢ Definition:

Students interact with technology-based learning environments, in stand alone or in collaborative mode. Thus, students could interact individually with the environment or by group, forming various cognitive systems. During interaction, two types of interaction data could be collected:

(a) the individual or the collaborative product (its final form and eventually intermediary instances of this product, during the interaction)

(b) student(s) actions registered into the environment logfile

Based on these interaction data, the application of 'data processing methods' could produce a number of "interaction analysis *'indicators''*. These indicators constitute variables that describe 'something' related to:

- the mode, the process or the 'quality' of the considered 'cognitive system' activity
- the features or the quality of the interaction product,
- the mode or the quality of the collaboration, when acting in the frame of a social context forming via the technology based learning environment.

taking into account that the ultimate goal of the interaction through a learning environment is to achieve:

(a) a better activity product , (b) better activity process, (c) better collaboration,

that could result in better learning effects.

The users of interaction analysis (IA) indicators could be: the student, the teacher, the system, or the researcher. In this document, we focus on how interaction analysis could support the participants of the learning process, thus: the students and the teacher.

In the ideal case, for each interaction session, *a number of complementary indicators* could be produced. These indicators could form an implicit *"model of the interaction"*. This model is a surrogate 'construct', a conceptual understanding of the process that takes place or has taken place. This model would have three components:

(a) A set of names of the *agents* that interact and the *means* that they use.

(b) A set of descriptive indicators (variables) representing "aspects' of the interaction

(c) An interpretation, relating all the available descriptive indicators

It may be useful to note, that there are two general categories of indicators:

(a) time dependent indicators, describing aspects that evolve during the process of the interaction

(b) time independent indicators, usually describing global aspects of the final product or of the whole process, that are processed at the end of the interaction session.

➢ **Prescriptive model of desired indicators**:

In order to prescribe what kinds of indicators we may need it is important to *consider it primarily from the users point of view* (compared to the possible points of views of cognitive psychologists, developers, etc.):

(A) The main participants of the interaction process via the learning environment ,usually the students, may need:

(a) awareness of their own *actions*, activities

(b) assessment of their *process* (indicators that give them an insight on their own process , e.g. strategies]

(c) assessment of the quality of their *product*

(d) awareness of *others participants (collaborators) actions*

(e) awareness of their own collaborative actions

(f) assessment of their *collaborative mode* or more generally of the *social* attitude during the collaborative process (indicators that give an insight on aspects of their collaborative attitude or wider social attitude, given that they do complex interactions, and they 'cannot' have a general view)

In general we could distinguish that the (a), (b), (c) concern cognitive aspects, while the (d), (e), (f) social ones.

Thus, students need: (A) a support on the **awareness** on their own individual or collaborative activity., (B) an **external assessment**, of their activity and their product.
Supporting them in a metacognitive level, it could gives them the means to self regulate their own activity during a session, or during forthcoming sessions.

(B) The teachers may need:

(a) to get an insight on their students *actions* and activities, that could allow to understand how *a product* is produced

(b) an insight on their *process*, in order to assess easily (quickly) their process (e.g. applied strategies), that could allow he/she to diagnose difficulties or abilities

(c) automatic assessment (or elements that could help them in an easy comparative assessment) of the quality of *their product* (eg. number or structure of nodes & links in a concept map)

(d) *an insight on* the *groups actions*, in order to understand how a collaboration is produced

(e) *an insight of the singular students actions, participating in a group*, in order to understand how collaboration is/was evolved

(f) assessment or elements for *assessment of their students collaborative or more general social attitude* (indicators that give an insight on aspects of their collaborative attitude or wider social attitude)

The "insight" could help them **to understand** how a product is produced, to infers difficulties thus **to diagnose**, while in the same time some indicators could help them to **assess** their process and/or product.

In general we could distinguish that the (a), (b), (c) concern cognitive aspects, while the (d), (e), (f) social ones.

It is to be noted that the teacher may be a participant of the technology based interaction process (e.g. when he/she supervise a synchronous collaboration). In that case, specific indicators of their own role like these of the previous general category (A), could be available for him/her.

- **Significance and Interpretative value of indicators:**

We could make a distinction, among:

(a) High level indicators: these that have an inherent interpretative value, and usually inferred by complex process from the raw data.

(b) Intermediary, Elaborated indicators

(c) Low level indicators, those that have not an autonomous interpretative value and are usually inferred directly from the raw data

This distinction does not mean that high level indicators are better or more significant that the low level ones. The significance of these indicators cannot be estimated a priori: it can only be pointed out by researches. (Eventually the "awareness related indicators" based on low level indicators on their participants actions, could be more effective –in terms of how students take them into account in order to self regulate their activity- , than the indicators assessing directly the quality of their final product, or of their applied strategy)

Another critical factor of the effectiveness of the produced indicators on the students or teachers support, is the way of the presentation of the indicators values: a literal information eventually is more or less effective that a direct guiding message on what students they must do.

Concluding, the significance of the produced indicators has to be directly related to their effectiveness on supporting interaction participants.

- **Interpretation of indicators:**

First of all, it is to be noted, that all the above indicators when interpreted by agents external of the participants: teacher or researcher or even system, it must be taken into account complementary information such as: other indicators, the learning activity product, the participants' profile, the context of interaction, etc.

For teachers, but eventually also for students, it is needed to produce indicators that are connected among them by an interpretative schema (see also in previous paragraphs about 'implicit model of interaction'):

We could distinguish two general kinds of these interpretative schema:

- Production of a complex system of indicators (usually a hierarchy of high and low level indicators)
- Definition of an implicit but clear interpretative schema that guides the use of the defined and produced indicators

➢ Interaction Analysis Indicator Attributes:

Indicator concept:
Each interaction analysis indicator is characterized by its main 'concept' (see Figure 2): the aspect of interaction that represents (eg. division of labor, collaboration intensity, participation rate, etc)

Dependencies: The indicator may be dependent or independent from external variables (such as time, or content).

Indicator values: the indicator takes values: **The form of the value** is a significant attribute: it can be numerical, literal, or graphical. **The status of the value** refers to whether the interaction analysis output gives only a value, a calibrated value or an interpreted value.

Indicator Purpose: The general purpose of the indicator, could be distinguished in: (a) cognitive, and (b) social. It has to be further determined as: awareness, understanding, diagnosis, assessment. It is to be noted that the indicator purpose is directly related with the indicator concept. The possible exploitation of the indicator by the users (students or teachers), is a different concept: A teacher could exploit the same information (e.g. indicator social/awareness of the actions) for inferences on collaboration but also for managerial aspects (e.g. decide to change the member of a group).

Participants of a technology based Learning Environment: An indicator refers to Participants of a technology based Learning Environment (LE). These participants could be: a student, a group of students, a wider virtual community, a teacher.

Interaction Analysis Indicator (IAI) Intended Users : An indicator is addressed to Interaction Analysis Indicator (IAI) Users. It may be addressed to: individual students, a group of students, a teacher, a researcher. It is to be noted that even if the indicator concept is the same, the values form or status may be different depending the intended user.

An indicator has usually a specific time of appropriate use: There are indicators that take their values on the fly (during the interaction), while others can take their values at the end of the interaction process, and therefore be exploited by the intended users.

Validity field: it is needed to explore and define the validity field of each indicator, as well as the limits of this validity. In order to define the validity field, it is to be considered the kind of the learning environment, the content of the activity, the learning participants profile, the intended users.

Learning Environment: The interaction through different kind of environments, as well as the different activity means provided to users, in most of the cases demands different indicators. It is useful to distinguish at least among three general categories of learning environments: (a) environments for individual use, (b) action based collaborative environments (usually demanding synchronous interaction) and (b) text production oriented collaborative environments (usually demanding asynchronous interaction).

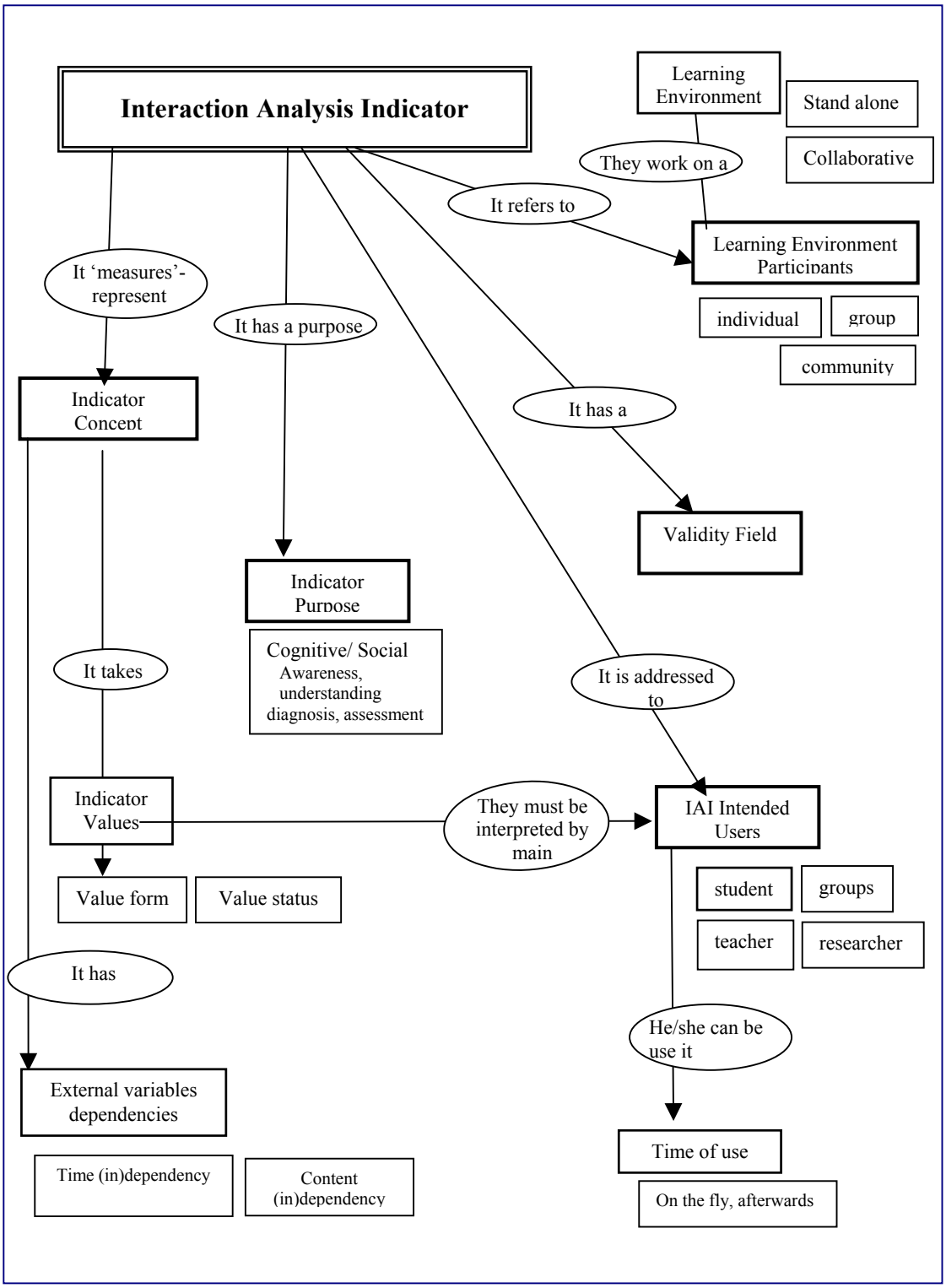


Figure 2. Interaction Analysis Indicator Attributes

3.3. Indicators' Attributes: Indicators Presentation Templates

In order to be able analyse in profound the developers related work that has directly or indirectly to do with Interaction Analysis Indicators, a number of templates was produced (see tables A-D).

The templates are based on the previous definition of Interaction analysis indicator, as well as on the indicator attributes prescription.

OVERVIEW OF INDICATOR DESCRIPTION TEMPLATES

INDICATOR' DESCRIPTION :
- NAME
- VARIABLE/underlying CONCEPT
- INDICATORS' VALUE FORM
- DATA SELECTED
- POINT OF VIEW
- DATA PROCESS METHOD
- *DIAGRAMMATIC DESCRIPTION OF PROCESS*
- INDICATOR VALUES' CALIBRATION

INDICATOR' STATUS:
- PURPOSE,
- INDICATOR USER
- TIME OF USE
- INFORMATION INTERPRETATION AMBIGUITY

GENERAL DATA SOURCE DESCRIPTION :
- ACTION DEFINITION {in LOGFILE}
  - CONCEPTUAL DIAGRAM OF INTERACTION
- STUDENTS' INTERACTION PRODUCT FEATURES

CONTEXT OF INDICATOR VALIDITY
- LEARNING ENVIRONMENT NAME
- LEARNING ENVIRONMENT CATEGORY
- ACTIVITY TOOLS
- USER PROFILE
- TASK
  - CONTENT TYPE
  - DIVISION OF LABOR
- USER'S COMMUNITY

Figure 3: Overview of Indicators description templates

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	
CONCEPT of indicator	***Literal designation and literal description of the***
Indicators' Value FORM	----------[**visual, numerical, literal**] • **Insert Figure N, in case of visual form** **[e.g. the specific indicator variation per time, or the variation of the specific indicator (y) in relation with another indicator (x)]** ***(if needed)***
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	***What data are used, but also what aspects of the data are taken into account? (e.g. messages from raw data. It is measured the number of messages. It is not used th content of the messages)*** ***Which lower level indicators are used? (eventually)***
"ANALYSIS" POINT OF VIEW:	**[ACTION ORIENTED, STRUCTURAL/STATE ORIENTED, AUTHORSHIP ORIENTED, PROCESS ORIENTED, …]**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	***Equation or algorithm applied or external processing software used, or any other method***
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	**** Insert Figure N+1.** **Hierarchies/ trees or any conceptual diagram of source data process: *(if needed)***
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	***In case that the values of the indicator were calibrated into the specific learning environment and context of use, Insert here the range of values, as well as the meaning of these values regarding the quality of interaction (process, content or collaboration mode)***

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* **2. What indicator users could do on the base of this information?**
INDICATOR USER	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** *To whom is addressed?*
TIME OF USE	*When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)?*
INFORMATION INTERPRETATION AMBIGUITY	1. ----------[Low, medium, high] *2. Information interpretation: short description* *What the 'IAT' user' [student, teacher, system, researcher] could decode as information from the output form of indicator values: possible interpretations per indicator*
USE OF INDICATOR	
MODE OF INDICATOR USE	*Describe one or more mode of uses of this indicator, regarding the Interaction Analysis user [student, teacher, system, researcher] (conditions of use)*

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	{source of data}:{e.g. Identifier, time stamp, type of object, user, action , etc}
CONCEPTUAL DIAGRAM of raw data collection	** Figure N. how it is considered the situation in which the indicator is derived [e.g. **channels of communication]**

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	
CATEGORY OF LEARNING ENVIRONMENT	[COLLABORATIVE PROBLEM SOLVING, COLLABORATIVE PLATFORM, FORUM, etc]
LE ACTIVITY TOOLS	*Main Tools available to students*
Learning Environment USER PROFILE:	[YOUNG STUDENT, ADULT STUDENT, TEACHER]
TASK category:	[PROBLEM SOLVING, EXPERIMENTATIONS, ARGUMENTATION, TEXT PRODUCTIONS] *Short Description*
CONTENT TYPE:	[LOW CONCEPTUAL, HIGH CONCEPTUAL] *Short Description*
DIVISION OF LABOUR:	[CONTIGUOUS, PEER-TO-PEER COORDINATED, PEER TO PEER FREE, DISTRIBUTED,]
USERS' COMMUNITY	[INDIVIDUAL-TWO PERSON GROUP, THREE PERSON GROUP, COMMUNITY] *One or more settings could be indicated*

*** Minimum and sufficient information in order to can answer the question: Under what context & conditions some analysis outputs could be useful?*

INTERACTION ANALYSIS TOOLS

** In case that the indicator(s) are produced by an independent tool, give here a brief description*

Name	
Description	
Indicators kinds that could be inserted/presented	
Kinds of covariation (or dependence) that could be derived	
Intended Users	

3.4. Summary on the currently applied Interactions' Analysis Indicators

3.4.1. What indicators concern?

The following tables A-H present an overview of the main indicators (See Appendix) that are introduced by researchers participating in the ICALTS JEIRP.

There are collected/identified about 45 indicators. They are presented briefly in seven different categories, according to:

(a) their main general "concept" & purpose

(b) their level of elaboration: high level/ low level indicators

The categories are the following ones:

A. High level indicators, related to collaboration quality, modes, state, structure

B. Elaborated indicators, related to collaboration quality [in text production oriented systems, based on argumentation]

C. Elaborated indicators, related to argumentation quality [in text production oriented systems based on argumentation]

D. Low level indicators, related to argumentation quality [in text production oriented systems based on argumentation]

E. Indicators related to awareness, in action based systems

F. Indicators that concerns Participation assessment

G. Content related / dependent indicators

H. Cognitive indicators related to strategies (processed manually)

Globally, there are (see Tables A-H):

- A High level Indicators category (A), that contains indicators that seem to have an autonomous interpretative value and are defined for different categories of learning environment
- Three sub-categories (B, C, D) of elaborated indicators, as well as lower level indicators that are produced and applied in text production oriented systems, based on argumentation
- A category that contains the indicators defined in action based systems
- A category that concerns participation assessment (F) in various systems types (distinct category due to the similarity of indicators definitions)

All the above categories contain indicators that have social/collaborative purpose. The underlying concepts concerns mainly social and collaborative aspects and only indirectly cognitive ones.

- Only two categories (G H) have a clear cognitive purpose, and characterize the form or the content of the collaborative product, or even the strategies applied by students.

A	***High level indicators related to collaboration quality, modes, state, structure***			
	Indicator name	**Concept**	**Purpose**	**Validity field** ***(Kind of learning environment)***
A1	**Conversation and action balance**	This indicator reflects the balance between the production of problem-solving actions and dialogue related actions. It has the form of two complementary sub-indicators The indicator relies on a rough distinction between planning and evaluating action (in dialogue) and implementation (doing actions) *Value form:* The indicator is calibrated, & visualized by a color coded graph	Social & indirectly cognitive-strategies **Students:** Awareness on their own action-conversation balance *Users:* mainly students,	*Defined in :* an "action based system" that demands synchronous collaboration
A2	**Division of Labor**	This indicator reflects the division of labor adopted by two persons who act on a set of resources (e.g. intersections in a traffic simulation, parts of a conceptual diagram, etc.). It is possible to identify three types of division of labor: ⇨ Task based division: each person acting on separate resources. ⇨ Role based division: one person doing all the actions on all resources. ⇨ Concurrent division: both subjects acting more or less equally on all resources. *Value form:* Complex visualization	Social/collaborative & managerial *Users:* Addressed mainly to the researcher, & in the second degree to the teacher	*Defined in an:* "action based system" that demands synchronous collaboration ⇨↳ ***it could be applied:*** to a text production oriented system, based on asynchronous collaboration
A3	**Actor's degree centrality** [Social Network Analysis]	The degree centrality of an actor in a social network represents the number of links that the actors maintain with other actors. ***Value form:*** Represented into a sociogram, geometrical properties are used, such as *spring embedding or multidimensional scaling*, the most prominent actors (i.e., the ones with higher centrality) appear at the center of the network and the least active (i.e., the ones with lower centrality) actors are at the periphery.	Collaboration state oriented [structural?] It serves as social awareness of their actors *Users:* mainly teachers & researchers. It could be used also by students (adults)	*Defined in an:* "in a text production oriented system" with various 'resources' that demands asynchronous collaboration [bscw]

A4	**Network degree centralization (C_D)** [SNA]	The centralization of a social network measures the degree to which the activity of a network depends on the activity of a particular member or a very small set of members *Value form:* Numerical. Can be qualitatively interpreted by the inspection of sociograms.	Social (Collaboration state) *Users:* mainly teachers & researchers. It could be used also by students (adults)	*Defined in an:* "in a text production oriented system" with various 'resources' that demands asynchronous collaboration [bscw]
A5	**Network density (Δ) [SNA]**	The density of a social network measures the degree of activity of this network with respect to the relationship that is being measured. *Value form:* Numerical. Can be qualitatively interpreted by the inspection of sociograms.	Social (Collaboration state) *Users:* mainly teachers & researchers. It could be used also by students (adults)	*Defined in an:* "in a text production oriented system" with various 'resources' that demands asynchronous collaboration [bscw]
A6	**Activity Level**	This indicator reflects the level of activity of groups who use an online pedagogical project manager. It shows the contributions of different role groups (students, teachers) to the production of files and messages. *Value Form:* Color coded visualisation	Social/ MANAGERIAL The purpose of this indicator is to act as a alert. The indicator does not give information about the quality of the messages, or files that are produced by the groups *Users:* mainly teachers. It could be used also by students (adults)	*Defined in:* "a text production oriented system" with various 'resources' that demands asynchronous collaboration. Use of an online- project manager system.
A7	**Collaboration level in the group** [in an argumentative discussion, system with a number of resources [defined into a specific environment]	The indicator refers to the contributions added by learning environment users when they participate in an argumentative discussion *Value Form:* literal in a range of enumerated values (from worst to best), The indicator is defined via the calculation of others intermediary indicators: Work Amount, Argumentation, Coordination, Cooperation, Collaboration, Initiative, Creativity, Elaboration, Conformity (see Bn, Cn]	Social/ (collaboration quality) *Users:* mainly students, teachers, system	*Defined in:* "a text production oriented system" with various 'resources' that demands asynchronous collaboration and argumentative activity

A8	**Collaborative Activity Function** (CAF)	It indicates if there is high or low degree Collaborative action Consider a collaboration session interval [t_0-t_m]. The time interval is quantised using a parameter n: $t_i=t_0+i*d$, where $d=(t_m-t_0)/n$. We define the collaborative action function $CA(t_i)$ as follows: **$CA(t_i)=\sum_{k=1}^{k\max} Agents(k, t_i) * Interactions(k, t_i)$** Where k values [k:1(1)k_{max}] corresponds to the interaction channels {k=1=>chat, k=2=>sticks, etc}. **Active Agents(k,t_i):** computes the agents that have posted at least one "message" through channel k during (t_{i-1}-t_i] interval. **Interactions(k,t_i):** expresses the amount of interactions that have implemented through channel k during (t_{i-1}-t_i]. *Value Form:* Numerical that can be visualized Graph : CAF->time	Social	*Defined in :* an "action based system" that demands synchronous collaboration

B	***Elaborated indicators, related to collaboration quality [in text production oriented systems based on argumentation]***			
	Indicator name	**Concept**	**Purpose**	**Validity field** ***(Kind of learning environment)***
B1	**Work Amount:**	it provides a measure of the amount of work carried out by the group for generating the task solution. Inferred from McontributionsNOmber, McontributionSize, Elaboration [see C1-C10]	Social/ & (cognitive)	*Defined in:* "a text production oriented system" demanding asynchronous collaboration and argumentative activity
B2	**Argumentation:**	it supplies a measure of the degree of discussion that happened within the group. Inferred from DephTree, Interactivity, Initiative,Work	Social/ & (cognitive)	*Defined in:* "a text production oriented system" demanding argumentative activity
B3	**Coordination**	it shows the degree of intercommunication that appeared within the group members. Inferred from Argumentation, CoordinationMessages, Initiative	Social	*Defined in:* "a text production oriented system" demanding argumentative activity
B4	**Cooperation**	it considers how the argumentation process developed, though taking into account the conformist (or non-conformist) attitude of the individuals as well as the degree of creativity they added to the discussion for improving the group solution. Inferred from Argumentation, Conformity, Creativity	Social & (cognitive)	*Defined in:* "a text production oriented system" demanding argumentative activity
B5	**Collaboration**	it offers an overall assessment of the collaborative attitude of the group during the experience. Inferred from Argumentation, coordination and cooperation		*Defined in:* "a text production oriented system" demanding argumentative activity

C	***Elaborated indicators, related to argumentation quality [in text production oriented systems based on argumentation]***			
	Indicator name	**Concept**	**Purpose**	**Validity field** ***(Kind of learning environment)***
C1	**Initiative**	it quantifies the degree of involvement in the work and responsibility that bears each contribution type. Hence, a proposal means, for its author, an involvement in and binding to the task stronger than making a question	Cognitive//social	*Defined in:* "a text production oriented system" demanding argumentative activity
C2	**"Creativity"**	it quantifies the degree of complexity, originality and richness of ideas implied by the elaboration of the text for each type of contribution. Thus, for instance, elaborating a proposal requires more creativity than making a comment and, in turn, more than elaborating a question.	Cognitive//social	*Defined in:* "a text production oriented system" demanding argumentative activity
C3	**Elaboration**	this attribute is related to the previous one and quantifies the amount of work which is necessary for elaborating the text of a contribution. For instance, elaborating a counterproposal implies more work than making a question or a comment	Cognitive//social	*Defined in:* "a text production oriented system" demanding argumentative activity
C4	**Conformity**	it quantifies the degree of agreement implied by a contribution with relation to the one it is linked to. Thus, for example, the contribution type agreement shows total accord but the counterproposal shows few or no conformity at all.	Cognitive//social	*Defined in:* "a text production oriented system" demanding argumentative activity
C5	**Opinion difference visualization** *ICAR*	When two students have different opinions (for and against) in relation to a particular argument on a graph, this difference of opinion is shown visually. Each student is assigned a color and when a student has expressed an opinion, the box is surrounded by his or her color (below in blue and in green). When two students disagree, the argument (box) becomes "scrunched". *[This indicator is integrated into the graphical part of the argumentation learning environment. The indicator appears in real time as the opinion difference is made by the system].*	**Social/Collaborative/ Cognitive/ Managerial**	*Defined in :* an "action based system" (argumentation system) that demands synchronous collaboration

D	***Low level indicators, related to argumentation quality*** ***[in text production oriented systems based on argumentation]***			
	Indicator name	**Concept**	**Purpose**	**Validity field** ***(Kind of learning environment)***
D1	**Average Number of Contributions**	number of contributions added by the whole group within a collaboration space. The total number of contributions is divided into the number of group members having carried out the collaborative scenario.	Social/cognitive	*Defined in:* "a text production oriented system" demanding argumentative activity
D2	**Average Contribution Size**	average size of the contributions within a collaboration space, computed in terms of the number of characters of each contribution	Social/cognitive	*Defined in:* "a text production oriented system" demanding argumentative activity
D3	**Process Tree Depth**	maximum depth of the process scheme within an elaboration workspace	Social/cognitive	*Defined in:* "a text production oriented system" demanding argumentative activity
D4	**Group Interactivity**	It counts the percentage of contributions in a process scheme answered by a user other than their author. It provides a measure of the alternation that occurred during the argumentative discussion leading to the solution	Social/cognitive	*Defined in:* "a text production oriented system" demanding argumentative activity
D5	**Answered Contributions**	average number of answers given by the user to contributions made by another author	Social/cognitive	*Defined in:* "a text production oriented system" demanding argumentative activity
D6	**Contributions Answered By Others: users**	average number of contributions authored by the user that have been answered by other	Social/cognitive	*Defined in:* "a text production oriented system" demanding argumentative activity
D7	**Follow-Up Contributions**	average number of contributions authored and then answered by the same user	Social/cognitive	*Defined in:* "a text production oriented system" demanding argumentative activity
D8	**Group Read**	It counts the number of times the notes of a certain group have been read in one session	Social/cognitive	*Defined in:* "a text production oriented system" demanding argumentative activity
D9	**Others re-read**	The number of times that a "user" (it can be a group using the same login name) re-reads a contribution of others in a session.	Social/cognitive	*Defined in:* "a text production oriented system" demanding argumentative activity

D 10	**Self Re-read**	The number of times that a "user" (it can be a group using the same login name) opens a contribution of his/her own and re-reads it in a session.	Social/cognitive	*Defined in:* "a text production oriented system" demanding argumentative activity

E	***Indicators that concerns Participation assessment***			
	Indicator name	**Concept**	**Purpose**	**Validity field** ***(Kind of learning environment)***
E1	**Learner's ratio of participation** ***Collide***	The ratio of participation is a measurement of the activeness of one individual learner in a group process.. Diagrammatic as a pie chart, representing the whole number of activities a the pie and the numer of learner's activities as a piece of the pie.	Social	*Defined in :* an "action based system" that demands synchronous collaboration
E2	**Participation percentage** ***LTEE***	The participation – involvement of agents in the collaboration, any kind of action Numerical that can be visualized $PART(t_i) = \frac{Agents(t_i)}{TotalAgents}$ **Agents(t_i):** The total number of different agents that posted at least one message during $\mathbf{t_i}$ time slot. **TotalAgents:** The total number of agents collaborating. $PART \in [0,1]$, if PART~>0 then none is "acting", if PART~>1 then every body is "acting".	Social	*Defined in :* an "action based system" that demands synchronous collaboration
E3	**Participation_count** ***Intermedia***	It measures the number of times a certain student has posted messages or made changes to a shared object	Social	*Defined in:* "a text production oriented system" with various 'resources' that demands asynchronous collaboration.

F	*Indicators that concerns Elaborated & low level indicators concerning actions*			
	Indicator name	**Concept**	**Purpose**	**Validity field** ***(Kind of learning environment)***
F2	**Non Verbal Action (NVA)**	The percentage of the total (significant) actions in the log file that is not chat messages. Mathematical formula computed by an external to the main system software module. As part of the COLEMON Tool. $NVA(t_i) = \begin{cases} \frac{\sum_{k=1}^{k\max} \text{Interactions}(k, t_i) - \text{Interactions}(\text{"Chat"}, t_i)}{\sum_{k=1}^{k\max} \text{Interactions}(k, t_i)}, & \sum_{k=1}^{k\max} \text{Interactions}(k, t_i) > 0 \\ 0 & \sum_{k=1}^{k\max} \text{Interactions}(k, t_i) = 0 \end{cases}$ $NVA \in [0,1]$ If NVA ~> 1 then the agents are not chatting, if NVA ~> 0 then agents are just chatting or not interacting at all.	Social	<u>*Defined in :*</u> an "action based system" that demands synchronous collaboration
F3	**Number of Messages per Participant**	How active was each participant as far as the sending of messages is concerned.	Social	<u>*Defined in :*</u> an "action based system"
F4	**Selected Agent Contribution (SAC)**	The contribution of a specific agent to the total action [e.g. student1, student2, student3, teacher] The total number of messages posted by agent in through the k-channel during the t_i time slot. *Value Form:* Numerical that can be visualized. Graph: "SACagent1 -> time", or comparative ""SACagent1 -> time"", ""SACagent2 -> time"", $SAC \in [0,1]$	Social	<u>*Defined in :*</u> an "action based system" that demands synchronous collaboration
F5	**Interactions**	The number of "*actions"* (in any channel) in the previous time slot. It can be computed for each channel separately. **Interactions(k,t_i):** expresses the amount of interactions that have implemented through channel k during (t_{i-1}-t_i]. Where k values [k:1(1)k_{max}] corresponds to the interaction channels {k=1=>chat, k=2=>sticks, etc}. It is obvious that the function **Interactions(agent,k,t_i)** could be useful too. *Value Form*: Numerical that can be visualized by graph: Interactions -> time	Social	<u>*Defined in :*</u> an "action based system"
F6	**Active Agents**	The number of collaborative agents that posted at least one message (in any channel) in the previous time slot. It can be computed for each channel Agents(k,ti): computes the agents that have posted at least one message through channel k during (ti-1-ti] interval. Where k values [k:1(1)kmax] corresponds to the interaction channels {k=1=>chat, k=2=>sticks, etc}. *Value Form*: Numerical that can be visualized by graph: Interactions -> time	social	<u>*Defined in :*</u> an "action based system"

F7	**Authorship awareness** *LTEE*	It presents the history of authorship of each "entity" that is inserted, modified or deleted into the shared workspace *Value form:* There is a color based codification of the author of each significant 'action' related to the items that were inserted into the workspace. For instance, a node of a concept map could be indicated by a [red I*nserted*, blue M*odified*, red M*odified*, red D*eleted*]. The indicator value can be presented during the collaborative activity or afterwards, into the space of the collaborative product (e.g. the constructed concept map,	Social/ cognitive	*Defined in :* an "action based system" that demands synchronous collaboration

G	*Content related indicators*			
	Indicator name	**Concept**	**Purpose**	**Validity field** ***(Kind of learning environment)***
G1	**Action classification** *COLLIDE*	Classification is fixed for the learning environment, so designer has to assign categories carefully [how many nodes, how many entities, how many relations]	cognitive	*Defined in :* an "action based system" that demands synchronous collaboration
G2	**Object/Relation type's ratio** *COLLIDE*	The ratio of object/relation types is a measurement of the balanceness of results of modelling. Diagrammatic as a pie chart, representing the whole number of objects/relations as the pie and the number of objects/relations of one type as a piece of the pie. (one pie categories of relations, another pie=> categories of nodes) per group	cognitive	*Defined in :* an "action based system" that demands synchronous collaboration
G3	**Inserted (or deleted) "Items" per Participant (IOP)** ***LTEE***	The number of objects that each participant has inserted at the shared workspace. (presented per category) IOP shows the inserted objects at the shared workspace per participant. If the IOP for one participant is big, then this participant did most of the insertions at the shared workspace.	cognitive	*Defined in :* an "action based system" that demands synchronous collaboration
G4	**Monitoring experiment outcomes.** *Twente*	Real-time registration and visualisation of the outcome of experiment trials (e.g., a reaction time).during an online psychological experiment. Trial data that come in from computers connected to a central 'monitor' are accumulated, and average results are computed and updated as new data comes in. The values that are obtained by the monitoring system indicate the deviation from the theoretical 'norm'. Visual (graph), numerical (table)	Cognitive Demonstrate to students what the collective results from their experiment are.	*Defined in :* an "action based system" that works in a stand alone mode (Individual use)

H	*Cognitive indicators related to strategies (processed manually)*			
	Indicator name	**Concept**	**Purpose**	**Validity field** ***(Kind of learning environment)***
H1	**Heuristics use**	A set of general and specific heuristics related to experimentation and hypothesis testing is compared to student behavior Process: General Heuristics are compared with all experiments. Sets of experiments are constructed based on the selection of variables by the learner, and these sets are compared with specific heuristics. Each Heuristic has its own 'pattern' that can be compared to the students behavior.	cognitive	*Defined in :* an "action based system" (simulation) that works in a stand alone mode (Individual use)
H2	**"Discovery learning"** *(in a specific learning context of 'Optics')*	Registration of all the actions a student performs while working with a computer simulation about the subject of geometrical optics (called 'Optics') Calibration: A large range of values resulted from use of the learning environment. These gave a direct indication of the sequence with which operations were carried out, and also their frequency. The quality of interaction with the learning environment cannot directly be obtained from the logfiles.	Cognitive	*Defined in :* an "action based system" (simulation) that works in a stand alone mode (Individual use)
H3	**Knowledge development, in discovery learning processes.**	It was used a (shared) proposition scratchpad (expression builder) and a shared proposition table as support tools. In both studies logs from peer to peer communication as well as logs from the students' interaction with the environment were used as a window on the students' collaborative discovery learning process, that could identify: difficulties that occur during discovery learning	cognitive	*Defined in :* an "action based system" (simulation) that works in a stand alone mode (Individual use or side by side collaboration)

What exactly these indicators measure? What their main concept refers to?

A/. High level indicators => related to collaboration quality, modes, state, structure

- Division of labor among two collaborating partners [A2]
- Collaboration means [A1] (in action based systems)
- Structure of relations that are formed in the social activity, and acquired role of members in a wide community [A3-A5]
- Collaboration intensity [A7] (in action based system)
- Activity level -----process (managerial aspect), related to amount of the work (dues and deadlines)
- Collaboration quality in the group [A6] [overall assessment]

B. Elaborated indicators,=> related to collaboration quality [in text production oriented systems based on argumentation]

- Collaboration
- Cooperation
- Coordination

C. Elaborated indicators, related to argumentation quality [in text production oriented systems]

- Involvement aspects in an argumentation process : initiative, "
- Quality of argumentation: creativity", "elaboration", conformity
- Opinion difference visualization

D. Low level indicators, related to argumentation quality [in text production oriented systems]

- Quantitative information on the argumentative contributions (av number of contributions, av contribution size, process tree depth),
- The degree of the social interaction on the contributions (answered contributions, follow-up, group interactivity, others re-read, group reas)

F. Low level indicators concerning actions

- quantitative information on 'actions' in different action or communication means (non verbal actions, number of messages per participant, interactions)
- quantitative information related to human agents contribution

E. Indicators that concerns Participation assessment

- Various indicators of participation assessment defined for different environments

H. Low level content related/dependent indicators (in actions' based systems)

- differentiation among actions in different entities manipulated [action classification, object-relation ratio, used 'entities, per participant]

I. Cognitive indicators related to strategies (processed manually)

- Heuristics, & strategies [heuristics use, discovery learning, knowledge development in discovery learning process]

Comments:

Different aspects of collaboration are introduced, in different kind of collaborative environments. Researchers could find complementarities among these indicators, when used into the same environment, progressing towards the production of more complete interpretative 'models' of interaction, that could be extremely useful for the teachers.

There are extremely few 'cognitive indicators'. Most of them constitute low level indicators, with a poor interpretative value. A few high level cognitive indicators proposed by researchers, cannot actually be processed automatically, thus they can not yet assist actually teachers of students.

3.4.2. Comparing the purpose of collected indicators with the prescription of indicators needed

Most of the high level indicators have to do with the awareness of their actions or get insight on the collaborative process or state (when they are addressed to teachers or researchers). It seems that there is a lack of indicators that could allow teachers to directly/easily diagnose students' difficulties (in a cognitive level). All the other indicators categories presented in this document, which most of them are low level indicators, concerns participants supporting mostly on awareness on their own actions, or on their collaborators action/attitude.

As an example, the following table presents the general as well as the more specific purpose of the high level indicators. For each indicator, it presents the pupils that the corresponding indicator refer to, while identify the users of the indicators themselves (as they were tested by the corresponding research groups). Additionally, it is noticed the time that an indicator could be used (during the interaction or afterwards, or after long periods of time).

Table 1. High level indicators

	Indicator name	Purpose	Refers to	Value Form/Status	IAI Users	Time of use	Validity field *(Kind of learning environment)*
A1	**Conversation and action balance**	Social & indirectly cognitive-strategies students' awareness on their team collaborative mode	Group of two members	*Form:* color coded visualized *Status:* Calibrated value	The group of students (without separating participation of each member)	On the fly	*Defined in :* an "action based system" that demands synchronous collaboration
A2	**Division of Labor**	Social/collaborative *Elements forAssessment of their students collaborative attitude*	The Group distinguishing the participation of each member	*Form:* visualized *Status:* value	Tested with teacher-researcher	afterwards	*Defined in an:* "action based system" ***it could be applied:*** to a text production oriented system,
A3	**Actor's degree centrality** [Social Network Analysis]	Social/collaborative *Get an insight of the singular students actions, participating in a group*	All the humans agents of the community, distinguishing the participation of each member	*Form:* visualized *Status:* value	Tested with teachers & researchers. It could be used also by adults students	afterwards	*Defined in an:* "in a text production oriented system" with various 'resources' that demands asynchronous collaboration [bscw]
A4	**Network centralization degree** [SNA]	Social (Collaboration state) *Get an insight on* the *groups actions*, -Collaboration structure-	All the humans agents of the community,	*Form:* visualized *Status:* value	Tested with teachers & researchers.	afterwards	*Defined in an:* "in a text production oriented system" with various 'resources' that demands asynchronous collaboration [bscw]
A5	**Network density (Δ) [SNA]**	Social (Collaboration state) *Get an insight on* the *groups actions*, in order to understand how a collaboration is produced	All the humans agents of the community	*Form:* visualized *Status:* value	Tested with teachers & researchers.	afterwards	*Defined in an:* "in a text production oriented system" with various 'resources' that demands asynchronous collaboration
A6	**Collaboration level in the group** environment]	Social/ (collaboration quality) Assessment of collaboration	*The group*	*Form:* numerical *Status:* Calibrated value	Teachers, students	afterwards	*Defined in:* "a text production oriented system" with various 'resources' that demands
A7	**Collaborative Activity Function** (CAF)	Social/ (collaboration) *An insight on* the *groups actions*, in order to understand how a collaboration is produced	*The group*	*Form:* visualised *Status:* value	Teachers,	On the fly	*Defined in:* an "action based system" that demands synchronous collaboration

4. References

AVOURIS N., DIMITRACOPOULOU A., KOMIS V., MARGARITIS M., Participatory Analysis of Synchronous Collaborative Problem Solving using the OCAF Methodology and Tools, Proc.of CSCL2003 Community events, pp. 232-234, June 14-18, Bergen, 2003

BARROS, B., MIZOGUCHI, R. & VERDEJO (2001)., A platform for collaboration analysis in CSCL. An ontological approach, Proceedings Artificial Intelligence in Education AIED'2001. Pages 530-532. ISBN 0922-6389. IOS Press.

BARROS, B., VERDEJO, M.F., READ, T., MIZOGUCHI, R., (2002), Applications of a collaborative learning ontology, MICAI'2002 Advances in Artificial Intelligence. (Carlos A. Coello Coello, Alvaro de Albornoz, Luis Enrique Sucar, Osvaldo Cair? Battistutti Eds.): , Lecture Notes in Computer Science 2313 Springer-Verlag pp. 301-310

FESSAKIS G., PETROU A., DIMITRACOPOULOU A., (in press 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

GAíNER K., JANSEN M., HARRER A., HERRMANN K., HOPPE U. (in press 2003), Analysis methods for collaborative models and activities, In (Ed) U. Hoppe, Computer Support for Collaborative Learning: Designing for Change in Networked Learning Environments, CSCL 2003 congress: 14-18 June 2003, Bergen, Norway.

GIJLERS, H., & DE JONG, T. (in preparation). Sharing and confronting propositions in a collaborative discovery setting. Article draft.

GIJLERS, H., & DE JONG, T. (in preparation). The relation between prior knowledge and students' collaborative discovery learning processes. Accepted for publication in _Journal of Research in Science Teaching_

HULSHOF, C. D. (in press). Log file analysis. To appear in _Encyclopedia of Social Measurement_. Elsevier.

HULSHOF, C. D., EYSINK, T. H. S., LOYENS, S., & DE JONG, T. (in preparation), ZAPs: Using interactive programs for learning psychology. Article draft.

JERMANN P., SOLLER A., MUEHLENBROCK M., From Mirroring to Guiding: A Review of State of the Art Technology for Supporting Collaborative Learning ,Proceedings of ECSCL01, March 2001, Maastricht

JERMANN P., SOLLER A., LESGOLD A. (DRAFT), Computer Software Support for Collaboration Learning, Kluwer CSCL Series, Draft 8, Section3.

LUDVIGSEN, S., MORCH, A. (2003). Categorisation in Knowledge Building: Task-specific Argumentation in a co-Located CSCL Environment. Proceedings of CSCL 2003, Bergen, Norway. Kluwer Academic Publishers, 67-76.

LUND, K. (2004). Human Support in CSCL : what, for whom, and by whom ? In J.-W. Strijbos, P. Kirscher & R. Martens (Eds.). What we know about CSCL in Higher Education. pp. 167 -198. Dordrecht : Kluwer Academic Publishers.

MANLOVE, S. (2004). Interaction analysis with CoLab. Internal report.

MARTINEZ A., DIMITRIADIS Y., DE LA FUENTE P., (2003), Contributions to analysis of interactions for formative evaluation in CSCL, Chapter in book "Computers and education. Towards a lifelong learning society (editors: M. Llamas, M.J. Fernandez, L.E. Anido), Kluwer Academic, 227-238

MARTINEZ A., DIMITRIADIS Y., GOMEZ E., RUBIA B., DE LA FUENTE P., (2003), Combining qualitative and social network analysis for the study of classroom social interactions, Computers and Education, special issue on Documenting Collaborative Interactions: Issues and Approaches, vol 41, no. 4, pp. 353-368

MARTINEZ A., DE LA FUENTE P., DIMITRIADIS Y., (2003), An XML-based representation of collaborative interactions, International Conference on Computer Supported Collaborative Learning (CSCL 2003), Bergen, Norway

MORCH A., DOLOGEN J., OMDAHL K., (2003). Integrating Agents with an Open Source Learning Environment. In: Chee Y S, Law N, Lee K-T, Suthers D, ed. Proceedings of International Conference on Computers in Education 2003 (ICCE 2003), Dec. 2-5, Hong Kong: AACE Press, 393-401.

VEERMANS, K. H., & VAN JOOLINGEN, W. (1998). Using Induction to Generate Feedback in Simulation Based Discovery Learning Environments. Intelligent Tutoring Systems, 5, 196-205.

VEERMANS, K. H., & VAN JOOLINGEN, W. (in preparation). Combining heuristics and formal methods in a tool for supporting simulation-based discovery learning. Paper to appear in _Lecture Notes of Computer Science_.

VEERMANS, K. H., VAN JOOLINGEN, W., & DE JONG, T. (in preparation). Using Heuristics to Facilitate Discovery Learning in a Simulation Learning Environment in a Physics Domain. Submitted for publication.

VERDEJO M. , BARROS B., READ T.,& RODRIGUEZ-ARTACHO M., A system for the Specification and Development of an Environment of Distributed CSCL Scenarios, In CERRI S., GOUARDERES G., & PARAGUACU (Eds): ITS2002, LNCS 2363, pp. 139-148, 2002, Springer-Verlag Berlin Heidelberg 2002.

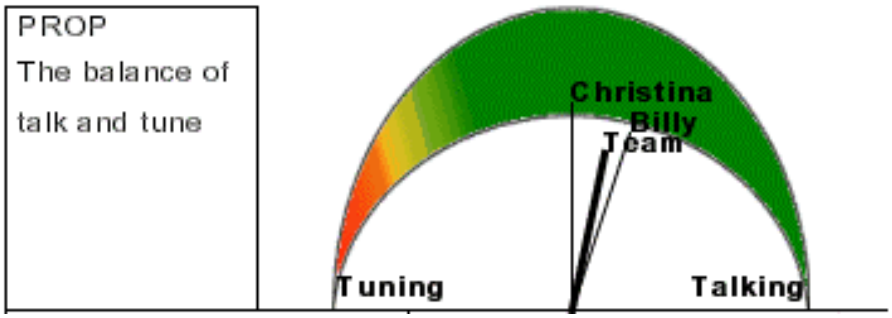
VOSNIADOU ST.& KOLLIAS V., Using Collaborative, Computer-Supported, Model Building to Promote Conceptual Change in Science, In Powerful learning environments: Unraveling basic components and dimensions, E. De Corte, L. Verschaffel, N. Entwistel and J. Van Merrienboer (Eds.), Advances in Learning and Instruction, Elsevier Press, 2003.

5. Annex

In this annex, there are presented in a brief but sufficient manner the Interaction analysis indicators, introduced and applied by research laboratories' groups, in a rich variety of learning environments. In case, that a specific interaction analysis tool, external of the learning environment was used in order to visualize the indicators, and to present them to the learning activity participants, these tools are also briefly presented.

An.1. Indicators: laboratory CRAFT/EPFL

An.1.1. "Conversation and action balance" Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Conversation and action balance**
CONCEPT of indicator	This indicator reflects the balance between the production of problem-solving actions and dialogue related actions. The indicator relies on a rough distinction between two aspects of problem-solving: planning and evaluating action (in dialogue) and implementation (doing actions on a simulation interface).
Indicators' Value FORM	The figure shows the visual form presented to the students once a minute. The "pie" is colored red on the left side (titled "tuning", these are the actions in the context that the indicator was developed in) and green on the right side (titled "talking"); hence, this particular presentation of the indicator contains a normative aspect (green is good, red is bad). There is one "needle" for each student and one for the team. 
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	The indicator relies on a proportion (Talk-Action Proportion TAP) that is based on the number of words produced and the number of manipulations of the simulation (e.g. change a parameter). The proportion is computed every minute for a given number of time intervals (typically 5 times 1 minute)
"ANALYSIS" POINT OF VIEW:	**PROCESS ORIENTED**

INDICATOR CALCULATION: "DATA PROCESS METHOD"

(a) First, we compute the total number of actions and words over n sequences to be included in the indicator.

$$actions_{tot} = \Sigma actions_i = actions_1 + \ldots + actions_n$$
$$words_{tot} = \Sigma words_i = words_1 + \ldots + words_n$$

(b) Then, for each sequence i we compute the relative proportion of actions and words in this sequence relatively to the total number of actions and words. This results in 2 * n values that represent the contribution of each sequence to the overall number of actions. The sums of the pactionsi as well as the sum of the pwordsi are equal to 1.

$$pactions_i = actions_i / actions_{tot}$$
$$pwords_i = words_i / words_{tot}$$

where:

$$\Sigma actions_i = 1$$
$$\Sigma pwords_i = 1$$

(c) Finally, we compute the TAP indicator by summing the differences between the relative proportions of actions and words. The final index varies between –n to +n.

$$TAP = \sum_i^n \frac{pactions_i - pwords_i}{pactions_i + pwords_i}$$

As an example, let's take the case of n=5 sequences. The two first rows of Table 1 contain the number of actions and the number of words produced by a subject during 5 sequences. Note that there were no actions produced in sequence 3 and that there were no words produced in sequence 4.

Step (a) is illustrated by the last column of the two first rows of Table 1 which contains the total number of actions and words produced during the five sequences.

Step (b) is illustrated in Table 1 as well. The proportions for each sequence correspond to the count of events divided by the row total. For example, the first cell in Table 1 for Pactions contains 0.28 which corresponds to 5 actions at that sequence divided by 18 actions total during the five sequences.

Step (c) consists adding up the relative action and word proportions from Table 1 as follows:

$$TAP = (.15 / .41) + (-.16/ .38) + (-.47 / .47) + (.11 / .11) + (-.37 / .63) = -0.6425$$

Table 1: Talk-Action Proportion (TAP) calculation

			Sequence (i)					
			1	***2***	***3***	***4***	***5***	Total
Step	(a)	Actions	**5**	2	0	2	9	**18**
		Words	2	4	7	0	2	15
	(b)	Pactions	**.28**	.11	0	.11	.50	1
		Pwords	.13	.27	.47	0	.13	1
	(c)	Pactions-Pwords	.15	-.16	-.47	.11	-.37	
		Pactions+Pwords	.41	.38	.47	.11	.63	
		(Pactions-Pwords) /(Pactions+Pwords)	.37	-.42	-1.0	1.0	-.59	**-0.64**

	This negative value of TAP indicates a slight tendency towards Talk versus Action. This is quite different from the conclusions drawn from a simple comparison of the total number of actions with the total number of words. As a matter of fact, this comparison would have given the advantage to the actions (18 actions > 15 words). However, because we compare the relative proportions of actions and words, the weight of actions and words are independent. The 2 actions in sequence 4 count as much as the 7 words in sequence 3, both result in a value of –1 and +1 respectively. Looking at sequence 2, 2 actions account for 11% of the total number of actions and 4 words account for 27% of the total number of words. This gives the 4 words more weight in the final comparison (27% > 2*11%).
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	The indicator varies according to the number of sequences (time periods) that are taken into account. For n time periods, it varies from –n to +n. We used it in an experimental study with 5 time periods. A value of -5 indicates pure action (tuning traffic light parameters in a collaborative traffic simulation) without dialogue. A value of + 5 indicates pure dialogue without any implementation. A value of 0 indicates a balance between action and dialogue . The visual form of the indicator attaches a positive meaning to negative values of the indicator ("it is better to talk together rather than silently pursue a trial and error strategy").

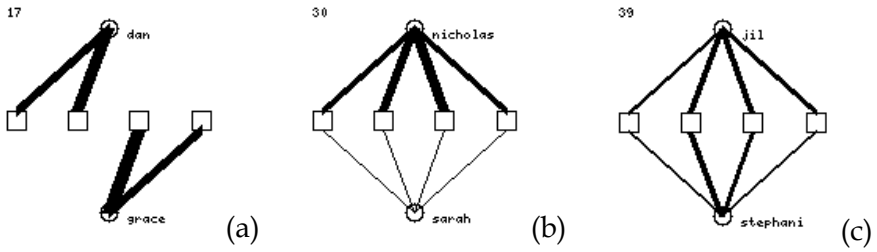
B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* **SOCIAL/COLLABORATIVE, COGNITIVE, MANAGERIAL** The goal of the indicator (as presented in its visual form) is to foster more reflexive problem-solving. By giving talking a positive connotation ("it is good to talk more than to implement things"), we hoped to foster the production of plans as well as a more explicit discussion of the division of labor and other social rules that govern collaboration. **2. What indicator users could do on the base of this information?** The indicator can serve many purposes depending on the analysis that is made. For instance, because it displays values for both collaborators, it could be used as a basis for reflections about the division of labor (e.g. one person does all the actions while the other does only talk). Given that collaborators know that planning is an important aspect of problem-solving, they could use the value of indicator to diagnose whether they are discussing the problem often enough.
INDICATOR USER	**THE STUDENT, THE TEACHER, THE RESEARCHER** *To whom is addressed?*

	The visual form presented earlier is addressed to the students. However, the underlying indicator could be useful for a teacher as well as for the researcher. A teacher could for instance use it to monitor the "level of interactivity" or the "verbosity" of students. The researcher can use it in covariance analyses to relate it to learning outcomes conditions or as a dependent measure to evaluate the effect of an intervention.
TIME OF USE	The indicator is displayed during the interaction and it is updated once a minute.
INFORMATION INTERPRETATION AMBIGUITY	1. Low *2. Information interpretation: short description* Because of the normative information that is displayed alongside the indicator, the interpretation is straightforward (e.g. "we do not talk enough"). More sophisticated interpretations are possible (e.g. in terms of division of labor), but they require that the students or the teacher hold a "psychological" model of interaction that can be used to diagnose the indicator.
USE OF INDICATOR	
MODE OF INDICATOR USE	The students use the graphical form of the indicator as a tool to support the regulation of their interaction. Experimental results show that the presentation of the indicator had positive effects on the verbosity, the number of plans produced and on the precision of these plans. On-line use.

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	The indicator is computed by the system based on Java Events before being written to the logfile. It could however be computed by parsing a logfile that contains at least the following items. {logfile}:{time stamp, action_code, user} action_code is either SEND_NOTE or ACTION
CONCEPTUAL DIAGRAM of raw data collection	

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	COTRAS : COllaborative TRAffic Simulator
CATEGORY OF LEARNING ENVIRONMENT	**COLLABORATIVE PROBLEM SOLVING, EXPERIMENTAL TOOL**
LE ACTIVITY TOOLS	Chat and Traffic Simulation
Learning Environment USER PROFILE:	**ADULT STUDENT**
TASK category:	**PROBLEM SOLVING, EXPERIMENTATIONS** *Short Description* Our subjects' task consists of tuning a traffic-light simulation by adjusting the timing of traffic lights in a way to minimize the cars' waiting time at intersections. A shared simulation presents the traffic situation and can be acted upon by the two subjects simultaneously. The task belongs to the complex dynamic systems category.
CONTENT TYPE:	**LOW CONCEPTUAL** *Short Description* The task requires that subjects understand three heuristic strategies to tune traffic lights correctly. An intuitive approach based on proportions of flows can be applied to obtain satisfactory results. The task is very practical, and does not require a high level of conceptual reasoning, except aspects related to the control of complex dynamic systems (e.g. latency between changes and effects, propagation of changes through the system, and so on).
DIVISION OF LABOUR:	**CONTIGUOUS, PEER TO PEER FREE, DISTRIBUTED, ….** The division of labour is up to the subjects. They can for instance split the task by each choosing a part (a subset of intersections, or a subset of flows) of the traffic situation. Another way to divide labour consists of one subject doing all the implementation and both subjects participating in planning the changes. Still another way consists of equally participating in implementation on all intersections.
USERS' COMMUNITY	**TWO PERSON GROUP, extendable to more** The indicator can be computed for one person. However, it is unlikely that individuals will use a chat tool to share plans and evaluations with themselves. Taking the average of the indicator for several people or presenting a comparison thereof adds the social dimension to the indicator. We tested the indicator with two person groups, but it could be used up to 10 users. The visual form of the indicator should probably be adapted for larger groups.

An.1.2. Division of Labor indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Division of Labor**
CONCEPT of indicator	This indicator reflects the division of labor adopted by two persons who act on a set of resources (e.g. intersections in a traffic simulation, parts of a conceptual diagram, etc.). It is possible to identify three types of division of labor based on the indicator. ⇨ Task based division of labor consists of each person acting on separate resources. ⇨ Role based division of labor consists of one person doing all the actions on all resources. ⇨ Concurrent division of labor consists of both subjects acting more or less equally on all resources.
Indicators' Value FORM	The figure below illustrates the three types of division of labor. Circles represent subjects; Rectangles represent resources (in our case intersections in a traffic simulation). The thickness of lines connecting subjects and resources represent the proportion of actions performed by the subjects on each resource. The proportions sum up to 1 for each intersection. (a) Task based (b) Role based (c) No division, Concurrent editing. Squares represent resources and circles represent persons.  Figure 1. Visualization of the division of labor. The figure below show the visual representation of the division of labor for 43 pairs in one of our experimental studies. Each pair is represented by a point in the graph. Circles represent Concurrent division of labor, diamonds represent Task based division of labor and triangles represent Role based division of labor. More details about the calculation of the coordinates of each point are given below. ----------→

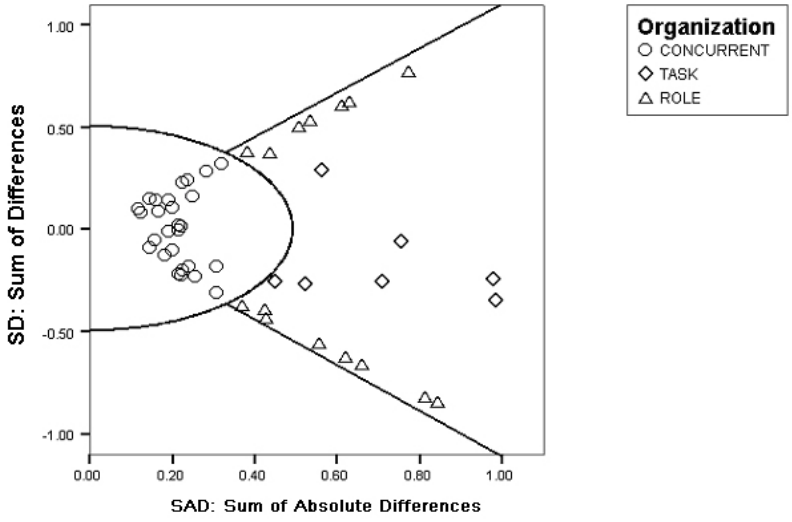


Figure 2 Three types of division of labor.

It is also possible to represent the evolution of the indicator over time. In the graphs below, the large square represents the overall division of labor (considering the whole interaction) and the smaller squares represent the evolution of the division of labor over time.

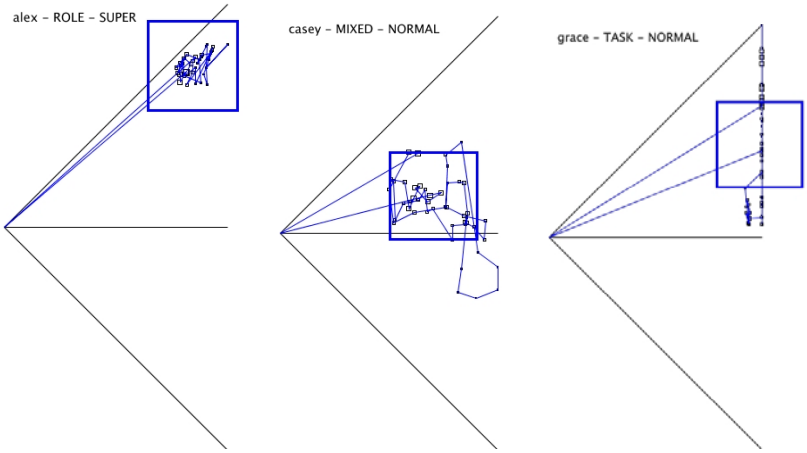
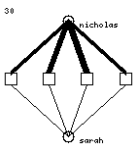
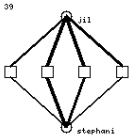
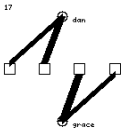
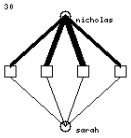


Figure 3 Evolution of the division of labor.

"ANALYSIS" POINT OF VIEW:	PROCESS ORIENTED
INDICATOR CALCULATION: "DATA PROCESS METHOD"	The formal definition of the three types of division of labor relies on two variables based on the difference between the counts of actions made by each subject on each resource: the sum of differences (SD) and the sum of absolute differences (SAD). In the two equations below, S1 and S2 stand for Subject 1 and Subject 2. A stands for Action. S1A and S2A stand for the total number actions made by Subject1 and Subject2 respectively, regardless of the resource. The index i (1 to 4) corresponds to the resources (four in this case) so that S1A1 represents the number of actions made by Subject 1 on resource 1. The sum of differences (SD) varies between -1 and +1 and gives an indication about who made more actions, regardless of the resource. A value of -1 indicates that S2 made all the actions, a value of +1 indicates that S1 made all the actions and a value of 0 indicates that both subjects participated equally to the production of actions. $$SD = \frac{\sum_i (S1Ai - S2Ai)}{S1A + S2A}$$ The sum of absolute differences (SAD) varies between 0 and +1 and gives an indication about the overall asymmetry of tunings. A value of zero indicates that both subjects made exactly the same number of tunings and a value of +1 indicates that all the tunings were made by one subject. $$SAD = \frac{\sum_i \left|S1Ai - S2Ai\right|}{S1A + S2A}$$ Our definition of the division of labor relies on the combination of these two variables. Table 2 contains the graphical representations of the prototypical cases defined by the values of SD and SAD. SD differentiates cases where both subjects participated equally (SD = 0) from the cases where one subject dominated the actions (SD = -1 and SD = +1). SAD allows to differentiate the cases where both subjects did actions upon all resources (SAD = 0) and the cases where subjects specialized on a separate set of resources (SAD = 1). ----------→

DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	The indicator relies on a two variables that are based on the number of actions produced by each subject on each resource. The indicator can be computed for arbitrary time intervals. The definitions of action and resource encompass any action that can be computationally identified. We used manipulations of graphical controls as a basis for the indicator, but we imagine that the same calculations are possible with clicks on sentence-openers in a dialogue interface. The division of labor would then correspond to different speech-acts used by subjects.

Table 2 Formal definition of the Division of Labor

	Sum of Absolute Differences (SAD)	
Sum of Differences (SD)	0	1
1	N / A	Role 
0	Concurrent 	Task 
-1	N / A	Role 

We now define two formal criteria that would enable a system to establish the type of division of labor that a pair adopts. The scatter plot in Figure 2 shows the position of 43 pairs with the SAD represented on the horizontal axis and the SD represented on the vertical axis. Table 2 might help to interpret the positions on the scatter plot. The circles on Figure 2 correspond to the Concurrent division of labor, the diamonds correspond to the Task division of labor and the triangles correspond to the Role division of labor.

- When SAD and SA are both between -0.5 and 0.5, the subjects participate more or less equally to the implementation, thus adopting a Concurrent division of labor. This constraint is represented in Figure 2 by a circle centered at the origin (0;0) with a radius of 0.5. The criterion is that the distance from the origin is smaller or equal to 0.5.This corresponds to the situation where either subject at least made 25% of the implementation actions.
- When SAD and SD are equal (regardless of their sign), pairs are situated on the diagonals drawn on Figure 2. When a pair's position is close to the diagonal and that it is out of the circle, one of the subjects has made more than 75% of the actions

	on all resources. The pair divided labor in terms of Role, one subject making nearly all the implementation. The rest of the pairs are situated in the centre of the graph, outside of the circle and away from the diagonals. These pairs adopted a Task based division of labor. Each subject works on separate resources. These pairs would ideally be situated on the x-axis of the graph at SAD = 0. They are not exactly situated on the x-axis because one subject usually does slightly more actions than the other.

VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	The indicator relies on two variables that vary between 0 and 1; -1 and +1 respectively. The indicator can be computed for arbitrary time intervals. However, it makes sense to consider intervals that contain at least as many actions as there are resources.

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* **SOCIAL/COLLABORATIVE, COGNITIVE, MANAGERIAL** The goal of the indicator is to allow identification of different types of division of labor. It does not contain normative information. The interpretation and diagnosis is left to the teacher or the students with respect to a "psychological" model of desired interaction. **2. What indicator users could do on the base of this information?** The indicator about division of labor can serve different purposes. One possibility is to enforce the use of a particular division of labor, for example Concurrent. Whenever the position of the pair on Figure 2 is outside the circle centered on (0;0) the teacher could intervene and ask students to work together on the same resources. Another way to use the indicator would be to use it in order to adapt other types of interventions. For example, is the division of labor is Role based, one could encourage the "implementer" to also participate in dialogue; or encourage the other learner to evaluate the implementations.
INDICATOR USER	**THE RESEARCHER** *To whom is addressed?* The indicator and the visual forms presented earlier are primarily addressed to the researcher. The visualization and the variables that underlie the indicator are rather complex to understand. The drawings in Figure 1 could however be used as a graphical feedback to the students or a teacher.
TIME OF USE	The indicator can be computed during the interaction for an arbitrary

	timespan.
INFORMATION INTERPRETATION AMBIGUITY	1. Low *2. Information interpretation: short description* The interpretation of the visual form of the indicator is rather simple based on the three types of division of labor that we identified. It is more difficult to relate a given type of division of labor at a given time to the student's activity. Another indicator should be used simultaneously to allow the researcher or the teacher to assess whether the current division of labor is adequate, or productive.
USE OF INDICATOR	
MODE OF INDICATOR USE	The researcher uses the graphical and numeric form of the indicator to identify division of labor. In our experiments, we used the proportion of sequences (one sequence is about 2 minutes) classified as Concurrent, Role, Task as covariates to study whether different types of division of labor lead to more organization messages. It appears that more organization messages ("you do it", "shall I proceed") were produced in Role based division of labor.

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	The indicator is computed by the system based on Java Events before being written to the logfile. It could however be computed by parsing a logfile that contains at least the following items. {logfile}:{time stamp, action_code, user, resourceID} action_code is ACTION resource_id refers to the resource that the action targets
CONCEPTUAL DIAGRAM of raw data collection	

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	COTRAS : COllaborative TRAffic Simulator

CATEGORY OF LEARNING ENVIRONMENT	**COLLABORATIVE PROBLEM SOLVING, EXPERIMENTAL TOOL**
LE ACTIVITY TOOLS	Chat and Traffic Simulation More generally, the indicator described here requires that actions upon a number of resources can be separately identified.
Learning Environment USER PROFILE:	**ADULT STUDENT**
TASK category:	**PROBLEM SOLVING, EXPERIMENTATIONS** ***Short Description*** Our subjects' task consists of tuning a traffic-light simulation by adjusting the timing of traffic lights in a way to minimize the cars' waiting time at intersections. A shared simulation presents the traffic situation and can be acted upon by the two subjects simultaneously. The task belongs to the complex dynamic systems category.
CONTENT TYPE:	**LOW CONCEPTUAL** ***Short Description*** The task requires that subjects understand three heuristic strategies to tune traffic lights correctly. An intuitive approach based on proportions of flows can be applied to obtain satisfactory results. The task is very practical, and does not require a high level of conceptual reasoning, except aspects related to the control of complex dynamic systems (e.g. latency between changes and effects, propagation of changes through the system, and so on).
DIVISION OF LABOUR:	**CONTIGUOUS, PEER TO PEER FREE, DISTRIBUTED, ….** The division of labour is up to the subjects. They can for instance split the task by each choosing a part (a subset of intersections, or a subset of flows) of the traffic situation (Task). Another way to divide labour consists of one subject doing all the implementation and both subjects participating in planning the changes (Role). Still another way consists of equally participating in implementation on all intersections (Concurrent).
USERS' COMMUNITY	**TWO PERSON GROUP** The indicator can be computed for two persons and n resources. We tested the indicator with four resources, but it could be with more. The visual form and the formula to compute the indicator should be adapted for larger groups of people.

An. 1.3. Activity Level Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Activity Level**
CONCEPT of indicator	This indicator reflects the level of activity of groups who use an online pedagogical project manager. It shows the contributions of different role groups (students, teachers) to the production of files and messages. The goal of the visual form is to enable a teacher to quickly indentify groups which need help or encouragement.
Indicators' Value FORM	The visual form consists of an interactive SVG file. Teachers can navigate from the global view of the class to the local view of a particular group my clicking on the small circles. Figure 4 View of a class. Circles represent groups. ⇨ The color of circles represents the marks that the groups obtained. ⇨ The size of the circles represents the average length of messages that were posted by the members of the groups. ⇨ The distance to the center of the large circle represents the overall activity (the closer to the center, the more messages and files were produced in the environment). The box to the right shows the email addresses of the group members, as well as the number of files and messages that were posted by the group that is selected. Groups who are late with regard to the deadline for a deliverable appear in red. ---------→

	 Figure 5 View of a group, circles represent students, squares represent teachers. The color of the shapes represents the recency of the activity. Purple color shows recent messages and blue color represents older messages. The distance of the shapes to the center of the large circle represents overall activity (files and messages) for each user.

DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	The indicator relies on a count of files and messages as well as on the size of the messages that are posted by members of study groups.
"ANALYSIS" POINT OF VIEW:	**STRUCTURAL/STATE ORIENTED, AUTHORSHIP ORIENTED**

INDICATOR CALCULATION: "DATA PROCESS METHOD"	The distance to the center of the circle in the visualization represents an overall indicator of activity. It is computed by giving a different weight (coeff) to messages and files. Indeed, in our case there were more messages produced than files. Distance = CoeffMessages×NbMessages+CoeeffFiles×NbFiles In order to arrange the points around the large circle we use the following formulas: $X = O_x + R \times \sin(\frac{2\pi n}{N})$ $Y = O_y + R \times \cos(\frac{2\pi n}{N})$ $0 \leq n < N, n \in \mathbb{N}$ where N is the number of groups Ox and Oy are the coordinates of the center of the circle. R is the radius of the circle In order to normalize the distance to the center (so that is varies from 0 to 1) we use the following formula that implements the indicator: $CoeffGlobal = \frac{\frac{Mg}{Mt} + \frac{Fg}{Ft}}{2}$ where : Mg is the number of messages produced by a group Mt is the total number of message produced by all groups Fg is the number of files produced by a group Ft is the total number of files produced by all groups The combination of the two formulas above leads to the following expression of the x and y position for a group $X = O_x + (R - CoeffGlobal \times R) \times \sin(\frac{2\pi n}{N})$ $Y = O_y + (R - CoeffGlobal \times R) \times \cos(\frac{2\pi n}{N})$ $0 \leq n < N, n \in \mathbb{N}$ The visual form also contains indications about the size and recency of messages, as well as about the marks obtained and the punctuality of deliverables. These dimensions are expressed as type of shapes, colors and size . Activity = f(NbMessages,NbFiles, SizeMessages,DateMessages,Mark,Punctuality) The visualization is obtained by an XSLT transformation of the system state, which is represented in a large XML file.

VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	The calibration consists of determining how much importance is given to the number of files and the number of messages respectively (CoeffMessages and CoeffFiles above). It is possible to display the distance based only messages or only files by assigning coefficients of zero to either component.

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* **MANAGERIAL** The goal of the indicator (as presented in its visual form) is to help teachers identify groups which need help or encouragement. When tutoring many online groups it is difficult to have a general overview of the level of activity. The purpose of this indicator is to act as a alert. The indicator does not give information about the quality of the messages, or files that are produced by the groups. **2. What indicator users could do on the base of this information?** The indicator can help a teacher to identify active and inactive groups.
INDICATOR USER	**THE TEACHER** *To whom is addressed?* The visual form presented earlier is primarily addressed to the teachers. However, the visualization could could also be displayed to students to create a sense of community and maybe of competition among groups.
TIME OF USE	The indicator is displayed on demand during the course of the avtivity (which typically lasts a whole semester).
INFORMATION INTERPRETATION AMBIGUITY	1. Low *2. Information interpretation: short description* The information is straightforward to interpret. The center of the large circle represents good behavior (active groups). Hence, groups which are at the periphery of the circle need help and encouragement.

USE OF INDICATOR	
MODE OF INDICATOR USE	The teachers can use the graphical form of the indicator as a tool to identify problematic groups. This particular indicator and its visual form were developed as a semester project and were not actually used by the teachers. However, the data that is visualized corresponds to 35 real groups working on a project.

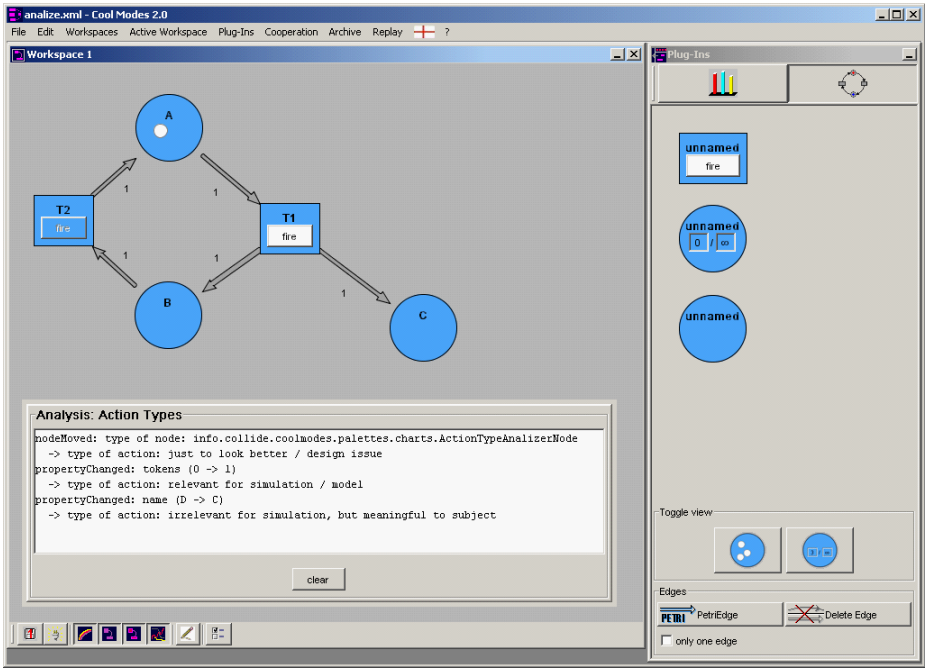
C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	The indicator is computed by the system based on an XML file that describes the groups, the projects, the phases (with deadlines), the messages, and the files delivered.
CONCEPTUAL DIAGRAM of raw data collection	

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	Teamframes
CATEGORY OF LEARNING ENVIRONMENT	**Online Pedagogical Project Manager**
LE ACTIVITY TOOLS	Weblog and File Repository implemented as a Postnuke module Demo at http://teamframes.epfl.ch/ Login: student / student Login: teacher / teacher
Learning Environment USER PROFILE:	**TEACHER, ADULT STUDENT**
TASK category:	**PROJECT MANAGEMENT** *Short Description* The students work in groups of five during a whole academic year on a project about management of technology. The teacher determines a series of phases and deliverables that the students have to produce. The environment serves as a discussion forum and a file repository. The users have access to a Gant Chart like visualization of their project and also have access to the files and messages produced by other groups.
CONTENT TYPE:	**HIGH CONCEPTUAL**

	Short Description The task requires that the students write a report about concepts in management of technology. Each teacher can structure the project differently, assign various roles to the students. The indicator that we described above is independent of the content of the course.
DIVISION OF LABOUR:	**CONTIGUOUS, PEER TO PEER FREE, DISTRIBUTED, ….** The division of labour is up to the students and the teacher
USERS' COMMUNITY	**FIVE PERSON GROUP, CLASS of 35 GROUPS** The community for a user is the study group, and the whole class which participates in the course. The visual for of the indicator can be computed for one person or one group. In the first case, the indicator informs about the individual contributions of the members of a group. In the second case, the indicator informs about the overall activity of a group.

An.2. Indicators: laboratory COLLIDE

An.2.1. Action classification Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Action classification**
CONCEPT of indicator	Abstraction from low-level information to user-readable format
Indicators' Value FORM	Textual. 
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	Type of each action conducted by users
"ANALYSIS" POINT OF VIEW:	Processing action-oriented
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Looking up classification table and assigning appropriate classification
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	none
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	Calibration embedded in classification table, which is specific for each plugin

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* COGNITIVE/MANAGERIAL **2. What indicator users could do on the base of this information?** *?* *teachers could try to stimulate students, when classification is of low contribution for the task]* *student could self-regulate their behaviour, when the classifications show little relevance*
INDICATOR USER	**TO [THE STUDENT, THE TEACHER, THE RESEARCHER]**
TIME OF USE	Usually on-the-fly visualization
INFORMATION INTERPRETATION AMBIGUITY	1. medium 2. description Classification is fixed for the plugin, so designer has to assign categories carefully
USE OF INDICATOR	
MODE OF INDICATOR USE	*see purpose*

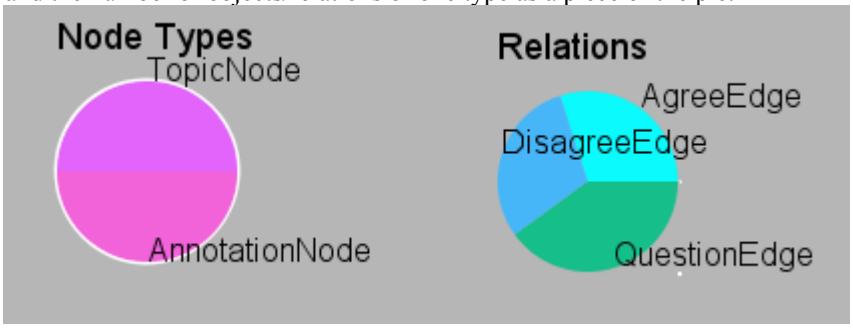
C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	{action trace}:{type of action}
CONCEPTUAL DIAGRAM of raw data collection	** Figure N. **?**

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	Cool Modes, FreeStyler.

CATEGORY OF LEARNING ENVIRONMENT	**[COLLABORATIVE PROBLEM SOLVING, SHARED WORKSPACE]**
LE ACTIVITY TOOLS	**DIVERSE, RANGING FROM CHAT TO EXECUTABLE MODELS**
Learning Environment USER PROFILE:	**all**
TASK category:	**[ARGUMENTATION, MODELLING]**
CONTENT TYPE:	all the spectrum, depends on the task
DIVISION OF LABOUR:	Free division of labour
USERS' COMMUNITY	**[**small groups**]**

References	*Harrer, A., Bollen, L., Klassifizierung und Analyse von Aktionen in Modellierungswerkzeugen zur Lernerunterstützung, Workshop Modellierung 2004, Marburg, 2004.*

An.2.2. Object/Relation type's ratio Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Object/Relation type's ratio**
CONCEPT of indicator	The ratio of object/relation types is a measurement of the balancedness of results of modelling.
Indicators' Value FORM	Diagrammatic as a pie chart, representing the whole number of objects/relations as the pie and the number of objects/relations of one type as a piece of the pie. 
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	Relative number of objects/relations in a modelling result
"ANALYSIS" POINT OF VIEW:	Summarical state-oriented
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Counting absolute numbers in a table and calculating relative values
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	none
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	None, interpretation by the user

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* SOCIAL/COLLABORATIVE **2. What indicator users could do on the base of this information?** *?* *teachers could try to balance the ratio by stimulating e students to use other objects]* *student could self-regulate their behaviour, when the diagramm shows little/too much unbalancedness*
INDICATOR USER	**TO [THE STUDENT, THE TEACHER, THE RESEARCHER]**
TIME OF USE	Usually on-the-fly visualization
INFORMATION INTERPRETATION AMBIGUITY	1. low 2. description Counting is objective, interpretation may introduce unsure factors
USE OF INDICATOR	
MODE OF INDICATOR USE	*see purpose*

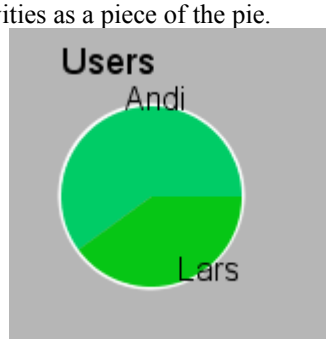
C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	{state/snapshot}:{object/relation attribute}
CONCEPTUAL DIAGRAM of raw data collection	** Figure N. **?**

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	Cool Modes, FreeStyler.
CATEGORY OF LEARNING ENVIRONMENT	**[COLLABORATIVE PROBLEM SOLVING, SHARED WORKSPACE]**
LE ACTIVITY TOOLS	**DIVERSE, RANGING FROM CHAT TO EXECUTABLE MODELS**

Learning Environment USER PROFILE:	**all**
TASK category:	**[ARGUMENTATION, MODELLING]**
CONTENT TYPE:	all the spectrum, depends on the task
DIVISION OF LABOUR:	Free division of labour
USERS' COMMUNITY	**[**small groups**]**

References	*Gaßner, K., Jansen, M., Harrer, A., Herrmann, K., Hoppe, H.-U. (2003). Analysis Methods for Collaborative Models and Activities. In Proceedings of Computer Support for Collaborative Learning CSCL2003, Kluwer Academic Publishers, Dordrecht*

An.1.3. Learner's ratio of participation Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Learner's ratio of participation**
CONCEPT of indicator	The ratio of participation is a measurement of the activeness of one individual learner in a group process..
Indicators' Value FORM	Diagrammatic as a pie chart, representing the whole number of activities a the pie and the numer of learner's activities as a piece of the pie. 
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	Relative number of actions of one user in the action trace
"ANALYSIS" POINT OF VIEW:	Summarical action-oriented
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Counting absolute numbers in a table and calculating relative values
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	none
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	None, interpretation by the user

B.) INDICATOR' STATUS:	
PURPOSE:	1. What's the purpose of the indicator? SOCIAL/COLLABORATIVE 2. What indicator users could do on the base of this information? Teachers could try to balance the ratio by stimulating non-active students] student could self-regulate their behaviour, when the diagramm shows little/too much participation
INDICATOR USER	**TO [THE STUDENT, THE TEACHER, THE RESEARCHER]**
TIME OF USE	Usually on-the-fly visualization
INFORMATION INTERPRETATION AMBIGUITY	1. low 2. description Counting is objective, interpretation may introduce unsure factors
USE OF INDICATOR	
MODE OF INDICATOR USE	*see purpose*

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	{action trace}:{user attribute}
CONCEPTUAL DIAGRAM of raw data collection	** Figure N. **?**

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	Cool Modes, FreeStyler.
CATEGORY OF LEARNING ENVIRONMENT	**[COLLABORATIVE PROBLEM SOLVING, SHARED WORKSPACE]**
LE ACTIVITY TOOLS	**DIVERSE, RANGING FROM CHAT TO EXECUTABLE MODELS**

Learning Environment USER PROFILE:	**all**
TASK category:	**[ARGUMENTATION, MODELLING]**
CONTENT TYPE:	all the spectrum, depends on the task
DIVISION OF LABOUR:	Free division of labour
USERS' COMMUNITY	**[**small groups**]**

References	*Gaßner, K., Jansen, M., Harrer, A., Herrmann, K., Hoppe, H.-U. (2003). Analysis Methods for Collaborative Models and Activities. In Proceedings of Computer Support for Collaborative Learning CSCL2003, Kluwer Academic Publishers, Dordrechtr*

An.2.4. Social Network Analysis Features (General on SNA)

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Social Network Analysis Features**
CONCEPT of indicator	Different features of social structures computed by algorithms from Social Network Analysis
Indicators' Value FORM	Numerical, can be visualized as graph
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	Structure of posting to a communication forum
"ANALYSIS" POINT OF VIEW:	SUMMARICAL/ACTION-ORIENTED
INDICATOR CALCULATION: "DATA PROCESS METHOD"	*Mathematical formula, usually summation of graph-theoretical features (number of paths, indegree, outdegree)*
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	Calibration somewhat embedded in algorithms, but no values for "good" or "bad" phenomena

B.) INDICATOR' STATUS:	
PURPOSE:	*1. **What's the purpose of the indicator?*** SOCIAL/COLLABORATIVE **2. What indicator users could do on the base of this information? ?** *teacher could stimulate non-participating students, students could try to balance their interaction between fellow students*

INDICATOR USER	**TO [THE STUDENT, THE TEACHER, THE RESEARCHER]**
TIME OF USE	Varies, since forae are asynchronous, complexity of calculation is no hindrance to provide feedback during the learning process.
INFORMATION INTERPRETATION AMBIGUITY	1. high *2. description* Interpretation of the computed features may be misleading, since usually content of contributions (even type of contribution) is not considered at all (is high participation/low quality better than the other way round?)
USE OF INDICATOR	
MODE OF INDICATOR USE	*See purpose*

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	{forum contributions}:{response-relation to other contributions} Contributions are represented by XML-documents
CONCEPTUAL DIAGRAM of raw data collection	** Figure N.

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	SPREKON
CATEGORY OF LEARNING ENVIRONMENT	**[FORUM]**
LE ACTIVITY TOOLS	**General/GroupPosting, Buddy List**
Learning Environment USER PROFILE:	**All possible**
TASK category:	**[DISCUSSION]** .
CONTENT TYPE:	Whole range
DIVISION OF LABOUR:	Not explicit, may be conducted using the content of contributions

USERS' COMMUNITY	**[**seminar group, 10 students, not used in large environment**]**

INTERACTION ANALYSIS TOOLS

** In case that the indicator(s) are produced by an independent tool, give here a brief description*

Name	***SNA for SPREKON***
Description	**Stand-alone tool parses SPREKON contributions, computes SNA features, and visualizes results with the graphic library "dot"**
Indicators kinds that could be inserted/presented	**SNA features (density, prestige, betweenness, centrality, centralization)**
Kinds of covariation (or dependence) that could be derived	
Intended Users	**Researcher, Teacher, Students**

References	*Harrer, A. Analysis and Intelligent Support of Learning Communities in Semi-structured Discussion Environment, Proc. of AIAI 2004, Toulouse (to appear August 2004)*

An.3. Indicators: laboratory LTEE/UAEGEAN

An.3.1. Overview

A) Group of Indicators

COLLABORATIVE ACTION FUNCTION (CAF)
Collaborative action (specific definition)
[global indicator]

Low level indicators:

NON VERBAL ACTION (NVA)
The percentage of the total actions in the log file that is not chat messages [NVA ~> 1 the agents are not chatting, if NVA ~> 0 then agents are just chatting or not interacting at all.]

INTERACTIONS or INTERACTIONS per channel
The number "*messages" posted* (in any channel) in the previous time slot. It can be computed for each channel separately. [e.g. chat, or specific actions: run, relations, objects, etc]

SELECTED AGENT CONTRIBUTION (SAC)
The contribution of a specific agent to the total action [e.g. student1, student2, student3, teacher] $SAC \in [0,1]$ if SAC~>0 then the agent did not act in the previous time slot while if SAC~>1 then agent monopolized the action in the last time slot.

PARTICIPATION PERCENTAGE (PART)
The participation – involvement of agents in the collaboration, [any kind of activity] $PART \in [0,1]$, if PART~>0 then none is acting, if PART~>1 then every body is acting.

AGENTS
The number of collaborative agents that posted at least one message (in any channel) in the previous time slot. It can be computed for each channel separately.

All the above indicators are processed (under selection) and they are visualised through the **COLEMON tool** (a tool external of the learning environment)

These indicators were used and tested in various combinations (in order to have specific interpretative value) in the frame of a synchronous collaborative environment. These indicators that can be processed by COLEMON, is currently used and tested in the frame of asynchronous collaboration.

B) Group of indicators

KEY POSSESSION PER PARTICIPANT [in case that the synchronous collaboration is coordinated)
Percentage of the time of key possession per participant

Messages per Participant
Number of messages sent in a chat

MAIN ACTIONS' CATEGORIES PER PARTICIPANT:
(e.g.)
Insertions of items per participant [Number]
Delete of items per participant [Number]
Modifications of items per participant [Number]

The above two-three simple indicators, they are used simultaneously in order to assess the collaborative mode between two students or the degree of the intervention of the teacher when the latter supervise or guide a group}

LIST OF ACTIVITY PRODUCT' ITEMS per category:
E.g.

- ⇨ List of each item of entities categories
- ⇨ List of each item of relations categories

ACTIVITY PRODUCT' ITEM HISTORY (members Contribution, per product' item)
It presents the history of each item of individual or collaborative activity [who is inserted it, who is modified it, etc)
It is visualised into snapshots of the shared space,

The above "indicators" are presented into the "Activity Analysis" tool, which is associated to the ModellingSpace learning environment

CAF related indicators and Content related indicators are used in conjunction with the **CORPET tool**, that visualise the history [in terms of its evolution during the time) of the individual or the collaborative product [it is a variation of video-like playback of the shared workspace in the frame of synchronous collaboration).
CORPET it is not an indicator, but a 'tool', that can be used in order to put into context and interpret the previous indicators.

Summarising:

We use two different analysis tools ['CAF', 'Activity analysis'], that incorporate a number of low level indicators as well as a high level indicator, and a tool that serve as an interpretational support tool.
The combination of the above indicators is done through an interpretative schema

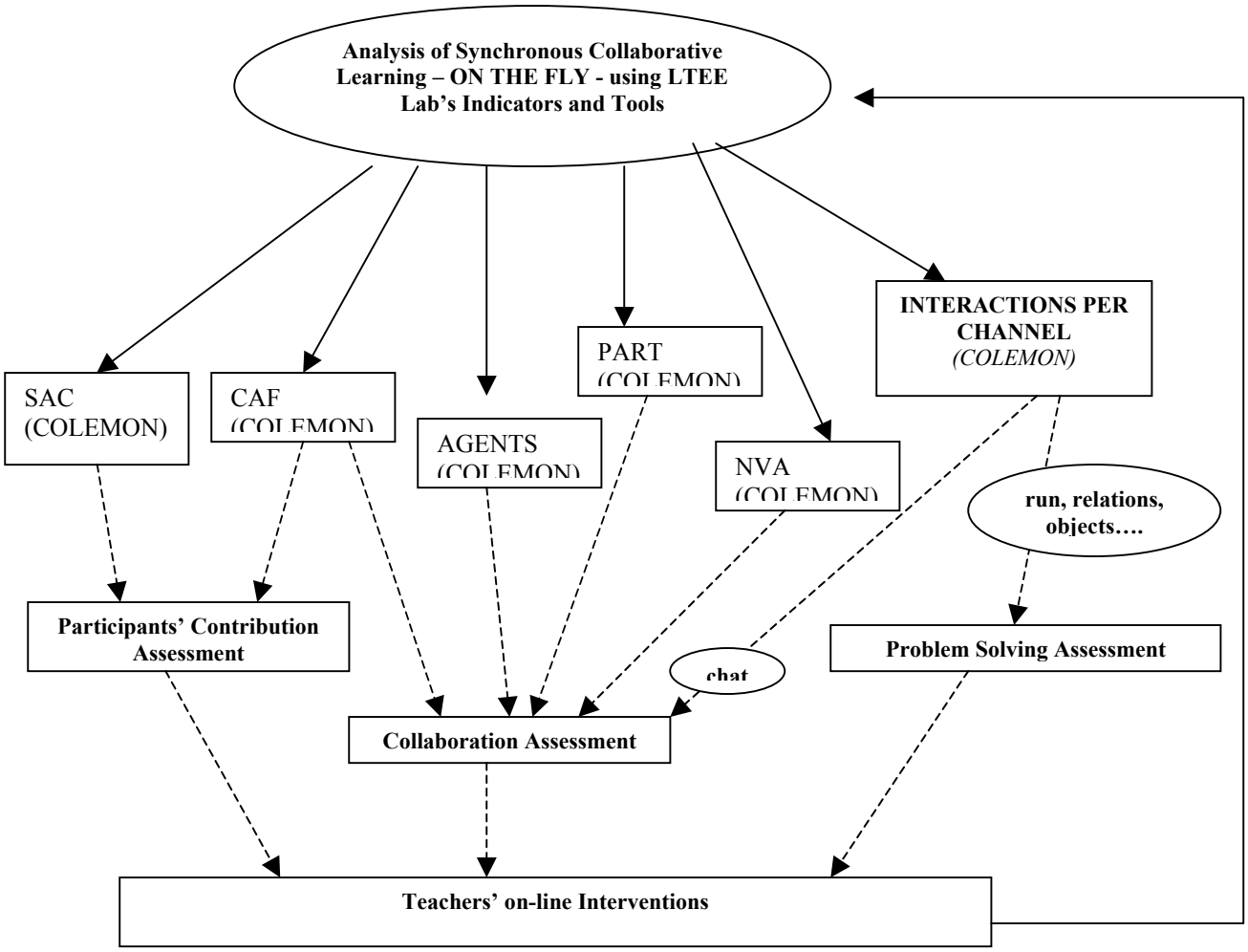


Figure N. Interpretative Schema 1 (*by Argyro Petrou*)

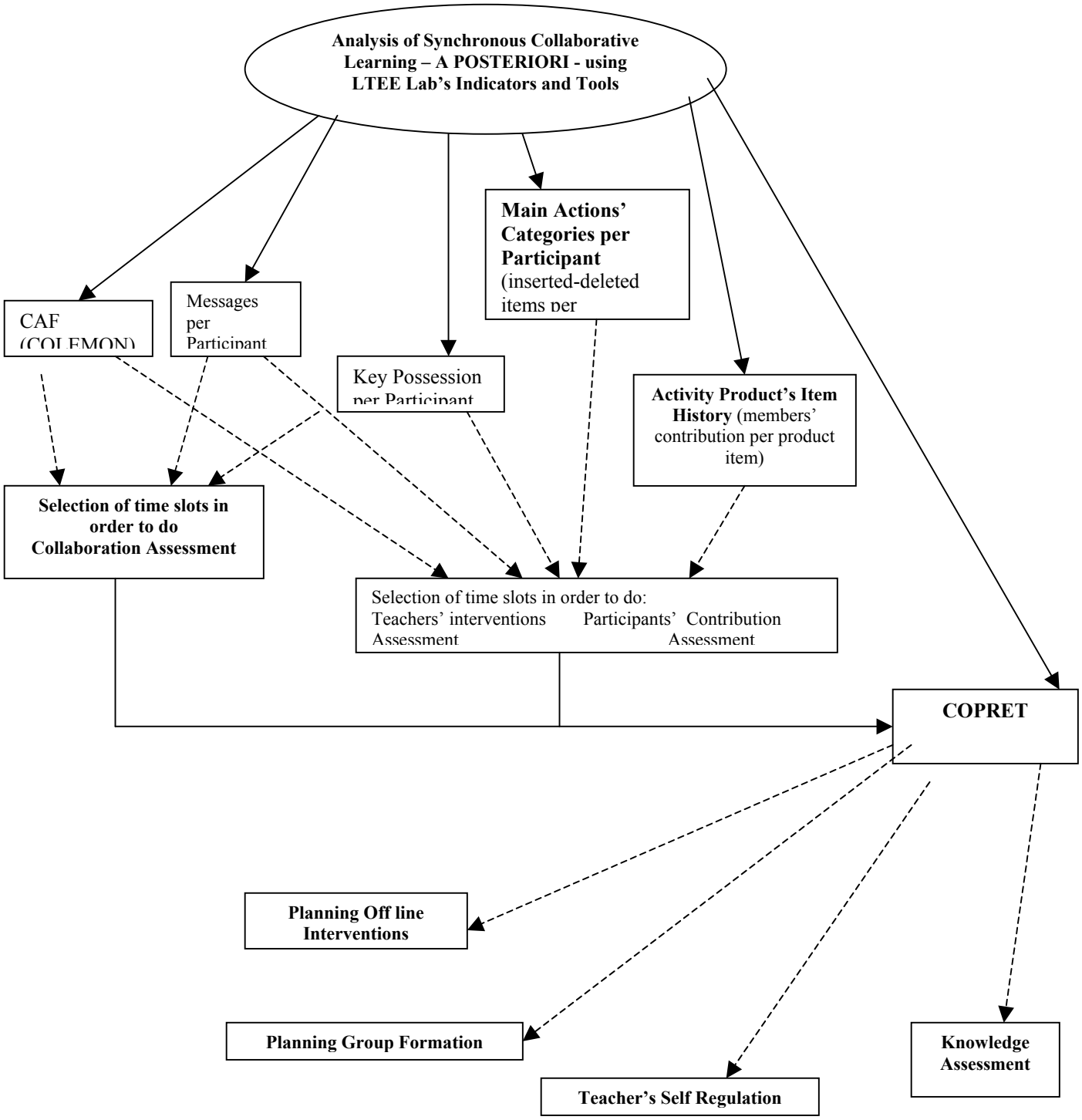


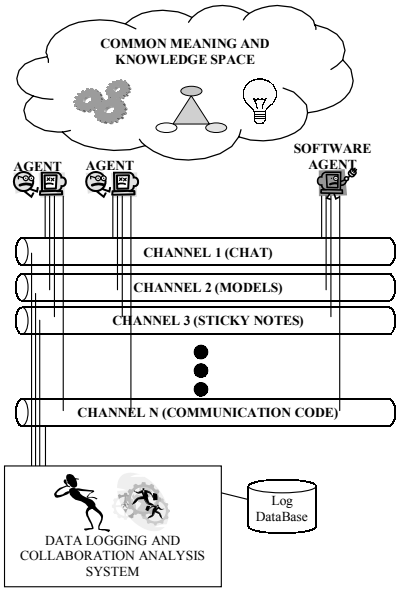
Figure N+1. Interpretative Schema 2 (*by Argyro Petrou*)

An.3.2. "Collaborative Action Function" Indicator

A) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/Symbol	COLLABORATIVE ACTION FUNCTION (CAF)
CONCEPT of indicator	Collaborative action
Indicators' Value FORM	Numerical that can be visualized Graph : CAF->time
DATA PROCESS	
DATA USED FOR ANALYSIS:	*Log file records of atomic actions.*
"ANALYSIS" POINT OF VIEW:	Action oriented.
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Mathematical formula computed by an external to the main learning environment software module. It is computed by the COLEMON Tool. Consider a collaboration session interval $[t_0\text{-}t_m]$. We quantize the time interval using a parameter n: $t_i=t_0+i*d$, where $d=(t_m-t_0)/n$. We define the collaborative action function $CA(t_i)$ as follows: $\mathbf{CA(t_i)}=\sum_{k=1}^{k\,\max} \text{Agents}(k, t_i) * \text{Interactions}(k, t_i)$ Where k values $[k:1(1)k_{max}]$ corresponds to the interaction channels {k=1=>chat, k=2=>sticks, etc}. **Agents(k,t_i):** computes the agents that have posted at least one message through channel k during $(t_{i-1}\text{-}t_i]$ interval. **Interactions(k,t_i):** expresses the amount of interactions that have implemented through channel k during $(t_{i-1}\text{-}t_i]$.
DIAGRAMMATIC DESCRIPTION OF INDICATORS CALCULATION	-
VALUES CALIBRATION	
INDICATOR VALUES' CALIBRATION	Information is produced by the comparison of curves rather than absolute values.

B) INDICATOR' STATUS:	
PURPOSE:	**MANAGERIAL, SOCIAL/COLLABORATIVE,** **[MONITORING, ASSESSMENT, SELF-REGULATING, DIAGNOSTIC.** **A. As a diagnostic tool for the teacher.** **(1.) During the collaboration: a.** Evaluation of the collaborative action of the group. **b.** Selection of time points for teacher intervention or more detailed observation. **c.** Assessment of agents' contribution to the collaborative action. (**2.) After the collaboration session: a.** Detection of critical time points for further analysis (through other analysis' tools). **b.** Collaboration quality and cognitive problems' diagnosis. **c.** Design of the next didactical activities. **d.** Students' assessment. **B. As teachers' or students' style pattern estimator:** **(1.)** CAF can be used to estimate the style of teachers ('facilitator' or 'instructive') as well

	as the style of students (initiative-active or pathetic, collaborative or competitive). (**2.**) Furthermore, CAF can be used as a mirror in order for the agents to be aware of their collaboration style pattern. C. Other applications: Comparison and assessment of collaborative learning tools: CAF is highly independent from its born environment (MODELLINGSPACE) and could be applied in several collaborative learning environments compatible to the general model of figure 1, for assessment and comparison
INDICATOR USER	The teacher, the researcher,
TIME OF USE	***During and after collaboration.***
INFORMATION INTERPRETATION AMBIGUITY.	If there is action - LOW Who is acting - LOW What communication channel is used - LOW Compare the contribution of each agent and/or channel to the total action - MEDIUM.
USE OF INDICATOR	
MODE OF INDICATOR USE	***It is used by the teacher to see if there is any progress in the problem solving process in terms of model development.***

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	Id | time | user | action | attribute | typology | comments
CONCEPTUAL DIAGRAM OF RAW DATA COLLECTION.	 **Figure 1.** Logical topology of synchronous collaboration

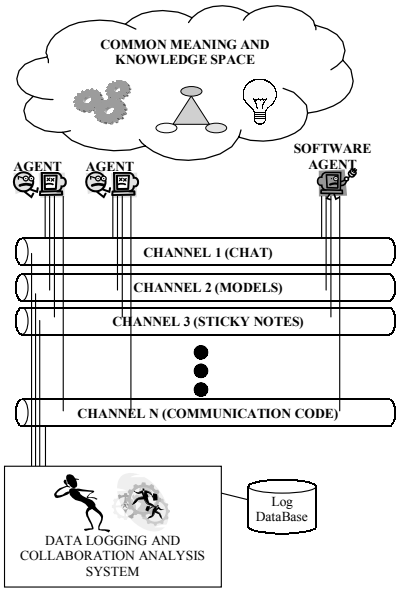
D). LEARNING ENVIRONMENT:	
LEARNING ENVIRONMENT NAME:	MODELLINGSPACE
CATEGORY OF LEARNING ENVIRONMENT	Collaborative Problem Solving
ACTIVITY TOOLS	Chat, Common Work Space, Memo Sticks, Specific Tools Features
USER PROFILE:	Teacher, Researcher, Students
TASK CATEGORY:	Synchronous collaborative model development for general problem solving.

CONTENT TYPE:	A broad variety.
DIVISION OF LABOUR:	Problem solving and modelling are not usually decomposable in a general and obvious way. It demands intentional interaction and communication. Participants decide the work distribution while they work. Student's participants are rather organised in a peer network. If teacher participates it is possible to have formal hierarchical or coordinated distributed social organizations. The final form of social organization is not imposed by the system. It is rather shaped by the participants.
USERS' COMMUNITY	Two to many persons

An.3.3. "Non Verbal Action" Indicator (NVA)

A) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/Symbol	**NON VERBAL ACTION (NVA)**
CONCEPT of indicator	The percentage of the total (significan t) actions in the log file that is not chat messages.
Indicators' Value FORM	Numerical that can be visualized
DATA PROCESS	
DATA USED FOR ANALYSIS:	**Log file records of significant atomic actions: [all the actions or only the significant ones]**
"ANALYSIS" POINT OF VIEW:	**Action oriented.**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Mathematical formula computed by an external to the main system software module. As part of the COLEMON Tool. $NVA(t_i) = \begin{cases} \dfrac{\sum_{k=1}^{k\max} \text{Interactions}(k, t_i) - \text{Interactions}(\text{"Chat"}, t_i)}{\sum_{k=1}^{k\max} \text{Interactions}(k, t_i)}, & \sum_{k=1}^{k\max} \text{Interactions}(k, t_i) > 0 \\ 0 & \sum_{k=1}^{k\max} \text{Interactions}(k, t_i) = 0 \end{cases}$ Obviously $NVA \in [0,1]$.
DIAGRAMMATIC DESCRIPTION OF INDICATORS CALCULATION	
VALUES CALIBRATION	
INDICATOR VALUES' CALIBRATION	If NVA ~> 1 then the agents are not chatting, if NVA ~> 0 then agents are just chatting or not interacting at all.

B) INDICATOR' STATUS:	
PURPOSE:	SOCIAL/COLLABORATIVE, SELF-REGULATING The agents can do: (a) Collaboration assessment (b) Self regulation
INDICATOR USER	The teacher, the researcher, the student?
TIME OF USE	***During and after collaboration.***
INFORMATION INTERPRETATION AMBIGUITY.	1. Medium *2.* Description If NVA ~> 1 then the agents are not chatting, if NVA ~> 0 then agents are just chatting or not interacting at all. Graphically the same information can be produced comparing the interactions to the chat_msgs curves
USE OF INDICATOR	
MODE OF INDICATOR USE	***It is used by the teacher to see if there is any progress in the problem solving process in terms of model development.***

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	Id | time | user | action | attribute | typology | comments
CONCEPTUAL DIAGRAM OF RAW DATA COLLECTION.	 **Figure 1.** Logical topology of synchronous collaboration

D). LEARNING ENVIRONMENT:	
LEARNING ENVIRONMENT NAME:	MODELLINGSPACE
CATEGORY OF LEARNING ENVIRONMENT	Collaborative Problem Solving
ACTIVITY TOOLS	Chat, Common Work Space, Memo Sticks, Specific Tools Features
USER PROFILE:	Teacher, Researcher, Students
TASK CATEGORY:	Synchronous collaborative model development for general problem solving.
CONTENT TYPE:	A broad variety.
DIVISION OF LABOUR:	Problem solving and modelling are not usually decomposable in a general and obvious way. It demands intentional interaction and communication. Participants decide the work distribution while they work. Student's participants are rather organised in a peer network. If teacher participates it is possible to have formal hierarchical or coordinated distributed social organizations. The final form of social organization is not imposed by the system. It is rather shaped by the participants.
USERS' COMMUNITY	Two to many persons

An.3.4. "Selected Agent Contribution" Indicator (SAC)

A) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/Symbol	**SELECTED AGENT CONTRIBUTION (SAC)**
CONCEPT of indicator	The contribution of a specific agent to the total action [e.g. student1, student2, student3, teacher]
Indicators' Value FORM	Numerical that can be visualized Graph: ""SACagent1 -> time"", or comparative ""SACagent1 -> time"", ""SACagent2 -> time"",
DATA PROCESS	
DATA USED FOR ANALYSIS:	**Log file records of atomic actions [actions in the shared workspace and/or chat]: [significant or all of them?]**
"ANALYSIS" POINT OF VIEW:	**Action oriented.**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Mathematical formula computed by an external to the main system software module. As part of the COLEMON Tool. $$SAC(agent,t_i)=\begin{cases}\dfrac{\sum_{k=1}^{k\max}\text{Interactions}(k,\text{agent},t_i)}{\sum_{k=1}^{k\max}\text{Interactions}(k,t_i)}, & \sum_{k=1}^{k\max}\text{Interactions}(k,t_i)>0\\ 0 & \sum_{k=1}^{k\max}\text{Interactions}(k,t_i)=0\end{cases}$$ Where: $\text{Interactions}(k,\text{agent},t_i)$ = The total number of messages posted by agent in through the k-channel during the t_i time slot. **Obviously** $SAC\in[0,1]$
DIAGRAMMATIC DESCRIPTION OF INDICATORS CALCULATION	
VALUES CALIBRATION	
INDICATOR VALUES' CALIBRATION	$SAC\in[0,1]$ if SAC~>0 then the agent did not act in the previous time slot while if SAC~>1 then agent monopolized the action in the last time slot.

B) INDICATOR' STATUS:	
PURPOSE:	SOCIAL/COLLABORATIVE, SELF-REGULATING The agents can do: (a) Collaboration assessment (b) Self regulation
INDICATOR USER	The teacher, the researcher, the student?
TIME OF USE	***During and after collaboration.***

INFORMATION INTERPRETATION AMBIGUITY.	1. Medium *2.* Description SAC is the percentage of actions produced by a specific agent [e.g. student1, student2, student3, teacher] during the last time slot. $SAC \in [0,1]$ if SAC~>0 then the agent did not act in the previous time slot while if SAC~>1 then agent monopolized the action in the last time slot. Graphically in the last case CAF curve is the same to the selected agents Interactions curve.
USE OF INDICATOR	
MODE OF INDICATOR USE	***It is used by the teacher to see if there is any progress in the problem solving process in terms of model development.***

C.) GENERAL DATA SOURCES DESCRIPTION:

ACTION DEFINITION INTO THE LOGFILE:

Id	time	user	action	attribute	typology	comments

CONCEPTUAL DIAGRAM OF RAW DATA COLLECTION.

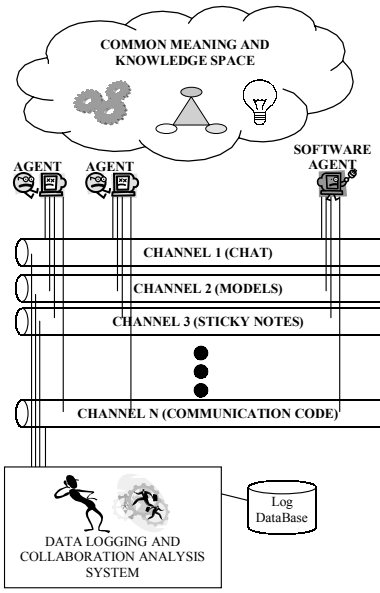


Figure 1. Logical topology of synchronous collaboration

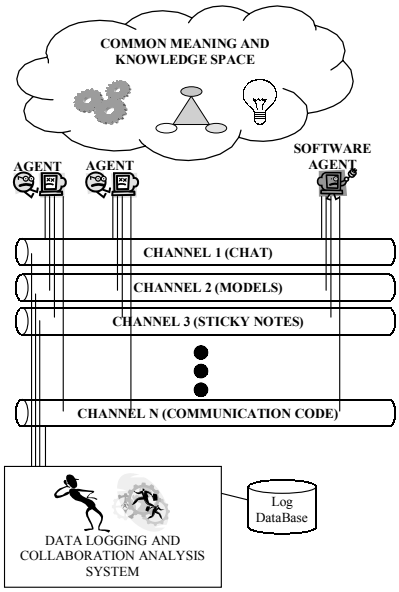
D). LEARNING ENVIRONMENT:	
LEARNING ENVIRONMENT NAME:	MODELLINGSPACE
CATEGORY OF LEARNING ENVIRONMENT	Collaborative Problem Solving
ACTIVITY TOOLS	Chat, Common Work Space, Memo Sticks, Specific Tools Features
USER PROFILE:	Teacher, Researcher, Students
TASK CATEGORY:	Synchronous collaborative model development for general problem solving.
CONTENT TYPE:	A broad variety.
DIVISION OF LABOUR:	Problem solving and modelling are not usually decomposable in a general and obvious way. It demands intentional interaction and communication. Participants decide the work distribution while they work. Student's participants are rather organised in a peer network. If teacher participates it is possible to have formal hierarchical or coordinated distributed social organizations. The final form of social organization is not imposed by the system. It is rather shaped by the participants.
USERS' COMMUNITY	Two to many persons

An.3.5. "Participation Percentage" Indicator (PART)

A) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/Symbol	**PARTICIPATION PERCENTAGE (PART)**
CONCEPT of indicator	The participation – involvement of agents in the collaboration, any kind of action
Indicators' Value FORM	Numerical that can be visualized
DATA PROCESS	
DATA USED FOR ANALYSIS:	**Log file records of atomic actions:**
"ANALYSIS" POINT OF VIEW:	**Action oriented.**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Mathematical formula computed by an external to the main system software module. As part of the COLEMON Tool. $PART(t_i) = \frac{Agents(t_i)}{TotalAgents}$ **Agents(t_i):** The total number of different agents that posted at least one message during **t_i** time slot. **TotalAgents:** The total number of agents collaborating. Obviously $PART \in [0,1]$, if PART~>0 then none is "acting", if PART~>1 then every body is "acting".
DIAGRAMMATIC DESCRIPTION OF INDICATORS CALCULATION	
VALUES CALIBRATION	
INDICATOR VALUES' CALIBRATION	Obviously $PART \in [0,1]$, if PART~>0 then none is "acting", if PART~>1 then every body is "acting".

B) INDICATOR' STATUS:	
PURPOSE:	SOCIAL/COLLABORATIVE, SELF-REGULATING The agents can do: (a) Collaboration assessment (b) Self regulation
INDICATOR USER	The teacher, the researcher, the student?
TIME OF USE	***During and after collaboration.***
INFORMATION INTERPRETATION AMBIGUITY.	1. Medium *2.* Description PART is the percentage of agents that have been acted in the last time slot, for example if PART=0.5 then half of the agents did send messages any of the channels in the last time slot. Graphically if CAF is equal to the interactions then only one agent is acting, the more higher the CAF than interactions curve the more the agents.

USE OF INDICATOR	
MODE OF INDICATOR USE	***It is used by the teacher to see if there is any progress in the problem solving process in terms of model development.***

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	Id | time | user | action | attribute | typology | comments
CONCEPTUAL DIAGRAM OF RAW DATA COLLECTION.	 **Figure 1.** Logical topology of synchronous collaboration

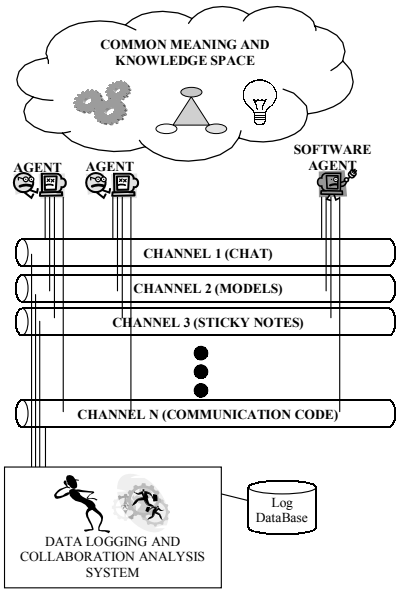
D). LEARNING ENVIRONMENT:	
LEARNING ENVIRONMENT NAME:	MODELLINGSPACE
CATEGORY OF LEARNING ENVIRONMENT	Collaborative Problem Solving
ACTIVITY TOOLS	Chat, Common Work Space, Memo Sticks, Specific Tools Features
USER PROFILE:	Teacher, Researcher, Students
TASK CATEGORY:	Synchronous collaborative model development for general problem solving.
CONTENT TYPE:	A broad variety.
DIVISION OF LABOUR:	Problem solving and modelling are not usually decomposable in a general and obvious way. It demands intentional interaction and communication. Participants decide the work distribution while they work. Student's participants are rather organised in a peer network. If teacher participates it is possible to have formal hierarchical or coordinated distributed social organizations. The final form of social organization is not imposed by the system. It is rather shaped by the participants.
USERS' COMMUNITY	Two to many persons

An.3.6. "Interactions" Indicator

A) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/Symbol	**INTERACTIONS**
CONCEPT of indicator	The number of "*actions"* (in any channel) in the previous time slot. It can be computed for each channel separately.
Indicators' Value FORM	Numerical that can be visualized
DATA PROCESS	
DATA USED FOR ANALYSIS:	**Log file records of atomic actions:**
"ANALYSIS" POINT OF VIEW:	**Action oriented.**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Mathematical formula computed by an external to the main system software module. As part of the COLEMON Tool. Consider a collaboration session interval $[t_0\text{-}t_m]$. We quantize the time interval using a parameter n: $t_i=t_0+i*d$, where $d=(t_m-t_0)/n$. **Interactions(k,t_i):** expresses the amount of interactions that have implemented through channel k during $(t_{i-1}\text{-}t_i]$. Where k values $[k:1(1)k_{max}]$ corresponds to the interaction channels {k=1=>chat, k=2=>sticks, etc}. It is obvious that the function **Interactions(agent,k,t_i)** could be useful too.
DIAGRAMMATIC DESCRIPTION OF INDICATORS CALCULATION	
VALUES CALIBRATION	
INDICATOR VALUES' CALIBRATION	If interactions are zero then in the specific channel there is no action. The more the messages the more the possible collaboration.

B) INDICATOR' STATUS:	
PURPOSE:	SOCIAL/COLLABORATIVE, SELF-REGULATING The agents can do: (a) Collaboration assessment (b) Self regulation
INDICATOR USER	The teacher, the researcher, the student?
TIME OF USE	***During and after collaboration.***
INFORMATION INTERPRETATION AMBIGUITY.	If interactions are zero then in the previous channel there is no action. The more the messages the more the possible collaboration.
USE OF INDICATOR	
MODE OF INDICATOR USE	***It is used by the teacher to see if there is any progress in the problem solving process in terms of model development.***

C.) GENERAL DATA SOURCES DESCRIPTION:

ACTION DEFINITION INTO THE LOGFILE:	Id | time | user | action | attribute | typology | comments
CONCEPTUAL DIAGRAM OF RAW DATA COLLECTION.	 **Figure 1.** Logical topology of synchronous collaboration

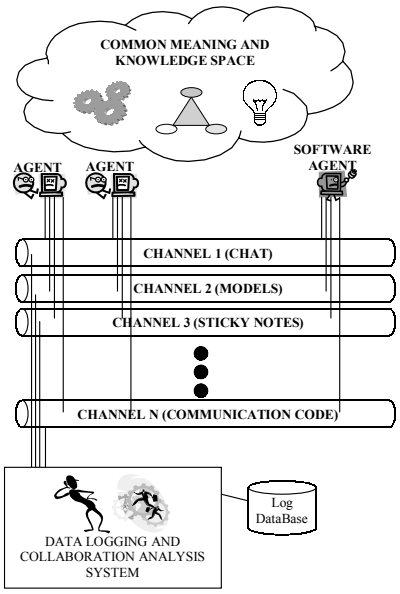
D). LEARNING ENVIRONMENT:	
LEARNING ENVIRONMENT NAME:	MODELLINGSPACE
CATEGORY OF LEARNING ENVIRONMENT	Collaborative Problem Solving
ACTIVITY TOOLS	Chat, Common Work Space, Memo Sticks, Specific Tools Features
USER PROFILE:	Teacher, Researcher, Students
TASK CATEGORY:	Synchronous collaborative model development for general problem solving.
CONTENT TYPE:	A broad variety.
DIVISION OF LABOUR:	Problem solving and modelling are not usually decomposable in a general and obvious way. It demands intentional interaction and communication. Participants decide the work distribution while they work. Student's participants are rather organised in a peer network. If teacher participates it is possible to have formal hierarchical or coordinated distributed social organizations. The final form of social organization is not imposed by the system. It is rather shaped by the participants.
USERS' COMMUNITY	Two to many persons

An.3.7. "Agents" Indicator

A) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/Symbol	**AGENTS**
CONCEPT of indicator	The number of collaborative agents that posted at least one message (in any channel) in the previous time slot. It can be computed for each channel separately.
Indicators' Value FORM	Numerical that can be visualized Graph
DATA PROCESS	
DATA USED FOR ANALYSIS:	Log file records of atomic actions.
"ANALYSIS" POINT OF VIEW:	Action oriented.
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Mathematical formula computed by an external to the main system software module. As part of the COLEMON Tool. Consider a collaboration session interval [t0-tm]. We quantize the time interval using a parameter n: ti=t0+i*d, where d=(tm-t0)/n. Agents(k,ti): computes the agents that have posted at least one message through channel k during (ti-1-ti] interval. Where k values [k:1(1)kmax] corresponds to the interaction channels {k=1=>chat, k=2=>sticks, etc}.
DIAGRAMMATIC DESCRIPTION OF INDICATORS CALCULATION	
VALUES CALIBRATION	
INDICATOR VALUES' CALIBRATION	If agents are zero then in the previous channel there is no action. The more the agents that where active the more the possible collaboration.

B) INDICATOR' STATUS:	
PURPOSE:	SOCIAL/COLLABORATIVE, SELF-REGULATING The agents can do: (a) Collaboration assessment (b) Self regulation
INDICATOR USER	The teacher, the researcher, the student?
TIME OF USE	***During and after collaboration.***
INFORMATION INTERPRETATION AMBIGUITY.	If agents are zero then in the previous channel there is no action. The more the agents that where active the more the possible collaboration.
USE OF INDICATOR	
MODE OF INDICATOR USE	***It is used by the teacher to see if there is any progress in the problem solving process in terms of model development.***

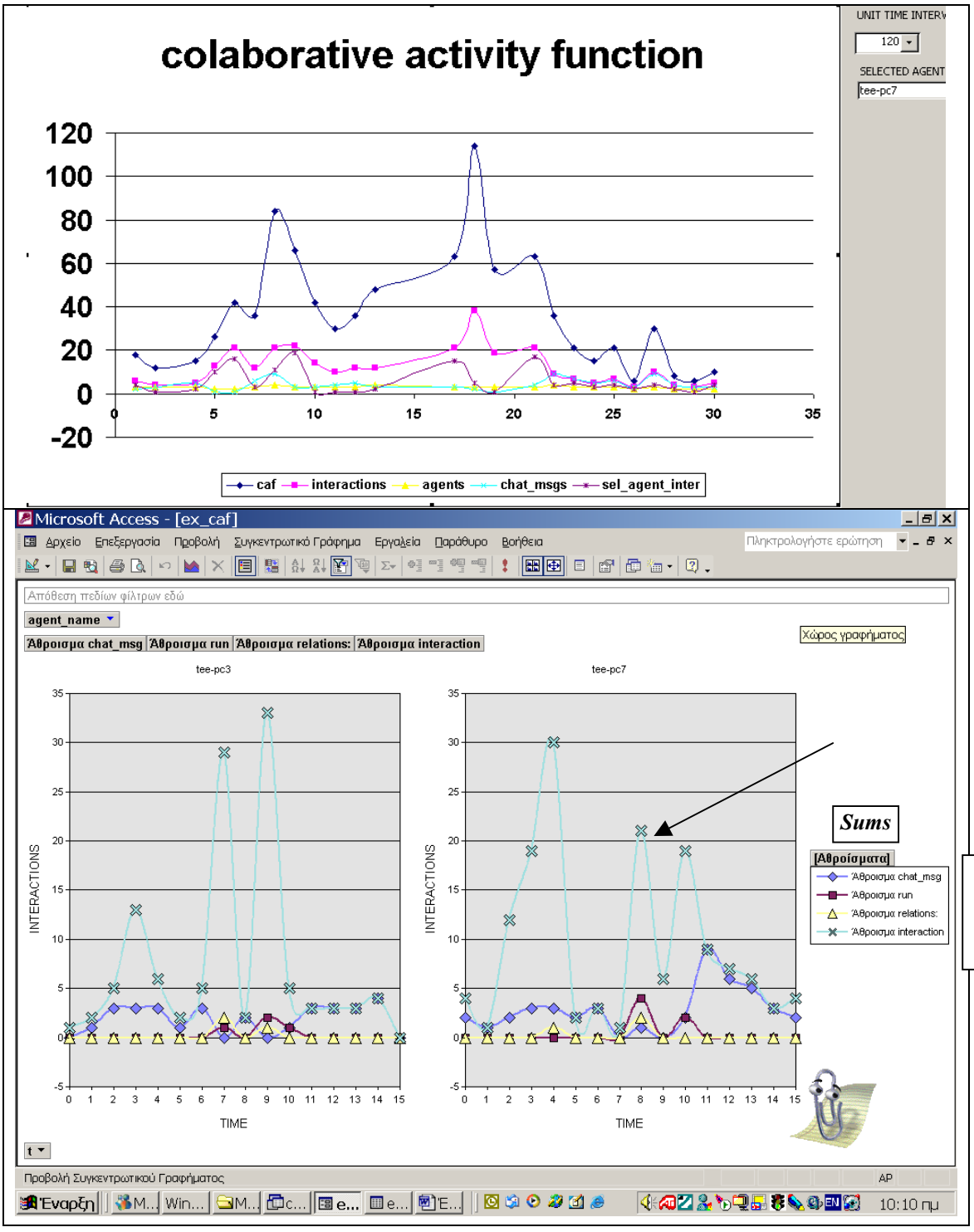
C.) GENERAL DATA SOURCES DESCRIPTION:							
ACTION DEFINITION INTO THE LOGFILE:	Id	time	user	action	attribute	typology	comments

CONCEPTUAL DIAGRAM OF RAW DATA COLLECTION.	 **Figure 1.** Logical topology of synchronous collaboration

D). LEARNING ENVIRONMENT:	
LEARNING ENVIRONMENT NAME:	MODELLINGSPACE
CATEGORY OF LEARNING ENVIRONMENT	Collaborative Problem Solving
ACTIVITY TOOLS	Chat, Common Work Space, Memo Sticks, Specific Tools Features
USER PROFILE:	Teacher, Researcher, Students
TASK CATEGORY:	Synchronous collaborative model development for general problem solving.
CONTENT TYPE:	A broad variety.
DIVISION OF LABOUR:	Problem solving and modelling are not usually decomposable in a general and obvious way. It demands intentional interaction and communication. Participants decide the work distribution while they work. Student's participants are rather organised in a peer network. If teacher participates it is possible to have formal hierarchical or coordinated distributed social organizations. The final form of social organization is not imposed by the system. It is rather shaped by the participants.
USERS' COMMUNITY	Two to many persons

An.3.8. COLEMON Interaction Analysis Tool

TOOL FOR INTERACTION ANALYSIS	
Name	**COLLABORATION LEVEL MONITORING (COLEMON)**
Description	A DBMS based application producing high quality flexible graphs of the CAF and other indicators. COLEMON produces flexible multivariate diagrams for the CAF and other indicators (Agents, Interactions etc) using data from modellingspace log file. Users can be teachers or researchers that need to monitor during collaboration or reflect and analyse after the session
Indicators kinds that could be inserted/presented	COLEMON -Collaborative Action Function -Interactions -Participation Percentage -Selected Agents Contribution -Non Verbal Actions
Kinds of covariation (or dependence) that could be derived	
Intended users	Researcher, Teacher, Student. . Can be used for social/collaborative, cognitive, diagnostic, self-regulating purposes. The agents can do: (a) Collaboration assessment (c)Teacher's interventions assessment (d) Teachers' Self regulation (e) Planning- group formation (f) Planning – off line interventions On the base of the graphs, tool users can identify time-slots for more detailed focus// with tools that could help in an interpretative process.
Screenshots	



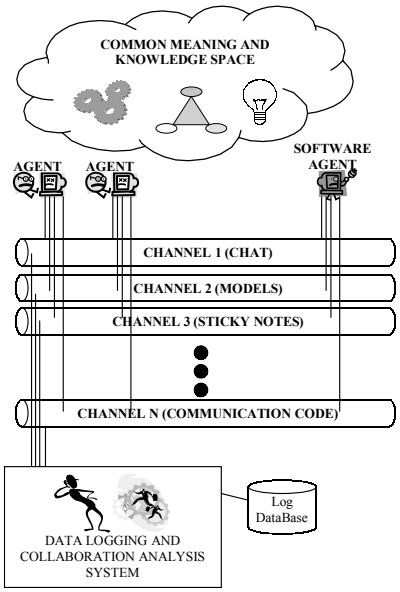
Interactions on chat
Interactions on 'Run'
Interactions on Relations
Interactions (global)

REFERENCES	FESSAKIS 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
	It is a first paper on caf,

An.3.9. "Key possession per participant" Indicator

A) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/Symbol	**KEY'S POSSESSION per PARTICIPANT (KPP)**
CONCEPT of indicator	**How active was each participant as far as the actions at the shared workspace is concerned.**
Indicators' Value FORM	**NUMERICAL**
DATA PROCESS	
DATA USED FOR ANALYSIS:	**The raw data for the analysis are activities (from log file records). Quantities or ratios of the data are considered.**
"ANALYSIS" POINT OF VIEW:	**Action oriented. Authorship oriented.**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	**No external processing software is used.**
DIAGRAMMATIC DESCRIPTION OF INDICATORS CALCULATION	
VALUES CALIBRATION	
INDICATOR VALUES' CALIBRATION	

B) INDICATOR' STATUS:	
PURPOSE:	SOCIAL/COLLABORATIVE, SELF-REGULATING
INDICATOR USER	The teacher, the researcher
TIME OF USE	***After collaboration.***
INFORMATION INTERPRETATION AMBIGUITY.	Medium KKP shows the percentage of the key's possession per participant. If the KPP for one participant is high, then this participant was dominated at the shared workspace. But we can not come to safe conclusions about the collaboration because he could just follow the instructions of the other participant(s).
USE OF INDICATOR	
MODE OF INDICATOR USE	• ***Comparison between collaborative learners*** • ***Teachers' own assessment***

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	**Id, time stamp, User, Action, Parameters**
CONCEPTUAL DIAGRAM OF RAW DATA COLLECTION.	 **Figure 1.** Logical topology of synchronous collaboration

D). LEARNING ENVIRONMENT:	
LEARNING ENVIRONMENT NAME:	MODELLINGSPACE
CATEGORY OF LEARNING ENVIRONMENT	Collaborative Problem Solving
ACTIVITY TOOLS	Chat, Common Work Space, Memo Sticks, Specific Tools Features
USER PROFILE:	Teacher, Researcher, Students
TASK CATEGORY:	Synchronous collaborative model development for general problem solving.
CONTENT TYPE:	A broad variety.
DIVISION OF LABOUR:	Problem solving and modelling are not usually decomposable in a general and obvious way. It demands intentional interaction and communication. Participants decide the work distribution while they work. Student's participants are rather organised in a peer network. If teacher participates it is possible to have formal hierarchical or coordinated distributed social organizations. The final form of social organization is not imposed by the system. It is rather shaped by the participants.
USERS' COMMUNITY	Two to many persons

An.3.9. "Number of messages per participant" Indicator

A) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/Symbol	**Number of Messages per Participant (NMP)**
CONCEPT of indicator	**How active was each participant as far as the sending of messages is concerned.**
Indicators' Value FORM	**NUMERICAL**
DATA PROCESS	
DATA USED FOR ANALYSIS:	**The raw data for the analysis is chatting (from log file records).** **Quantities or ratios of the data are considered.**
"ANALYSIS" POINT OF VIEW:	**Action oriented.** **Authorship oriented.**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	**No external processing software is used.**
DIAGRAMMATIC DESCRIPTION OF INDICATORS CALCULATION	
VALUES CALIBRATION	
INDICATOR VALUES' CALIBRATION	

B) INDICATOR' STATUS:	
PURPOSE:	SOCIAL/COLLABORATIVE, SELF-REGULATING
INDICATOR USER	The teacher, the researcher
TIME OF USE	***After collaboration.***
INFORMATION INTERPRETATION AMBIGUITY.	Medium NMP shows the number of the messages each participant sent. If the NMP for one participant is high, then this participant was chatting much, but we can not come to safe conclusions about the collaboration because we don't know the content of the messages.
USE OF INDICATOR	
MODE OF INDICATOR USE	• ***Comparison between collaborative learners*** • ***Teachers' own assessment***

C.) GENERAL DATA SOURCES DESCRIPTION: *as in previous indicator*	

D). LEARNING ENVIRONMENT: *as in previous indicator*

An.3.10. Inserted/Deleted Objects per participant" Indicator

A) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/Symbol	**Inserted (or deleted) Objects per Participant (IOP)**
CONCEPT of indicator	**The number of objects that each participant has inserted at the shared workspace.**
Indicators' Value FORM	**NUMERICAL**
DATA PROCESS	
DATA USED FOR ANALYSIS:	**The raw data for the analysis are activities (insertions) from log file records. Quantities or ratios of the data are considered.**
"ANALYSIS" POINT OF VIEW:	**Action oriented.** **Authorship oriented.**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	**No external processing software is used.**
DIAGRAMMATIC DESCRIPTION OF INDICATORS CALCULATION	
VALUES CALIBRATION	
INDICATOR VALUES' CALIBRATION	

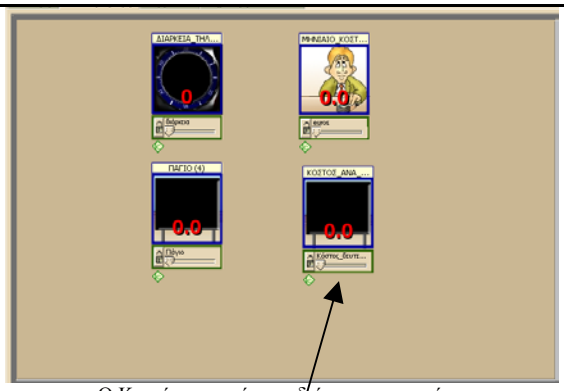
B) INDICATOR' STATUS:	
PURPOSE:	SOCIAL/COLLABORATIVE, SELF-REGULATING
INDICATOR USER	The teacher, the researcher.
TIME OF USE	***After collaboration.***
INFORMATION INTERPRETATION AMBIGUITY.	Medium IOP shows the inserted objects at the shared workspace per participant. If the IOP for one participant is big, then this participant did most of the insertions at the shared workspace. But we can not come to safe conclusions about the collaboration because he could just follow the instructions of the other participant(s).
USE OF INDICATOR	
MODE OF INDICATOR USE	• ***Comparison between collaborative learners*** • ***Teachers' own assessment***

C.) GENERAL DATA SOURCES DESCRIPTION: *as in previous indicator*	

D). LEARNING ENVIRONMENT: *as in previous indicator*

An.3.11. CoRPET Tool (an interpretation support tool)

TOOL FOR INTERACTION ANALYSIS	
Name	COPRET (COllaboration Progress REproduction Tool) Interpretation support tool
Description	COPRET is a more readable print out form of the log file which contains: ⇨ Chat history between students and between students and teachers ⇨ Information about key's possession ⇨ Snapshots of the shared workspace. One snapshot is produced, after an action like Insertion, Modification or Deletion occurred. COPRET respects the chronological order of events, containing teacher's interventions (messages or actions) as well as students' dialogues and actions. As a result, a Word file is produced, respecting the chronological order of events, containing teacher's interventions (messages or actions) as well as students' dialogues and actions. The file contains a number of screenshots (e.g. 12)
Indicators kinds that could be inserted/presented	
Intended users	**Researcher, Teacher**
Purpose	SOCIAL/COLLABORATIVE, COGNITIVE, DIAGNOSTIC, SELF-REGULATING **The agents can do:** (a) Collaboration assessment (b) Knowledge assessment **(c)Teacher's interventions assessment** (d) Self regulation (e) Planning- group formation (f) Planning – off line interventions
Time of Use	AFTER THE COLLABORATION Tool users can identify time-slots for more detailed focus, in order to put in context other indicators' interpretation.

Screenshots	**[00:04:53]|[Κυριάκος] Θα πρέπει να οας στη σελ. 8 και να κάνεις ότι λέει.** **[00:06:23]|[Κυριάκος] Τι γίνεται; Γιατί δεν το κάνεις** **[00:07:18]|[Ροδούλα] Δεν μπορώ να εισάγω τη σχέση, θα ήθελα λίγη καθοδήγηση. Αν θέλεις ζήτα το κλειδί και κάντο.** **[00:07:26]|[Κυριάκος] ΟΚ.** **[Ο Κυριάκος ζήτησε και πήρε το κλειδί].** **[00:07:38]|[Εκπαιδευτ.] Κυριάκο σε παρακαλώ μην πιέζεις τη Ροδούλα!**	 Ο Κυριάκος εμφάνισε ιδιότητες και τιμές

Dialogue between learners

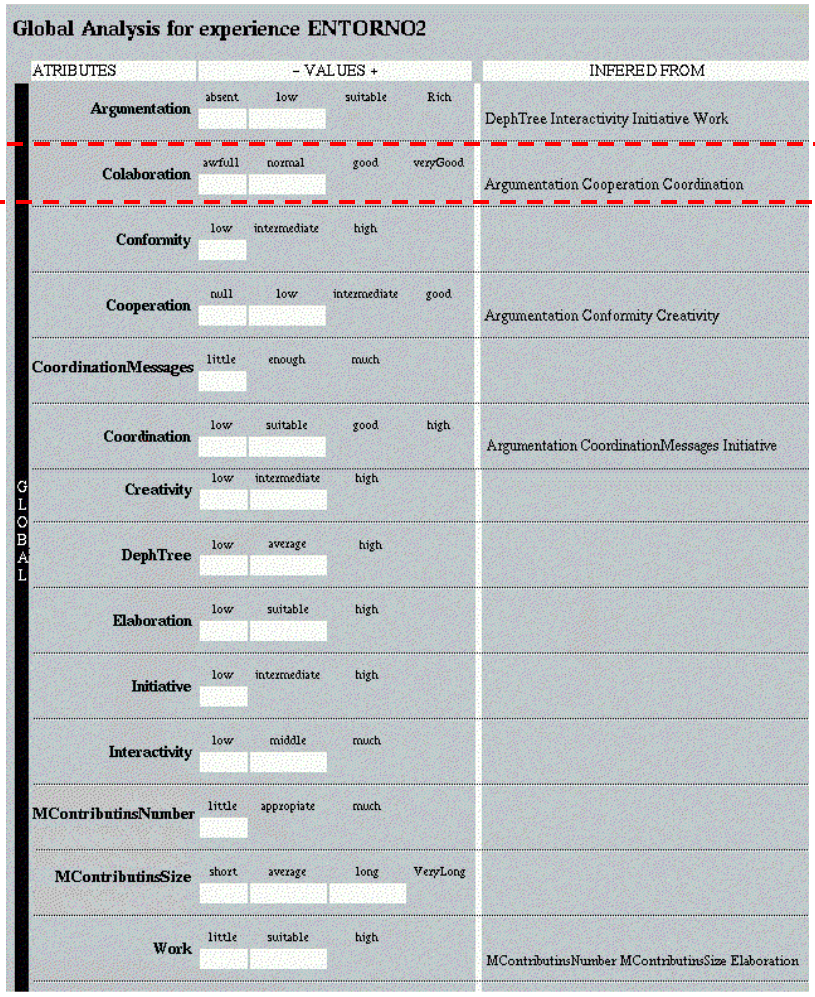
Common workspace right after the dialogue

REFERENCES	Petrou, A.& Dimitracopoulou, A. (2003) "Is synchronous computer mediated collaborative problem-solving 'justified' only when by distance? Teachers' points of views and interventions with co-located groups, during everyday class activities", *Proc. Of CSCL-2003,* Bergen, June 2003, pp. 369-377, Kluwer.

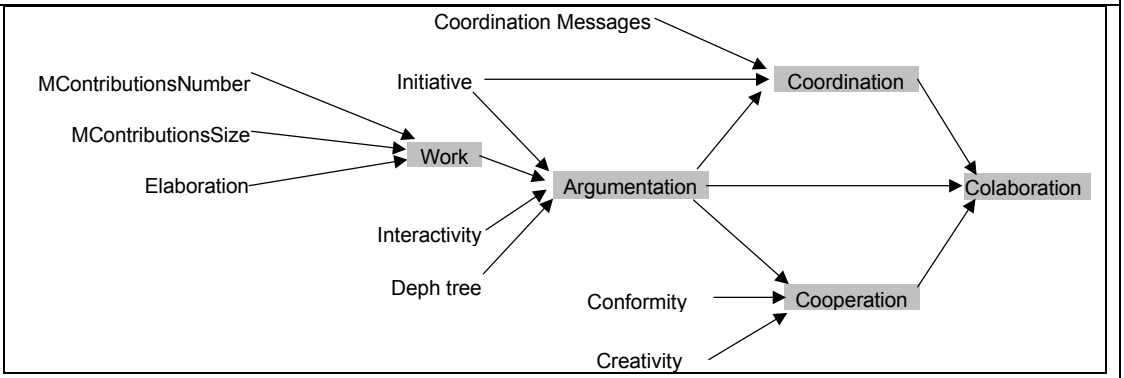
An.4. Indicators laboratory UNED

An.4.1. Collaboration level (in the group) Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**COLLABORATION-LEVEL IN THE GROUP**
CONCEPT of indicator	Group behaviour compared to other groups performing the same task
Indicators' Value FORM	LITERAL IN A RANGE OF ENUMERATED VALUES (from worst to best), and visual presenting all the results



DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	The data is represented by fuzzy values. Some of them are calculated from the log ant the others are obtained using fuzzy inference, in the analysis method. The method allows to consider different input data and inference rules to combine them. • Data **calculated from the log**: (For group behaviour analysis). Some of these also can be considered as indicators in their own. - Average Number of Contributions: number of contributions added by the whole group within a collaboration space. The total number of contributions is divided into the number of group members having carried out the collaborative scenario. - Average Contribution Size: average size of the contributions within a collaboration space, computed in terms of the number of characters of each contribution - Process Tree Depth: maximum depth of the process scheme within an elaboration workspace - Group Interactivity. It counts the percentage of contributions in a process scheme answered by a user other than their author. It provides a measure of the alternation that occurred during the argumentative discussion leading to the solution - Number of Contributions : number of contributions added by a user within an elaboration space. All the contributions added by the user in that elaboration space are counted. - Contribution Size: average size of the contributions added by a user within an elaboration space - Answered Contributions: average number of answers given by the user to contributions made by another author - Contributions Answered By Others: average number of contributions authored by the user that have been answered by other users - Follow-Up Contributions: average number of contributions authored and then answered by the same user - Coordination Messages: number of coordination messages, which type is communication generated by all the users - Planning Messages: number of planning messages, which type is communication generated by all the users - Help Messages: number of messages asking for help on the system use generated by all the users - Initiative: it quantifies the degree of involvement in the work and responsibility that bears each contribution type. Hence, a proposal means, for its author, an involvement in and binding to the task stronger than making a question - Creativity: it quantifies the degree of complexity, originality and richness of ideas implied by the elaboration of the text for each type of contribution. Thus, for instance, elaborating a proposal requires more creativity than making a comment and, in turn, more than elaborating a question. - Elaboration: this attribute is related to the previous one and quantifies the amount of work which is necessary for elaborating the text of a contribution. For instance, elaborating a counterproposal implies more work than making a question or a comment - Conformity; it quantifies the degree of agreement implied by a contribution with relation to the one it is linked to. Thus, for example, the contribution type agreement shows total accord but the counterproposal shows few or no conformity at all. • Data **inferred** in the method (see figure XX) - **Work:** it provides a measure of the amount of work carried out by the group for generating the task solution. Inferred from McontributionsNOmber, McontributionSize, Elaboration - **Argumentation:** it supplies a measure of the degree of discussion that happened within the group. Inferred from DephTree, Interactivity, Initiative,Work - **Coordination:** it shows the degree of intercommunication that appeared within the group members. Inferred from Argumentation, CoordinationMessages, Initiative - **Cooperation**: it considers how the argumentation process developed, though taking into account the conformist (or non-conformist) attitude of the individuals as well as the degree of creativity they added to the discussion for improving the group solution. Inferred from Argumentation, Conformity, Creativity - **Collaboration:** it offers an overall assessment of the collaborative attitude of the group during the experience. Inferred from Argumentation, coordination and cooperation.
"ANALYSIS" POINT OF VIEW:	**PROCESS ORIENTED**

INDICATOR CALCULATION: "DATA PROCESS METHOD"	It is a general method that uses the indicators and the relationship between them in a declarative way, as input. So, it is possible to change the relationship among them. Also rules are a parameter. So the method works with different knowledge bases of rules expressing to infer the indicators. INPUT: Scenario definition (Activites organizad in tasks (Ti)) OUPUT: Inferred variables For each Activity Ai and For each Task Ti OBTAIN THE REFERENCE VALUES Select all the Activities and Tasks from a repository of cases Calculate the reference values for the fuzzy process OBTAIN THE CALCULATED VALUES FOR ACTUAL ACTIVIY-TASK, Vi* GET THE FUZZY VALUES FOR THE CALCULATED VALUES Vi* GET RULES FROM THE KB Rules INIZIALIZE THE INFERRED VARIABLES, Ii* Conditions = Vi* + Ii* FUZZY INFER-PROCESS DE-FUZZY CONDITIONS SHOW RESULTS
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	 Fig1. Relationship among DEGREE indicators for obtaining the conclusions (Group behaviour analysis) Author admon RULES NAME | RULE 1 | NumberContributions_little,SizeContributions_short->Work_little 2 | Elaboration_low->Work_little 3 | Elaboration_suitable,NumberContributions_little,SizeContributions_average->Work_suitable 4 | Elaboration_suitable,NumberContributions_little,SizeContributions_long->Work_suitable 5 | Elaboration_suitable,NumberContributions_little,SizeContributions_VeryLong->Work_suitable 6 | Elaboration_suitable,NumberContributions_appropiate,SizeContributions_short->Work_suitable 7 | Elaboration_suitable,NumberContributions_appropiate,SizeContributions_average->Work_suitable 8 | Elaboration_suitable,NumberContributions_appropiate,SizeContributions_long->Work_suitable 9 | Elaboration_suitable,NumberContributions_appropiate,SizeContributions_VeryLong->Work_high 10 | Elaboration_suitable,NumberContributions_much,SizeContributions_short->Work_suitable 11 | Elaboration_suitable,NumberContributions_much,SizeContributions_average->Work_suitable 12 | Elaboration_suitable,NumberContributions_much,SizeContributions_long->Work_high 13 | Elaboration_suitable,NumberContributions_much,SizeContributions_VeryLong->Work_high 14 | Elaboration_high,NumberContributions_little,SizeContributions_average->Work_suitable 15 | Elaboration_high,NumberContributions_little,SizeContributions_long->Work_suitable 16 | Elaboration_high,NumberContributions_little,SizeContributions_VeryLong->Work_high 17 | Elaboration_high,NumberContributions_appropiate,SizeContributions_short->Work_suitable 18 | Elaboration_high,NumberContributions_appropiate,SizeContributions_average->Work_suitable Fig2. Translation of the relationship among the indicators into fuzzy rules, that form the Knowledge Base for the analysis method.
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	For the group behavior analysis, the values are calibrated with values of another cases of groups working in similar conditions, similar backgrounds and similar tasks.

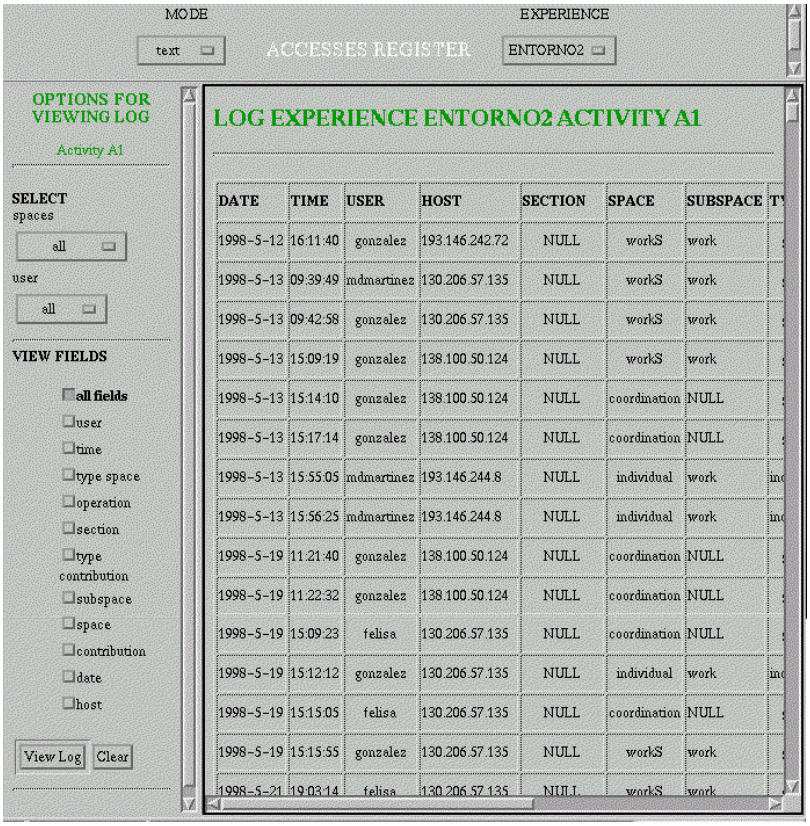
B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* Social/Collaborative
INDICATOR USER	*To whom is addressed?* To the student and to the teacher.
TIME OF USE	During the activity to give feedback to the group and afterwards in order to compare the results among different groups. *When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)?*
INFORMATION INTERPRETATION AMBIGUITY	1. ----------[Low, medium, high] *2. Information interpretation: short description* *What the 'IAT' user' [student, teacher, system, researcher] could decode as information from the output form of indicator values: possible interpretations per indicator*
USE OF INDICATOR	
MODE OF INDICATOR USE	We are looking for ways to improve peer interaction. To give feedback directly to students is one aspect but this should be complemented with the possibility to evaluate in which way the feedback affects positively their task performance. This involves (1) monitoring student's behaviour before and after feedback is provided,(2) be able to suggest possible correlation where changes are observed and finally (3) judging whether the feedback has been appropriate or not. ***Describe one or more mode of uses of this indicator, regarding the Interaction Analysis user [student, teacher, system, researcher] (conditions of use)***

C.) GENERAL DATA SOURCES DESCRIPTION:

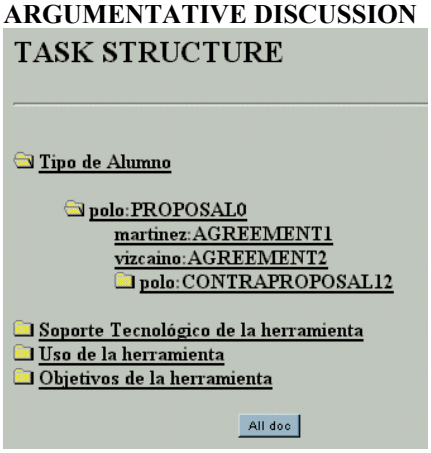
ACTION DEFINITION INTO THE LOGFILE:

The log and the process.

LOG:



PROCESS: CONTRIBTIONS ADDED BY THE USERS, IN AN ARGUMENTATIVE DISCUSSION



CONCEPTUAL DIAGRAM of raw data collection

how it is considered the situation in which the indicator is derived [e.g. **channels of communication]**

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	degree
CATEGORY OF LEARNING ENVIRONMENT	**COLLABORATIVE PROBLEM SOLVING**
LE ACTIVITY TOOLS	Main Tools available to students **Coordination workspace → for organizing the work and the agenda (using coordinatioy type messages)** **Elaboration workspace → for solving the task (using a conversational model)** **Agreement tools → for voting the agreements**
Learning Environment USER PROFILE:	**ADULT STUDENT**
TASK category:	**PROBLEM SOLVING, EXPERIMENTATIONS, ARGUMENTATION, TEXT PRODUCTIONS]** *Agumentation task.* An scenario is organised into activities which, in turn, can be divided into tasks and subtasks . A task consist on write a document about a Pre-selected topic using some material giving as input. The task is considered as finished when there is a jointly elaborated and agreed document. The experience's outcome includes a final document for each task as well as a representation of the elaboration process.
CONTENT TYPE:	[**LOW CONCEPTUAL, HIGH CONCEPTUAL**] *Short Description*
DIVISION OF LABOUR:	[**CONTIGUOUS, PEER-TO-PEER COORDINATED, PEER TO PEER FREE, DISTRIBUTED, ...**] The tasks are defined as collaborative, that is, all the users work in all the tasks. The results demonstrate that sometimes the users decide to divide the work assigning one task to one user or another ways or re-organizing the tasks in groups.
USERS' COMMUNITY	**[INDIVIDUAL-TWO PERSON GROUP, THREE PERSON GROUP, XXX, XXX,WIDE COMMUNITY]** Two-three students groups, and one teacher helping all the groups

Complementary Questions that could be explored after the explicitation of indicators:

- *How to coordinate the analysis of actions and dialogues*?

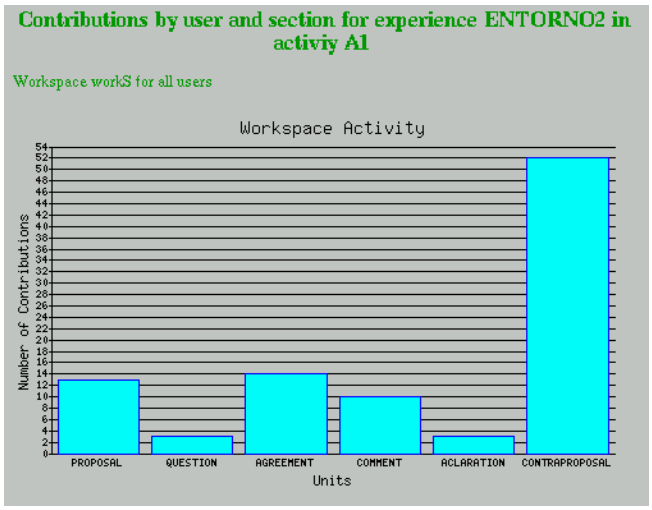
  Using patters relating the tasks and the actions done by the group members.
- How to inter-relate collaboration features with problem solving content and process?
- *How to go beyond simple quantitative indicators to more sophisticated ones?*

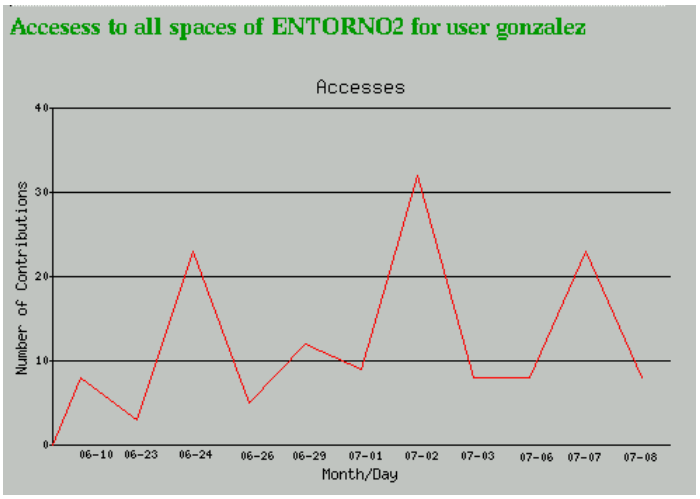
  Using knowledge-based systems. Here we have presented a method that can do that.

- *Quantitative or qualitative indicators (interpreting the context/content of interaction).*

We combine quantitative and qualitative indicators. We consider quantitative indicators those that are calculated from the log and the collaborative process (calculated variables) and qualitative, those that are calculated using the analysis method.

We can also represent graphically the quantitative indicators. For example, the contributions/type created in the system, the evolution of work during the collaboration process in a workspace:





- *How to provide a rich variety of analysis output to assist participants (of a specific or a variety of profiles).*

  In this document we have presented the analysis of group behaviour, but the method could be applied to another indicators and types of analysis. For example, we have also applied the method for studding the individual behaviour of each member of a group compared with the colleagues in the same group (see, Verdejo & Barros, 1999)

- *How to produce significant visualization tools that students are able to decode them and selfregulate their behavior.*

  WE have implemented a feedback mechanism that gets the results of the analysis method, presents the results and gives feedback to the members of the groups in form of messages. (see, Verdejo & Barros, 1999)

An.5. Indicators: Laboratory Intermedia

An.5.1. Participation_Count Indicator

A.) DESCRIPTION OF 'INDICATOR': DoCTA indicator	
INDICATOR IDENTITY	
NAME/ Symbol	**Participation_count**
CONCEPT of indicator	It measures the number of times a certain student has posted messages or made changes to a shared object
Indicators' Value FORM	----------[**visual, numerical, literal**] **Numerical**
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	From the logfile one can find out that a certain students have made contributions by posting to the discussion forum or made updates to the shared object of a whiteboard
"ANALYSIS" POINT OF VIEW:	**Process oriented** **[ACTION ORIENTED, STRUCTURAL/STATE ORIENTED, AUTHORSHIP ORIENTED, PROCESS ORIENTED, …]**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Productive interactions generated by the student, without checking whether or not the modification to the shared object has improved or degraded the quality of the object ***Equation or algorithm applied or external processing software used, or any other method***
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	**Not applicable**
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	**From 0 to 10000, assuming 10000 is the highest number of edits one would want to make on a shared object such as a discussion text or a drawing.**

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* SOCIAL/COLLABORATIVE, managerial **[SOCIAL/COLLABORATIVE, COGNITIVE, TECHNICAL, MANAGERIAL]** *(An indicator could also be multipurposal)* **2. What indicator users could do on the base of this information?** They can monitor who is active among the students, how many notes a certain student has posted, how often a certain make modifications, etc.
INDICATOR USER	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** The student, the teacher
TIME OF USE	Gradually a history is made that can be consulted even during the activity
INFORMATION INTERPRETATION AMBIGUITY	----------[Low, medium, high] Medium *2. Information interpretation: short description* It is not clear from measuring participation count whether or not the students are producing quality information when they participate or if they generate noise and/or deteriorating the common artifact
USE OF INDICATOR	
MODE OF INDICATOR USE	This indicator can give the users an idea about who participating and at what level of abstraction this occurs as well as the frequency of this activity. Other students can see of a certain student has responding to their previous contributions (postings, changes made)

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	{source of data}:{e.g. Identifier, time stamp, type of object, user, action , etc}
CONCEPTUAL DIAGRAM of raw data collection	** Figure N. how it is considered the situation in which the indicator is derived [e.g. **channels of communication]**

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	FLE (Future Learning Environment) and TeamWave Workplace (TW)
CATEGORY OF LEARNING ENVIRONMENT	**[COLLABORATIVE PROBLEM SOLVING, COLLABORATIVE PLATFORM, FORUM, XXX, XXX,]**
LE ACTIVITY TOOLS	Discussion forum (FLE) and shared whiteboard (TW) *Main Tools available to students*
Learning Environment USER PROFILE:	**[YOUNG STUDENT, ADULT STUDENT, TEACHER]**
TASK category:	[**PROBLEM SOLVING, EXPERIMENTATIONS, ARGUMENTATION, TEXT PRODUCTIONS]** Using discussion forum and participating in shared diagram editor
CONTENT TYPE:	[**LOW CONCEPTUAL, HIGH CONCEPTUAL**] Biology for secondary school students
DIVISION OF LABOUR:	[**CONTIGUOUS, PEER-TO-PEER COORDINATED, PEER TO PEER FREE, DISTRIBUTED,**] Distributed (FLE) and real time.(FLE and TW)
USERS' COMMUNITY	**[INDIVIDUAL-TWO PERSON GROUP, THREE PERSON GROUP, XXX, XXX,WIDE COMMUNITY]** Groups of 3-4 students, approx 50 students with 2 teachers in total. Two schools (FLE), 3 Universities (TW)

An.5.2. LOGIN_Time Indicator

A.) DESCRIPTION OF 'INDICATOR': DoCTA indicator	
INDICATOR IDENTITY	
NAME/ Symbol	**login_time**
CONCEPT of indicator	It measures the time a certain student has been logged on the system
Indicators' Value FORM	----------[**visual, numerical, literal**] Numerical
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	From the logfile one can find when the students have entered the learning environment and when they log off the login time can be computed
"ANALYSIS" POINT OF VIEW:	**Process oriented** **[ACTION ORIENTED, STRUCTURAL/STATE ORIENTED, AUTHORSHIP ORIENTED, PROCESS ORIENTED, …]**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Time elapsed, without checking whether or not there has been any activity during this period (related indicators need to check for this)
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	**Not applicable**
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	From 5 minutes to several days (assuming the session/course will run over several meetings). It should probably not extend 100 hours so minutes may be a good measurement unit.

B.) INDICATOR' STATUS:	
PURPOSE:	*2. What's the purpose of the indicator?* SOCIAL/COLLABORATIVE, managerial **[SOCIAL/COLLABORATIVE, COGNITIVE, TECHNICAL, MANAGERIAL]** *(An indicator could also be multipurposal)* **2. What indicator users could do on the base of this information?** They can monitor who is logged on and how long each student have been logged on. It can determine if a certain student has not participated. It could defined a threshold for what counts as "minimum login time" to qualify as participation in an online course
INDICATOR USER	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** The student, the teacher
TIME OF USE	Gradually a history is made that can be consulted even during the activity *When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)?*
INFORMATION INTERPRETATION AMBIGUITY	-[Low, medium, high] Medium *2. Information interpretation: short description* It is not clear from measuring login time whether or not the students are doing anything (could be logged in but leave the room) and if they are doing something that the something is activity towards accomplishing a goal shared with the other students, teacher.
USE OF INDICATOR	
MODE OF INDICATOR USE	This indicator can give the users an idea about who is logged on the system and what time of day they prefer to work. Other students who like to meet synchronously with certain students can check their login time history.

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	{source of data}:{e.g. Identifier, time stamp, type of object, user, action , etc}
CONCEPTUAL DIAGRAM of raw data collection	how it is considered the situation in which the indicator is derived [e.g. **channels of communication]**

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	FLE (Future Learning Environment) and TeamWave Workplace (TW)
CATEGORY OF LEARNING ENVIRONMENT	**[COLLABORATIVE PROBLEM SOLVING, COLLABORATIVE PLATFORM, FORUM, XXX, XXX,]**
LE ACTIVITY TOOLS	Discussion forum (FLE) and shared whiteboard (TW) *Main Tools available to students*
Learning Environment USER PROFILE:	**[YOUNG STUDENT, ADULT STUDENT, TEACHER]**
TASK category:	[**PROBLEM SOLVING, EXPERIMENTATIONS, ARGUMENTATION, TEXT PRODUCTIONS]** Using discussion forum and participating in shared diagram editing, but it could also be idle
CONTENT TYPE:	[**LOW CONCEPTUAL, HIGH CONCEPTUAL**] Biology for secondary school students
DIVISION OF LABOUR:	[**CONTIGUOUS, PEER-TO-PEER COORDINATED, PEER TO PEER FREE, DISTRIBUTED, ...**] Distributed (FLE) and real time.(FLE and TW)
USERS' COMMUNITY	**[INDIVIDUAL-TWO PERSON GROUP, THREE PERSON GROUP, XXX, XXX,WIDE COMMUNITY]** Groups of 3-4 students, approx 50 students and 2 teachers in total. Two schools (FLE), 3 Universities (TW)

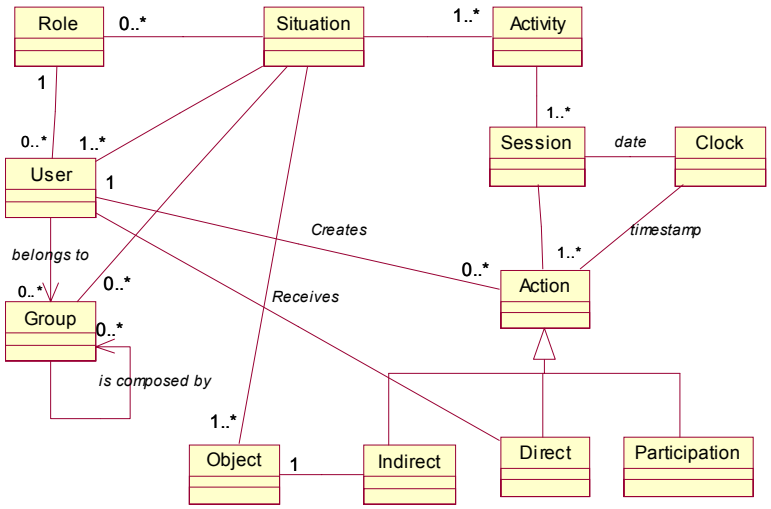
An.6. Indicators: Laboratory GSIC/University of Valladolid

An.6.1. Network Degree Centralisation Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Network degree centralization (C_D)**
CONCEPT of indicator	The centralization of a social network measures the degree to which the activity of a network depends on the activity of a particular member or a very small set of members
Indicators' Value FORM	Numerical. Can be qualitatively interpreted by the inspection of sociograms.
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	The nature of the data used to construct the links in the network can be any kind of action performed on the environment. For example, the actions of a user on a shared folder workspace such as BSCW. For example, a link between two users when a user reads a document created by another user; or a link between a user that created a document and the document itself.
"ANALYSIS" POINT OF VIEW:	The point of view is to study the structure of a group according to a specific relationship
INDICATOR CALCULATION: "DATA PROCESS METHOD"	For dichotomous relationships: $C_D' = \frac{\sum_{1 \le i \le g} [C_D(n^*) - C_D(n_i)}{[(g-1)(g-2)]}$ with $C_D(n^*) = \max_i C_D(n_i)$ *where* *g: number of nodes* *$C_D(n_i)$: centrality of node n_i*
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	For dichotomous relationships: [0,1], with 1 being the most centralized network.

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* SOCIAL/COLLABORATIVE
INDICATOR USER	TO THE TEACHER and THE RESEARCHER This indicator has been used to test how much a specific relationship depended on a single actor. When a value too high was found, the teacher could detect who is the most prominent actor by inspecting the centrality values of the actors (see the indicator "centrality". If this actor is the teacher him/herself, this can mean that the students are not participating in the activity, and they just use the tool to collect information from the teacher. In this case, some actions could be needed in order to encourage the students to participate more on the system.
TIME OF USE	Mainly off-line, i.e., when the activity has finished (although might be used during it)
INFORMATION INTERPRETATION AMBIGUITY	This indicator has a medium degree of ambiguity. The index shows the degree of interaction among a group of people or between a group of people and a group of objects. There is no absolute desiderable value, as it will depend on the nature of the relationship and on the number of actors involved.
USE OF INDICATOR	
MODE OF INDICATOR USE	See above at the "Indicator user" slot.

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	The definition of the action into the log file is based on a conceptual model of collaborative action (see figure below). With this model, we have defined a DTD that covers the different entities displayed here in order to provide for a generic and standard representation of collaborative action.
CONCEPTUAL DIAGRAM of raw data collection	

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	UVA-AO, UOC-IAG.
CATEGORY OF LEARNING ENVIRONMENT	[COLLABORATIVE PLATFORM, FORUM, SHARED WORKSPACE]
LE ACTIVITY TOOLS	BSCW, E-MAIL
Learning Environment USER PROFILE:	University students and teacher
TASK category:	Project based learning where students had to produce intermediate and final reports.
CONTENT TYPE:	The problem was the evaluation and design of computer systems.
DIVISION OF LABOUR:	Not specified a priori. Free division of labour.
USERS' COMMUNITY	**[**> 100 students and two teachers**]**

INTERACTION ANALYSIS TOOLS

** In case that the indicator(s) are produced by an independent tool, give here a brief description*

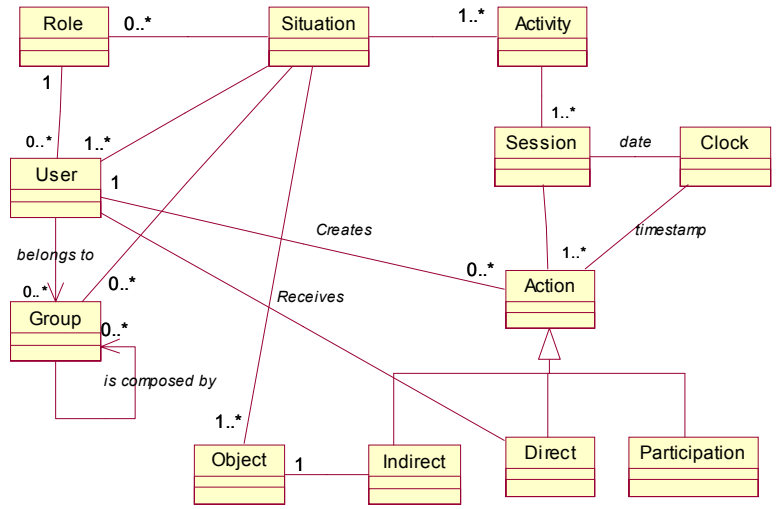
Name	**SAMSA (System for Adyacency Matrix and Sociogram-based analysis)**
Description	It collects the data from the XML log file and builds a social network, computing three different indexes. It allows the user to configure some aspects of the network, such as the set of actors being considered, the time period as well as the type of network (out of three possible types). Additionally, SAMSA provides the definition of the network in a SNA standard data format (DL's) that can be used by external SNA tools. This adds more possibilities of analysis oriented to the researchers.
Indicators kinds that could be inserted/presented	Network centralization, network density and actor's centrality
Kinds of covariation (or dependence) that could be derived	
Intended Users	Teachers and researchers. A tool for students is under development.

An.6.2. Actors' Degree Centrality Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Actor's degree centrality (c)**
CONCEPT of indicator	The degree centrality of an actor in a social network represents the number of links that the actors maintains with other actors. In the case of asymetric networks, we can distinguish between *in-degree* (links that finish in the actor) and *out-degree* (links that have the actor as their source) centrality.
Indicators' Value FORM	Numerical. Can be qualitatitively interpreted by the inspection of sociograms. "When a network is represented as a sociogram, and some geometrical properties are used, such as *spring embedding or multidimensional scaling*, the most central actors appear at the center of the network and the most peripherical appear at the end."
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	Links between actors or between an actor and an object. The nature of the link can be of any kind.
"ANALYSIS" POINT OF VIEW:	STRUCTURAL/STATE ORIENTED
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Degree in symmetric relationships: $C_D(n_i) = x_{i+} = \sum_i x_{ij} = \sum_j x_{ji}$ In-degree: $C_{iD}(n_i) = \sum_j x_{ij}$ Out-degree: $C_{oD}(n_i) = \sum_i x_{ij}$
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	$C_D(n_i) \in [0, n-1]$, n is the number of nodes The higher is the number degree, the most active the actor is with respect to the relationship represented in the network. There is no absolute desirable value, as it will depend on the nature of the relationship and on the number of actors involved.

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* SOCIAL/COLLABORATIVE
INDICATOR USER	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** Any of them.
TIME OF USE	Mainly afterwards the activity (although might be used during it)
INFORMATION INTERPRETATION AMBIGUITY	1. medium *2. description* The index shows the degree of interaction among an actor and its network.. There is no absolute desiderable value, as it will depend on the nature of the relationship and on the number of actors involved.
USE OF INDICATOR	
MODE OF INDICATOR USE	***Describe one or more mode of uses of this indicator, regarding the Interaction Analysis user [student, teacher, system, researcher] (conditions of use)*** - If a teacher observes than a particular actor shows a different value of centrality than expected (either lower or higher), he can try to *regulate* collaboration. Normally, this will happen when a teacher wants that the participants of a group participate more by encouraging the students with a lower centrality to participate more and viceversa.

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	- Based on a DTD that covers different aspects (see appendix). {source of data}:{e.g. Identifier, time stamp, type of object, user, action , etc}

CONCEPTUAL DIAGRAM of raw data collection	

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	UVA-AO, UOC-IAG.
CATEGORY OF LEARNING ENVIRONMENT	**[COLLABORATIVE PLATFORM, FORUM, SHARED WORKSPACE]**
LE ACTIVITY TOOLS	**BSCW, E-MAIL**
Learning Environment USER PROFILE:	**University Students and teacher**
TASK category:	**[ARGUMENTATION, TEXT PRODUCTIONS]** *Project based learning where students had to produce intermediate and final reports.*
CONTENT TYPE:	[**HIGH CONCEPTUAL**] *The problem was the evaluation and design of computer systems.*
DIVISION OF LABOUR:	[**CONTIGUOUS, PEER-TO-PEER COORDINATED, PEER TO PEER FREE, DISTRIBUTED, ….**] Not specified a priori. Free division of labour.
USERS' COMMUNITY	**[**> 100 students and two teachers**]**

Name	**SAMSA (System for Adyacency Matrix and Sociogram-based analysis)**
Description	It collects the data from the XML log file and builds a social network, computing three different indexes. It allows the user to configure some aspects of the network, such as the set of actors being considered, the time period as well as the type of network (out of three possible types). Additionally, SAMSA provides the definition of the network in a SNA standard data format (DL's) that can be used by external SNA tools. This adds more possibilities of analysis oriented to the researchers.
Indicators kinds that could be inserted/presented	Network centralization, network density and actor's centrality
Kinds of covariation (or dependence) that could be derived	
Intended Users	Teachers and researchers. A tool for students is under development.

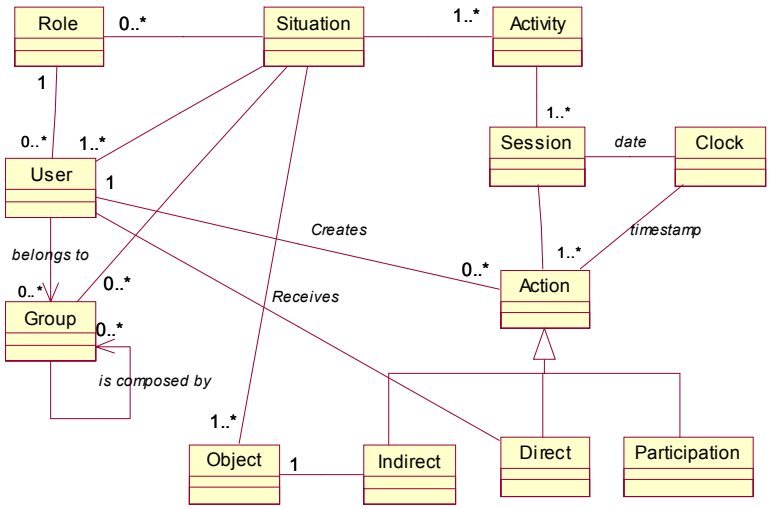
References	1. A. Martínez, Y.Dimitriadis, E. Gómez, B. Rubia, P. de la Fuente *Combining qualitative and social network analysis for the study of classroom social interactions,* Computers and Education, 41(4), pp. 353 – 368 (2003), ISSN/ISBN: 0360-1315 2. A. Martínez, P. de la Fuente, Y. Dimitriadis, Towards an XML-based representation of collaborative interactions, Designing for Change in Networked Learning Environments. (Eds: B.Wasson, S. Ludvigsen & U. Hoppe). 379-388, Kluwer Academic Publishers (2003), ISSN/ISBN: 1-4020-1383-3 3. A. Martínez, Y. Dimitriadis, J. Tardajos, O. Velloso, M.B. Villacorta. **Integration of SNA in a mixed evaluation approach for the study of participatory aspects of collaboration,** European Conference on Computer Supported Collaborative Work (ECSCW03), Workshop on Social Networks. Helsinki (2003).

An.6.3. Network Density Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Network density (Δ)**
CONCEPT of indicator	The density of a social network measures the degree of activity of this network with respect to the relationship that is being measured.
Indicators' Value FORM	Numerical. Can be qualitatively interpreted by the inspection of sociograms.
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	The nature of the data used to construct the links in the network can be any kind of action performed on the environment. For example, the actions of a user on a shared folder workspace such as BSCW. For example, a link between two users when a user reads a document created by another user; or a link between a user that created a document and the document itself.
"ANALYSIS" POINT OF VIEW:	The point of view is to study the structure of a group according to a specific relationship
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Δ = 2l / (g (g-1)) for symetric relationships Δ = l / (g (g-1)) for asymetric relationships*where* *l: number of links* *g: number of nodes*
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	For dichotomous relationships: [0,1], with 1 being the most dense network.

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* SOCIAL/COLLABORATIVE
INDICATOR USER	TO THE TEACHER and THE RESEARCHER This indicator has been used to test the level of activity in a classroom with respect to a specific relationship. When a value too low was found, the teacher intervened in order to encourage the students to participate more on the system.
TIME OF USE	Mainly off-line, i.e., when the activity has finished (although might be used during it)
INFORMATION INTERPRETATION AMBIGUITY	This indicator has a medium degree of ambiguity. The index shows the degree of interaction among a group of people or between a group of people and a group of objects. There is no absolute desiderable value, as it will depend on the nature of the relationship and on the number of actors involved.
USE OF INDICATOR	
MODE OF INDICATOR USE	See above at the "Indicator user" slot.

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	The definition of the action into the log file is based on a conceptual model of collaborative action (see figure below). With this model, we have defined a DTD that covers the different entities displayed here in order to provide for a generic and standard representation of collaborative action.
CONCEPTUAL DIAGRAM of raw data collection	

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	UVA-AO, UOC-IAG.
CATEGORY OF LEARNING ENVIRONMENT	[COLLABORATIVE PLATFORM, FORUM, SHARED WORKSPACE]
LE ACTIVITY TOOLS	BSCW, E-MAIL
Learning Environment USER PROFILE:	University students and teacher
TASK category:	Project based learning where students had to produce intermediate and final reports.
CONTENT TYPE:	The problem was the evaluation and design of computer systems.
DIVISION OF LABOUR:	Not specified a priori. Free division of labour.
USERS' COMMUNITY	**[**> 100 students and two teachers**]**

*** Minimum and sufficient information in order to can answer the question: Under what context & conditions some analysis outputs could be useful?*

INTERACTION ANALYSIS TOOLS

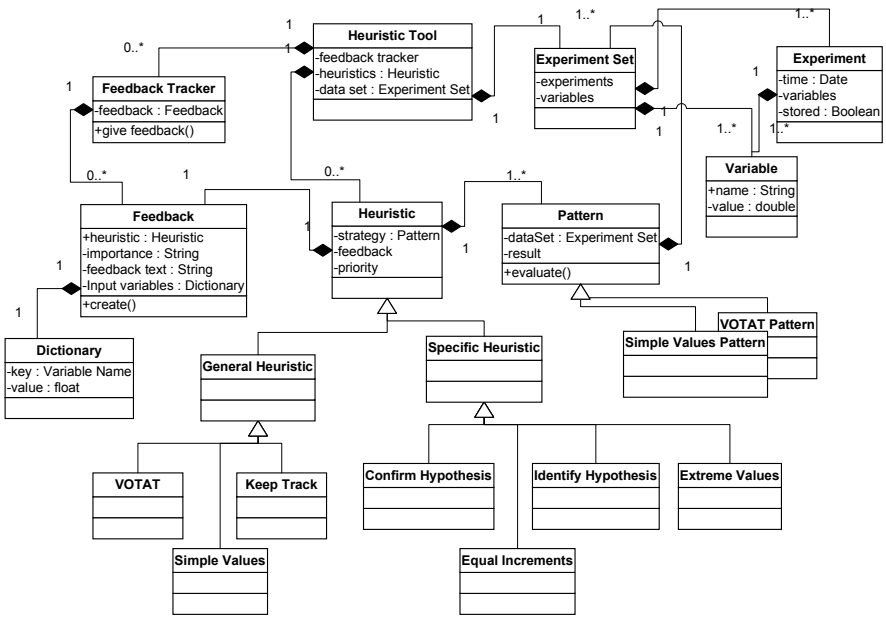
** In case that the indicator(s) are produced by an independent tool, give here a brief description*

Name	**SAMSA (System for Adyacency Matrix and Sociogram-based analysis)**
Description	It collects the data from the XML log file and builds a social network, computing three different indexes. It allows the user to configure some aspects of the network, such as the set of actors being considered, the time period as well as the type of network (out of three possible types). Additionally, SAMSA provides the definition of the network in a SNA standard data format (DL's) that can be used by external SNA tools. This adds more possibilities of analysis oriented to the researchers.
Indicators kinds that could be inserted/presented	Network centralization, network density and actor's centrality
Kinds of covariation (or dependence) that could be derived	
Intended Users	Teachers and researchers. A tool for students is under development.

References	4. A. Martínez, Y.Dimitriadis, E. Gómez, B. Rubia, P. de la Fuente *Combining qualitative and social network analysis for the study of classroom social interactions,* Computers and Education, 41(4), pp. 353 – 368 (2003), ISSN/ISBN: 0360-1315 5. A. Martínez, P. de la Fuente, Y. Dimitriadis, Towards an XML-based representation of collaborative interactions, Designing for Change in Networked Learning Environments. (Eds: B.Wasson, S. Ludvigsen & U. Hoppe). 379-388, Kluwer Academic Publishers (2003), ISSN/ISBN: 1-4020-1383-3 6. A. Martínez, Y. Dimitriadis, J. Tardajos, O. Velloso, M.B. Villacorta. **Integration of SNA in a mixed evaluation approach for the study of participatory aspects of collaboration,** European Conference on Computer Supported Collaborative Work (ECSCW03), Workshop on Social Networks. Helsinki (2003).

An.7. Indicators: Laboratory EDTE/University of Twente

An.7.1. "Heuristics use in Experimentation" Indicator

A.) DESCRIPTION OF 'INDICATOR': Heuristics use in Experimentation	
INDICATOR IDENTITY	
NAME/ Symbol	Heuristics use
CONCEPT of indicator	A set of general and specific heuristics related to experimentation and hypothesis testing is compared to student behavior
Indicators' Value FORM	----------[**visual, numerical, literal**] Boolean, Numerical, Text
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	Students' selection of variables for investigation and variables and values of students experiments
"ANALYSIS" POINT OF VIEW:	Process oriented
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	
INDICATOR CALCULATION: "DATA PROCESS METHOD"	General Heuristics are compared with all experiments. Sets of experiments are constructed based on the selection of variables by the learner, and these sets are compared with specific heuristics. Each Heuristic has its own 'pattern' that can be compared to the students behavior.

VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	Some Heuristics Boolean for used or not, others good-medium-poor

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* Feedback to students to support learning domain knowledge and learning general exploration/discovery skills **2. What indicator users could do on the base of this information?** Change their way of experimentation in the current environment, and reflect on their exploration
INDICATOR USER	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** ***To whom is addressed?*** To the student.
TIME OF USE	During the activity ***When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)?***

INFORMATION INTERPRETATION AMBIGUITY	1. ----------[Low, medium, high] Medium for analyses on actions performed in the learning environment. *2. Information interpretation: short description* In interpretation of experimentation behavior it is sometimes difficult to distinguish between deliberate thoughtful experiments and behavior that is mimicking thoughtful experiments (trying to copy behavior without understanding the motive).
USE OF INDICATOR	
MODE OF INDICATOR USE	The indicator is used to give feedback to students in the process of exploring a simulation. It gives heuristic feedback on the experimentation and data interpretation of these experiments, and aims to support learners by giving support, and triggering reflection on the exploration behaviour.

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	Registered interaction with the computer simulation: - Timestamp of the action that is performed - Type of action - Type of object - Action that is performed with the simulation (setting values for variables, start, stop) - Opening-closing support in the environment (assignments, explanations, tools) and actions within these tools, (answers, selecting variables etc)
CONCEPTUAL DIAGRAM of raw data collection	See also earlier diagram.

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	The learning environment was a physics (domain of collisions) simulation environment developed with the SimQuest authoring system.
CATEGORY OF LEARNING ENVIRONMENT	The learning environment is a computer-based discovery learning environment
LE ACTIVITY TOOLS	Simulation Interface, Assignments, Explanations, Experiment Storage & Graphing Tool Model progression levels (complexity dimension)

Learning Environment USER PROFILE:	Learners in pre-scientific education have used the simulation (ages 15-17 years).
TASK category:	The main tasks are exploration, experimentation, discovery and reflection on these activities. *Short Description* The students' task in the learning environment is to investigate/explore the environment and the different model progression levels. The idea is that they use and/or learn to use heuristics for experimentation and investigation and infer knowledge and understanding of the model that underlies the behaviour of different variables (ie., different types of collisions) in the simulation.
CONTENT TYPE:	*Short Description* The content of the simulation lies at different ranges of conceptual level. From the behaviour it is possible to induce the basic equations, on a higher level laws such as law preservation of momentum and preservation of energy can also be induced, but also heuristics like 'the difference between two velocities before and after an elastic collision are always equal'.
DIVISION OF LABOUR:	The learning is done individually.
USERS' COMMUNITY	In our studies students worked indivually with the computer simulation. The environment is suited for individual use or use by two students.

An.7.2.Knowledge development in discovery learning process Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbols	**Knowledge development, discovery learning processes.**
CONCEPT of indicator	*Literal designation and literal description of the indicator* In our studies we focus on collaborative discovery learning. More specifically the development of knowledge during collaborative discovery learning. The first study explored the possibilities and difficulties that occur during collaborative discovery learning. The second study focussed on ways to support students' collaborative discovery learning processes. We used a (shared) proposition scratchpad (expression builder) and a shared proposition table as support tools. In both studies logs from peer to peer communication as well as logs from the students' interaction with the environment were used as a window on the students' collaborative discovery learning process.
Indicators' Value FORM	**Numerical** Number of messages related to a certain discovery learning process (like stating a proposition, or designing an experiment). Number of experiments performed within the simulation environment. Number of times students used the supportive tools. **Quality** Quality of the experiments students performed with the simulation. We relate the number of messages related to a certain discovery learning category and the number and quality of the performed experiments to students' learning gains on an intuitive knowledge test. • **Insert Figure N, in case of visual form** **[e.g. the specific indicator variation per time, or the variation of the specific indicator (y) in relation with another indicator (x)]** ***(if needed)***

DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	In the first study students communicated face to face while they were working on a collaborative discovery learning task. In the second study students' communicated through a chat channel. In the first study students' face to face interaction was recorded, transcribed, coded and analyzed. In the second study students' interaction with the simulation as well as their chat messages were logged and analyzed. Face to face communication, chat communication and logs from students' interaction with the environment were used to gather information about students' collaborative discovery learning process. The analyses of the face to face communication and chat messages focussed on students' discovery learning processes. Face to face communication was segmented into utterances. After segmentation each utterance or message was categorized as on- or off-task communication. Off-task communication was not further categorized. On-task communication was further categorized as technical, regulative, or transformative. All utterances/messages related to technical features of the learning environment, for instance closing and opening an assignment or window, were coded as technical. Utterances related to planning or monitoring of the learning process were coded as regulative. Communication that directly yielded knowledge was coded as transformative. All messages referred to as transformative, were further analyzed. We distinguished the following transformative processes; orientation, generation of propositions, experimentation, and interpretation The analyses of students' interaction with the simulation environment focused on the number and quality of experiments students conducted within the environment and their use of supportive tools like the scratchpad or the proposition table.
"ANALYSIS" POINT OF VIEW:	**[ACTION ORIENTED, STRUCTURAL/STATE ORIENTED, AUTHORSHIP ORIENTED, PROCESS ORIENTED, …]** The main focus of the analysis is process oriented.
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Data was coded by hand. For the statistical analysis we used SPSS software. ***Equation or algorithm applied or external processing software used, or any other method***
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	***In case that the values of the indicator were calibrated into the specific learning environment and context of use, Insert here the range of values, as well as the meaning of these values regarding the quality of interaction (process, content or collaboration mode)***

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* **[SOCIAL/COLLABORATIVE, COGNITIVE, TECHNICAL, MANAGERIAL]** *(An indicator could also be multipurposal)* Cognitive and Collaborative **2. What indicator users could do on the base of this information?** The indicators described provide information about the development of knowledge in a collaborative discovery learning setting. More specifically the indicators focus on collaborative discovery learning processes. Information about the way students' construct knowledge and interact with the discovery learning environment can be used to develop tools to support students during collaborative discovery learning tasks. In the second study the indicators also provided information on the way students interacted with the tools we included in the environment.
INDICATOR USER	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** *To whom is addressed?* Researchers, educational designers.
TIME OF USE	*When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)?* Talk is recorded, actions and chat messages are logged during the activity. The researcher uses the data after the activity to gain understanding of the collaborative discovery learning process.
INFORMATION INTERPRETATION AMBIGUITY	1. ----------[Low, medium, high] Medium for face to face communication protocols Medium for chat protocols Low for activities from the learning environment. *2. Information interpretation: short description* A coding scheme is designed for the analyses of the chat protocols. Inter rater reliability (Cohen's Kappa) was satisfactory. *What the 'IAT' user' [student, teacher, system, researcher] could decode as information from the output form of indicator values: possible interpretations per indicator*

USE OF INDICATOR	
MODE OF INDICATOR USE	***Describe one or more mode of uses of this indicator, regarding the Interaction Analysis user [student, teacher, system, researcher] (conditions of use)*** Students' chat messages coded in terms of discovery learning processes as well as the logged interaction with the discovery learning environment provide information on the discovery learning processes students engage in during interaction with the environment. Furthermore, the information can be used to adjust the learning environment to the needs of students. For example: the indicators provide information about the use of tools designed to support the student.

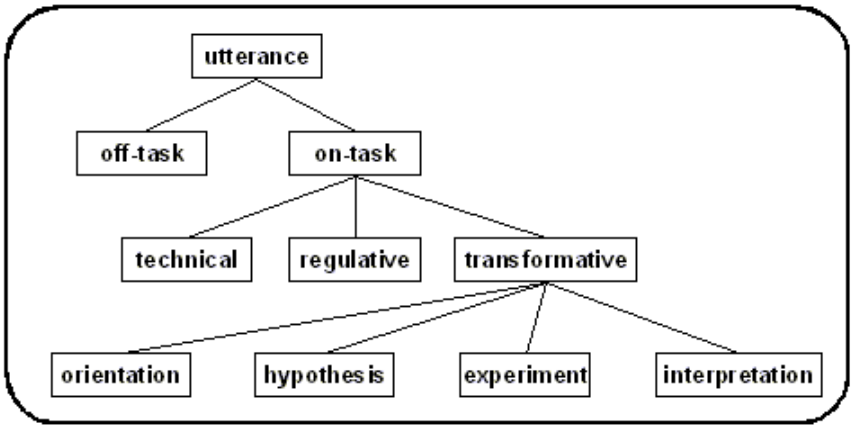
C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	Logged interactions with the environment: • Change of variable in the simulation • Execution of experiments • Consulting background information • Use of supportive measures and tools. Logged chat messages/ recorded communication (face to face) • Segmented into messages with a distinct communicative function • Coded in terms of discovery learning processes. {source of data}:{e.g. Identifier, time stamp, type of object, user, action , etc}
CONCEPTUAL DIAGRAM of raw data collection	

	Diagram of the analyses of utterances/ chat messages.

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	We use a simulation that is developed with the SimQuest authoring environment. The learning environment contains a simulation model of motion.
CATEGORY OF LEARNING ENVIRONMENT	The learning environment can be categorized as a collaborative discovery learning environment.
LE ACTIVITY TOOLS	Simulation Chat Tool Shared proposition table Proposition Scratchpad
Learning Environment USER PROFILE:	The application used in this study is designed for 15-16 years old students' from pre-university education.
TASK category:	*Main Task:* Experimentation and argumentation. *Short Description* In the learning environment students manipulate values of input variables, and observe the behaviour of output variables.
CONTENT TYPE:	[**LOW CONCEPTUAL, HIGH CONCEPTUAL**] *Short Description* The learning environment focuses on the domain of kinematics. The environment consists of three progression levels. The model in the, first, level focuses on initial velocity, acceleration, time and final velocity. The relevant variables are presented to the student one at a time. In the first progression level students can test relations like: "if the acceleration of a car equals zero than the final velocity of this car will equal the initial velocity". Within the second progression level the students work with simulations on distance covered. In the third, and final, progression level the concepts mass and friction are introduced to the students. In the second study support in the form of a (shared) proposition scratchpad and a (shared) proposition table is added to the environment. The scratchpad provided students with dropdown menu's containing variables and relations. In the shared proposition table we combined students' individual opinions about the truth-value of a proposition into one shared proposition table. The shared proposition table displayed the truth-value, both students assigned to a particular proposition. proposition table improved significantly from pre- to post-test and discussed significantly more alternative propositions.
DIVISION OF	[**CONTIGUOUS, PEER-TO-PEER COORDINATED, PEER TO PEER FREE, DISTRIBUTED,**

LABOUR:	Students collaborate in a peer to peer coordinated setting, sharing tools like the simulation, scratchpad and proposition table and communicate through a chat channel.
USERS' COMMUNITY	**[INDIVIDUAL-TWO PERSON GROUP, THREE PERSON GROUP, XXX, XXX,WIDE COMMUNITY]** Within our studies students work in dyads. ***One or more settings could be indicated*** The environment is suited for individual use or groups of two or three students.

An.7.3. "Optics Computer Simulation" Indicator

A.) DESCRIPTION OF 'INDICATOR': Optics computer simulation	
INDICATOR IDENTITY	
NAME/ Symbol	Discovery learning in the context of 'Optics'
CONCEPT of indicator	Registration of all the actions a student performs while working (and learning) with a computer simulation about the subject of geometrical optics (called 'Optics')
Indicators' Value FORM	----------[**visual, numerical, literal**] Words (to indicate actions) and numerical (to indicate time, positioning, etcetera)
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	Raw data gave an indication of every action that students performed in the computer simulation: what buttons were pressed at what time, what objects (lenses, lamps, other measures) were selected to put in the 'working area' of the simulation. What was done to the objects in the working area. Students could also drag objects over the working area. Not every pixel of dragging behavior was logged. Instead, whenever a student would start dragging and hold an object in one position of .5 seconds, a specific 'drag' operation was registered.
"ANALYSIS" POINT OF VIEW:	Action oriented
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Logfiles were created by the computer program itself. Each different actions was registered, together with detailed time information. Analysis of logfiles was done through a specifically created Perl script, after which the data was ready to be processed with tools like Excel and SPSS.
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	No diagrams were used to calculate indicators.
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	A large range of values resulted from use of the learning environment. These gave a direct indication of the sequence with which operations were carried out, and also their frequency. The quality of interaction with the learning environment cannot directly be obtained from the logfiles.

B.) INDICATOR' STATUS:	
PURPOSE:	1. ***What's the purpose of the indicator?*** Cognitive. **2. What indicator users could do on the base of this information?**

	Find out what type of actions students prefer to use, and discover sequences of actions that are more frequent than others, and which are indications of different cognitive activities.
INDICATOR USER	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** ***To whom is addressed?*** To the researcher.
TIME OF USE	Logfile analysis is done afterwards, when a complete logfile is available. ***When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)?***
INFORMATION INTERPRETATION AMBIGUITY	1. ----------[Low, medium, high] Low for actions performed in the learning environment. Analysis of clusters of actions (performed in sequence) is of medium difficulty. *2. Information interpretation: short description* A distinction was made between 'core' actions (which are central to working with the computer simulation) and 'peripheral' actions (which help the learner to work with the simulation or to understand specific information but which are not central to the task). Frequencies of each were tallied and, based on a number of distinctions between students, compared with each other. General level of activity could be inferred from the analysis of frequencies.
USE OF INDICATOR	
MODE OF INDICATOR USE	The indicator gives insight to the researcher into the discovery learning process that students go through as they work with a computer simulation.

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	Registered interaction with the computer simulation: - Action that is performed - Begin and end times of the action that is performed - Type of action - Object on which the action is performed - Consulting (built-in) background information - Use of other supportive measures (e.g., model progression)
CONCEPTUAL DIAGRAM of raw data collection	** Figure N. how it is considered the situation in which the indicator is derived [e.g. **channels of communication]**

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	The learning environment is called 'Optics', and was developed in the context of the Inductive Learning project (a short description can be found at http://web.swi.psy.uva.nl/projects/il/). A number of different studies have been carried out with this simulation that contains a model of geometrical optics.
CATEGORY OF LEARNING ENVIRONMENT	The learning environment is a computer-based discovery learning environment
LE ACTIVITY TOOLS	Simulation Notebook tool
Learning Environment USER PROFILE:	The simulation has been used by learners in vocational education (aged 15-16 years), learners in prescientific education (ages 15-16 years), and students in their first year of study (aged 18-19 years)
TASK category:	The main tasks are exploration, experimentation, and discovery. ***Short Description*** The students' task in the learning environment is to discover the rule system (or the *model*) that underlies the behavior of different variables (ie., different configurations of lamps and lenses) on a virtual optical workbench.
CONTENT TYPE:	***Short Description*** The content of the simulation lies at both a low and a high conceptual level. From the behavior of light through different types of lenses, it is possible to induce the rules that govern geometrical optics. At the lowest level basic equations such as the magnification law can be induced, at a higher level it is possible to induce the lens law.
DIVISION OF LABOUR:	The learning is done individually.
USERS' COMMUNITY	In our studies students worked indivually with the computer simulation. The environment is suited for individual use or use by two students.

An.7.4. Indicators related to experimental trials

A.) DESCRIPTION OF 'INDICATOR': ZAP project 'Very interactive Psychology'	
INDICATOR IDENTITY	
NAME/ Symbol	Monitoring experiment outcomes.
CONCEPT of indicator	Real-time registration and visualisation of the outcome of experiment trials during an online psychological experiment.
Indicators' Value FORM	----------[**visual, numerical, literal**] Visual (graph), numerical (table)
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	The outcome of a student's experiment trial (e.g., a reaction time).
"ANALYSIS" POINT OF VIEW:	Outcome oriented
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Trial data that come in from computers connected to a central 'monitor' are accumulated, and average results are computed and updated as new data comes in.
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	**Student 1** **Student 2** ⟶ Central computer (monitoring tool) ⟶ Visualization . . **Student *n***
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	The values that are obtained by the monitoring system indicate the deviation from the theoretical 'norm'.

B.) INDICATOR' STATUS:	
PURPOSE:	1. ***What's the purpose of the indicator?*** Demonstrate to students what the collective results from their experiment are.

	2. What indicator users could do on the base of this information? Better understand the way collective data is an average of a collection of individual data. Understand the base for psychological (cognitive) theories.
INDICATOR USER	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** ***To whom is addressed?*** To the teacher and students.
TIME OF USE	Analysis is performed in real-time, simultaneously with students' actions. Data can be made available for analysis at a later time. ***When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)?***
INFORMATION INTERPRETATION AMBIGUITY	1. ----------[Low, medium, high] Low for interpretation of visualized data. *2. Information interpretation: short description* Data is computed in real-time. The data is visualized in bar charts, in categories that are dependent on the type of psychological experiment that students participate in. The bar charts give an indication of the average data that results from the use of different experimental conditions, situations, or configurations.
USE OF INDICATOR	
MODE OF INDICATOR USE	The indicator gives insight to students about the way data collection leads to average 'norm' data. It can be seen how collecting individual data (which deviates from the norm) can result in a theoretically 'perfect' fit to a theoretical construct.

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	Registered interaction with the computer simulation: - Result of an experiment trial (e.g., a reaction time) - Student's computer identity (only used to distinguish between data sets, not for identifying students) - Start/stop information
CONCEPTUAL DIAGRAM of raw data collection	** Figure N. how it is considered the situation in which the indicator is derived [e.g. **channels of communication]**

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	The 'learning environment' is a set of computer-based modules called 'ZAPs'. ZAPs cover a range of psychological phenomena.. In the course of the ZAP-project, 45 modules were developed. About half of these modules is suitable for use in a data-monitoring environment. An overview of the ZAP project in English can be found at http://zap.psy.utwente.nl/english/
CATEGORY OF LEARNING ENVIRONMENT	ZAPs allow students to experience and discover phenomena, and also to be participant in psychological experiments. The monitoring facility is especially suitable to the latter type of 'learning environment'.
LE ACTIVITY TOOLS	Web-based learning module Theoretical explanation of the phenomenon Instruction to the activity (experience, discovery, or experiment)
Learning Environment USER PROFILE:	ZAPs were developed with first-year psychology students in mind. They can be used in the first year of the study, but also during courses in later years.
TASK category:	The main tasks are experiencing, discovering, or experimenting (dependent on the topic of the ZAP) *Short Description* Students' task in a ZAP is to learn about, and get an informational background on a psychological phenomenon, in a relatively short time. They read a short introductory text about the phenomenon, and then start the 'activity', in which they experience the phenomenon for themselves (through an experience, a discovery, or experiment task). Following the activity, they are given a theoretical background to the phenomenon they have just worked with.
CONTENT TYPE:	*Short Description* The content of the simulation lies at a low conceptual level.
DIVISION OF LABOUR:	The learning is done individually.
USERS' COMMUNITY	Students work individually with ZAPs. However, in the context of a course the visualization can be discussed between groups of students.

An.8. Indicators: Laboratory COSET/University of Athens

An.8.1. "Self Re-Read" Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**SELF RE-READ**
CONCEPT of indicator	***The number of times that a "user" (it can be a group using the same login name) opens a contribution of his/her own and re-reads it in a session.***
Indicators' Value FORM	----------[**visual, numerical, literal**] **Numerical**
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	In the logfile we use the file that records the notes created by each user and the file that records the notes read by each user.
"ANALYSIS" POINT OF VIEW:	**Process oriented** **[ACTION ORIENTED, STRUCTURAL/STATE ORIENTED, AUTHORSHIP ORIENTED, PROCESS ORIENTED, …]**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	The analysis was done on a logfile created by Knowledge Forum, using a special software called Analytic Toolkit. However it is a simple counting for each session for the times a particular note has been re-read. ***Equation or algorithm applied or external processing software used, or any other method***
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	**** Insert Figure N+1.** **Hierarchies/ trees or any conceptual diagram of source data process:** ***(if needed)***
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	***0 to 7 (for an one hour lesson) from our experience*** ***In case that the values of the indicator were calibrated into the specific learning environment and context of use, Insert here the range of values, as well as the meaning of these values regarding the quality of interaction (process, content or collaboration mode)***

B.) INDICATOR' STATUS:	
PURPOSE:	*1.* ***What's the purpose of the indicator?*** **Cognitive** **[SOCIAL/COLLABORATIVE, COGNITIVE, TECHNICAL, MANAGERIAL]** ***(An indicator could also be multipurposal)*** **2. What indicator users could do on the base of this information?** ***Find notes that seem special for the students. A note may be "special" due to expressing an opinion students are not sure about or an opinion that they are proud of or an opinion that got many comments from others***
INDICATOR USER	**To the teacher** **It could be addressed to the student as a form of a question to make her concentrate more on the process: What makes her come repetitively to a particular contribution she made?**
TIME OF USE	It is calculated after the activity. ***When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)?***
INFORMATION INTERPRETATION AMBIGUITY	1. –High-[Low, medium, high] *2. Emphasis on a particular note may be due to expressing an opinion that students are not sure about or an opinion that they are proud of or an opinion that got many comments from others* *What the 'IAT' user' [student, teacher, system, researcher] could decode as information from the output form of indicator values: possible interpretations per indicator*
USE OF INDICATOR	
MODE OF INDICATOR USE	***"troubling notes" can be searched for their semantic content and their position in the on-line discussion.***

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	
CONCEPTUAL DIAGRAM of raw data collection	

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	WebKnowledge Forum (it can be used in other similar environments ie SYNERGEIA or FLE3)
CATEGORY OF LEARNING ENVIRONMENT	**COLLABORATIVE PROBLEM SOLVING**
LE ACTIVITY TOOLS	
Learning Environment USER PROFILE:	**[YOUNG STUDENT, ADULT STUDENT, TEACHER]**
TASK category:	[**PROBLEM SOLVING, EXPERIMENTATIONS, ARGUMENTATION, TEXT PRODUCTIONS]** ***Students had to explain the operation of the heating system and produce final reports of their understanding combining text and images***
CONTENT TYPE:	[**LOW CONCEPTUAL, HIGH CONCEPTUAL**] ***Explanation of the heating system of a house***
DIVISION OF LABOUR:	[**CONTIGUOUS, PEER-TO-PEER COORDINATED, PEER TO PEER FREE, DISTRIBUTED, ….**] The groups presented their solutions to the same problem and commented freely on them.
USERS' COMMUNITY	**[INDIVIDUAL-TWO PERSON GROUP, THREE PERSON GROUP, XXX, XXX,WIDE COMMUNITY]** ***groups of two or three students, 25 students and a teacher in total***

An.8.2. "Others Re-Read" Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**OTHER RE-READ (Proposed)**
CONCEPT of indicator	***The number of times that a "user" (it can be a group using the same login name) re-reads a contribution of others in a session.***
Indicators' Value FORM	----------[**visual, numerical, literal**] **Numerical**
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	In the logfile we use the file that records the notes created by each user and the file that records the notes read by each user.
"ANALYSIS" POINT OF VIEW:	**Process oriented** **[ACTION ORIENTED, STRUCTURAL/STATE ORIENTED, AUTHORSHIP ORIENTED, PROCESS ORIENTED, …]**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	The analysis was done on a logfile created by Knowledge Forum, using a special software called Analytic Toolkit. However it is a simple counting for each session for the times a particular note has been re-read.
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	***0 to 7 (for an one hour lesson) from our experience***

B.) INDICATOR' STATUS:	
PURPOSE:	*1.* ***What's the purpose of the indicator?*** **Cognitive** **[SOCIAL/COLLABORATIVE, COGNITIVE, TECHNICAL, MANAGERIAL]** ***(An indicator could also be multipurposal)***

	2. What indicator users could do on the base of this information? ***Find notes written by others that seem special for the students. A note may be "special" due to friendship with the authors, or because they are good students or it is very interesting or students want to respond to it***
INDICATOR USER	**the teacher** **It could be addressed to the student as a form of a question to make her concentrate more on the process: What makes her come repetitively to a particular contribution she made?**
TIME OF USE	It is calculated after the activity. ***When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)?***
INFORMATION INTERPRETATION AMBIGUITY	1. –High-[Low, medium, high] *2. Emphasis on a particular note may be due to social or to cognitive reasons.* *What the 'IAT' user' [student, teacher, system, researcher] could decode as information from the output form of indicator values: possible interpretations per indicator*
USE OF INDICATOR	
MODE OF INDICATOR USE	***"special notes" can be searched for their semantic content and their position in the on-line discussion.***

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	
CONCEPTUAL DIAGRAM of raw data collection	

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	We propose it
CATEGORY OF	**COLLABORATIVE PROBLEM SOLVING**

LEARNING ENVIRONMENT	**[COLLABORATIVE PROBLEM SOLVING, COLLABORATIVE PLATFORM, FORUM, XXX, XXX,]**
LE ACTIVITY TOOLS	***Main Tools available to students***
Learning Environment USER PROFILE:	**[YOUNG STUDENT, ADULT STUDENT, TEACHER]**
TASK category:	[**PROBLEM SOLVING, EXPERIMENTATIONS, ARGUMENTATION, TEXT PRODUCTIONS]** ***Students had to explain the operation of the heating system and produce final reports of their understanding combining text and images***
CONTENT TYPE:	[**LOW CONCEPTUAL, HIGH CONCEPTUAL**] ***Explanation of the heating system of a house***
DIVISION OF LABOUR:	[**CONTIGUOUS, PEER-TO-PEER COORDINATED, PEER TO PEER FREE, DISTRIBUTED, ….**] The groups presented their solutions to the same problem and commented freely on them.
USERS' COMMUNITY	**[INDIVIDUAL-TWO PERSON GROUP, THREE PERSON GROUP, XXX, XXX,WIDE COMMUNITY]** ***groups of two or three students, 25 students and a teacher in total***

An.8.3. "Group Read" Indicator

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Group read**
CONCEPT of indicator	***It counts the number of times the notes of a certain group have been read in one session***
Indicators' Value FORM	----------[**visual, numerical, literal**] **Numerical**
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	From the logfile one can find the notes produced by each group and then the groups that have read (and reread) each note
"ANALYSIS" POINT OF VIEW:	**Process oriented** **[ACTION ORIENTED, STRUCTURAL/STATE ORIENTED, AUTHORSHIP ORIENTED, PROCESS ORIENTED, …]**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	Popularity = Sum (number of times each note of the group has been read in one session) ***Equation or algorithm applied or external processing software used, or any other method***
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	***0 to 15 for 2 hour session, from our experience of 25 participating students*** ***In case that the values of the indicator were calibrated into the specific learning environment and context of use, Insert here the range of values, as well as the meaning of these values regarding the quality of interaction (process, content or collaboration mode)***

B.) INDICATOR' STATUS:	
PURPOSE:	***What's the purpose of the indicator?*** *SOCIAL/COLLABORATIVE, COGNITIVE* **What indicator users could do on the base of this information?** ***They can monitor wether the popularity of the group varies in successive sessions. They can correlate the popularity with the content or the place of the note in an on-line asynchronous discussion.***
INDICATOR USER	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** ***The student, the teacher***
TIME OF USE	Gradually a history is made that can be consulted even during the activity ***When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)?***
INFORMATION INTERPRETATION AMBIGUITY	1. ----------[Low, medium, high] *2. Information interpretation: short description* *It is not clear if a group is "heard" because it produces many notes or because the group members have lots of friends or because they position themselves well in the on-line discussion and they make consistently good comments. More analysis is needed*
USE OF INDICATOR	
MODE OF INDICATOR USE	***The student can gain a sense of how much her group is "heard" in the community and think about the reasons. The teacher can search wether popularity correlates with sigfnificant contribution or with friendships or just with availability of notes***

C.) GENERAL DATA SOURCES DESCRIPTION:	
ACTION DEFINITION INTO THE LOGFILE:	
CONCEPTUAL DIAGRAM of raw data collection	

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	WebKnowledge Forum
CATEGORY OF LEARNING ENVIRONMENT	**[COLLABORATIVE PROBLEM SOLVING, COLLABORATIVE PLATFORM, FORUM, XXX, XXX,]**
LE ACTIVITY TOOLS	WebKnowledge Forum ***Main Tools available to students***
Learning Environment USER PROFILE:	**[YOUNG STUDENT, ADULT STUDENT, TEACHER]**
TASK category:	[**PROBLEM SOLVING, EXPERIMENTATIONS, ARGUMENTATION, TEXT PRODUCTIONS]** ***Students had to explain the operation of the heating system and produce final reports of their understanding combining text and images***
CONTENT TYPE:	[**LOW CONCEPTUAL, HIGH CONCEPTUAL**] ***Explanation of the heating system of a house***
DIVISION OF LABOUR:	[**CONTIGUOUS, PEER-TO-PEER COORDINATED, PEER TO PEER FREE, DISTRIBUTED, ….**] The groups presented their solutions to the same problem and commented freely on them.
USERS' COMMUNITY	**[INDIVIDUAL-TWO PERSON GROUP, THREE PERSON GROUP, XXX, XXX,WIDE COMMUNITY]** ***groups of two or three students, 25 students and a teacher in total***

An.9. Interaction Analysis Tool: Laboratory ICAR-CNRS Lyon

An.9.1. Opinion difference visualization

A.) DESCRIPTION OF 'INDICATOR':	
INDICATOR IDENTITY	
NAME/ Symbol	**Opinion difference visualization**
CONCEPT of indicator	When two students have different opinions (for and against) in relation to a particular argument on a graph, this difference of opinion is shown visually. Each student is assigned a color and when a student has expressed an opinion, the box is surrounded by his or her color (below in blue and in green). When two students disagree, the argument (box) becomes "scrunched".
Indicators' Value FORM	[**visual**] QuickTime™ et un décompresseur TIFF (LZW) sont requis pour visionner cett **[This indicator is integrated into the graphical part of the argumentation learning environment. The indicator appears in real time as the opinion difference is made by the system].**
DATA PROCESS	
DATA SELECTED FOR ANALYSIS:	The data that is used comes from the computerized interaction trace. Specifically, the fact that one student is "against" an argument and the other student "for" is highlighted visually. This is a content measurement and not a number measurement. There are no lower level indicators that are used in order to produce this indicator.
"ANALYSIS" POINT OF VIEW:	**[ACTION ORIENTED, STRUCTURAL/STATE ORIENTED, AUTHORSHIP ORIENTED, PROCESS ORIENTED, …] This is action oriented (put an opinion), state oriented (what is the current opinion?), authorship oriented (who has expressed the opinion?)**
INDICATOR CALCULATION: "DATA PROCESS METHOD"	If a box has two different opinions associated with it, then it becomes scrunched.
DIAGRAMMATIC DESCRIPTION OF INDICATOR CALCULATION	**Not applicable**
VALUES' CALIBRATION	
INDICATOR VALUES' CALIBRATION	***The value that contributes to the "scrunched" box is a "for" and "against" opinion pair. This value is in regard to a process (giving an opinion), a content (the value of the opinion) and collaboration modes (two opinions were expressed)***

B.) INDICATOR' STATUS:	
PURPOSE:	*1. What's the purpose of the indicator?* **[SOCIAL/COLLABORATIVE, COGNITIVE, MANAGERIAL]** ***This indicator is social because it stipulates where opinions are conflicting, and conflicts also have social causes and consequences.*** ***This indicator is collaborative because it points out the result of collaborative activity.*** ***This indicator is cognitive because it stipulates the content on which two users disagree.*** ***This indicator is managerial because, depending on the task, it could indicate how to manage the interaction, for example on what arguments users need to concentrate their attention.*** **2. What indicator users could do on the base of this information?** ***Students could explore their differences of opinion.*** ***Teachers could locate student misconceptions where argumentation occurs.*** ***Teacher educators could show teachers the problems students have in debating.*** ***Researchers could study the context in which disagreement (socio-cognitive conflict) occurs.***
INDICATOR USER	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** ***The student, the teacher, teacher educators and researchers***
TIME OF USE	Both during and after the activity, depending on the task and the user involved
INFORMATION INTERPRETATION AMBIGUITY	2. ----------[Low] *2. Information interpretation: short description* ***Users need to be told what the scrunched box represents (difference in opinion of two users on an argument or thesis), but once they know, there is not much room for mis-interpretation. Sometimes students did not see the point in expressing an opinion. They felt that the fact that they had added an argument to a graph meant that they agreed with it.***
USE OF INDICATOR	
MODE OF INDICATOR USE	***Students may explore the reasons behind their disagreement and therefore make more explicit their reasoning;*** ***Teachers may see where students disagree and therefore organize classroom discussion on the concepts involved;*** ***Teacher trainers can show teachers the problems students have in debating (confusion between argument and opinion, problems in elaborating arguments, etc.)*** ***Researchers can study the conditions under which disagreement (socio-cognitive conflict) occurs.***

C.) GENERAL DATA SOURCES DESCRIPTION:

ACTION DEFINITION INTO THE LOGFILE:	SandrineC challengeArgument,elisabethR.110.14,true SandrineC Grapheur 5. Attitudes, opinions and agree elisabethR supportArgument,elisabethR.110.15,true elisabethR Grapheur 5. Attitudes, opinions and agree The source of data is an entry in the interaction trace log file. Above, Sandrine is challenging a particular argument nu 110.14 (expressing an opinion "against" whereas Elisabeth is supporting another argument numbered 110.15 (expressi opinion "for").
CONCEPTUAL DIAGRAM of raw data collection	No answer No answer

D). CONTEXT OF INDICATOR VALIDITY:	
LEARNING ENVIRONMENT NAME:	DREW (Dialogical Reasoning Environment WebSite in the PWS (Pedagogical Web Site) in the European project SCALE (Internet-based Intelligent Tool to Support Collaborative Argumentation-based LEarning in Secondary Schools — http://www.euroscale.net/)
CATEGORY OF LEARNING ENVIRONMENT	**[COLLABORATIVE PLATFORM, or Dialogical and Graphical Argumentation Learning Environement]**
LE ACTIVITY TOOLS	***Chat, argumentation graph, collaborative text writing space, white board, replay tool (although the indicator is specifically built into — integrated — into the argumentation graph)***
Learning Environment USER PROFILE:	**[high school STUDENT, ADULT STUDENT, TEACHER]**
TASK category:	[**PROBLEM SOLVING, ARGUMENTATION, TEXT PRODUCTIONS**] The argumentation graph can be used in a variety of teaching-learning situations: as a way of taking notes from a text presenting a variety arguments on a particular topic, as a way of transferring content between two different semiotic representations (argumentative text to argumentation graph or vice versa), as a way of representing a debate, as a way of mediating a debate, etc.
CONTENT TYPE:	[**LOW CONCEPTUAL, HIGH CONCEPTUAL**] The opinion difference visualization indicator is a low conceptual indicator in the sense that the values leading to the visualization are either "for" or "against". However, in order to interpret the significance of this difference of opinion, users need also to understand the content of the argument or thesis in relation to which the opinions are expressed and this can become highly conceptual.
DIVISION OF LABOUR:	[**PEER-TO-PEER COORDINATED**]
USERS' COMMUNITY	**[INDIVIDUAL-TWO PERSON GROUP, THREE or FOUR PERSON GROUP]**

An.9.2. Interaction Replay Tool

INTERACTION ANALYSIS TOOL

A. BRIEF DESCRIPTION	
Name	**Interaction Replay**
Description	***It gives the possibility to replay an entire computer mediated collaborative interaction, in real time or step-by-step.*** The replayer is a tool that allows a user (teacher, researcher, student) to replay a computer mediated distance interaction in real time (or fast forward it, or go step-by-step). Although no specific parts of an interaction are highlighted (everything is replayed) such a tool can be conceived of as a way to reflect on a collaborative interaction in an open way.
Indicators kinds that could be inserted/presented	It can serve as an unprocessed data, that could help to interpret indicators. Alternatively, there are already indicators that are integrated into the interface and thus appear in the replayed interaction (Opinion difference visualization).
PURPOSE:	1. What's the purpose of the tool? [SOCIAL/COLLABORATIVE, COGNITIVE, TECHNICAL, MANAGERIAL] Social/Collaborative and Cognitive **2. What indicator users could do on the base of this information?** When they view a replayed interaction, teachers have access to the problem solving process and not just access to students' final results. In theory, this means that they can better diagnosis student problems in solving the task (for future tutoring) or otherwise see how students divide up different parts of the task (in our case building argument diagrams, or other sub tasks such as managing the interaction).
TOOL USER Intended user	**TO [THE SYSTEM, THE STUDENT, THE TEACHER, THE RESEARCHER]** ***To whom is addressed?*** ***To a teacher looking for new ways to understand student problem-solving and to researchers interested in studying the nature of collaborative activity***
TIME OF USE	***When it will be taken into account by the 'user'? (e.g. during the activity or afterwards)? Afterwards.***
DATA SELECTED FOR ANALYSIS:	**All of the elements of the recorded logfile are used. See the example below:**

INFORMATION INTERPRETATION AMBIGUITY	1. –High-[Low, medium, high] 2. What the 'IAT' user' [student, teacher, system, researcher] could decode as information from the output form of indicator values: possible interpretations per indicator *Since "interaction replay" is not really a specific indicator per se, and in fact displays all of the interaction, the possible interpretations are limited only by what each student, teacher or researcher chooses to focus on.*
Kinds of covariation (or dependence) that could be derived	**Not applicable**
USE OF TOOL	
MODE OF TOOL USE	***Describe one or more mode of uses of this indicator, regarding the Interaction:*** Analysis user [student, teacher, system, researcher] (conditions of use) In our case of argument graph construction accompanied by chat, we can name a few specific examples. A student could use the "interaction replay" to learn vicariously from other students' interactions or they could perform tasks based on transforming the interaction they see in specific ways within their own dyad. Teachers may notice the types of problems students have in using the technology (for example, arrow construction between boxes representing arguments), at what moment students choose to express their opinions on the graph, how they manage elaborating arguments for the different topics they treat in the debated question, to what extent students deepen and broaden their debate, how they manage their task and their interaction, etc. The system uses the log file to perform the interaction replay. A researcher replays the interaction in order to have time to study it in depth.

B). CONTEXT OF TOOL USAGE:	
LEARNING ENVIRONMENT NAME:	***DREW (Dialogical Reasoning Educational Website) within the PWS (Pedagogical Web Site) in the European project SCALE (Internet-based Intelligent Tool to Support Collaborative Argumentation-based LEarning in Secondary Schools) (www.euro-scale.net)***
CATEGORY OF LEARNING ENVIRONMENT	**[COLLABORATIVE PLATFORM]**
LE ACTIVITY TOOLS	***Main Tools available to students*** ***Chat, argumentation graph, collaborative text writing space, white board, replay tool***
Learning Environment USER PROFILE:	**[YOUNG STUDENT, ADULT STUDENT, TEACHER]**
TASK category:	**[PROBLEM SOLVING, EXPERIMENTATIONS, ARGUMENTATION in chat and argumentation in argumentation graphs, TEXT PRODUCTIONS]** ***Students have performed a variety of tasks with DREW. In general, they were asked to debate an open-ended question, for example on authorizing GMO production. They did this through reading material, constructing individual and collaborative***

	argumentative texts, individual and collaborative argumentation graphs and by chatting, all at a distance.
CONTENT TYPE:	[**HIGH CONCEPTUAL**] ***Students were encouraged to develop arguments in the space of debate***
DIVISION OF LABOUR:	[**PEER-TO-PEER COORDINATED**] ***Students divided their task as they saw fit (chatting, construction of arguments, etc.) However, each student was supposed to express his or her opinion on each of the arguments in the graph and that could only be done individually.***
USERS' COMMUNITY	[**INDIVIDUAL-TWO and four PERSON GROUP, THREE PERSON GROUP, XXX, XXX,WIDE COMMUNITY**] ***In general, we experimented with groups of two students at a distance, sometimes two pairs collaborated at a distance, one pair on each computer. This meant that there was a face-to-face interaction on each end of a computer mediated distance interaction.***

Example from the above table entry "data selected for analysis"

N	Time	Speaker	Utterance	Who	Tool
1	15:04:12	elisabethR	13 novembre 2001 15:04:12 CET~elisabethR~10.203.115.144/10.203.115.144	System	Control-Panel
2	15:04:12	elisabethR	13 novembre 2001 15:04:12 CET~elisabethR~Salon~nom~elisabethR~sujet6~	System	Control-Panel
3	15:04:12	elisabethR	13 novembre 2001 15:04:12 CET~elisabethR~Salon~msg~elisabethR nous a rejoint dans la piece Salon	System	Control-Panel
4	15:04:12	elisabethR	13 novembre 2001 15:04:12 CET~elisabethR~Salon~syn~	System	Control-Panel
5	15:04:12	SandrineC	13 novembre 2001 15:04:12 CET~SandrineC~10.203.115.161/10.203.115.161	System	Control-Panel
6	15:04:12	SandrineC	13 novembre 2001 15:04:12 CET~SandrineC~Salon~nom~SandrineC~sujet6~	System	Control-Panel
7	15:04:12	SandrineC	13 novembre 2001 15:04:12 CET~SandrineC~Salon~msg~SandrineC nous a rejoint dans la piece Salon	System	Control-Panel
8	15:04:12	SandrineC	13 novembre 2001 15:04:12 CET~SandrineC~Salon~syn~	System	Control-Panel
9	15:05:48	elisabethR	engagedUser,true	elisabethR	Grapheur
10	15:06:16	SandrineC	engagedUser,true	SandrineC	Grapheur
11	15:06:32	elisabethR	Coucou	elisabethR	Chat
12	15:06:48	SandrineC	je sius l!	SandrineC	Chat
13	15:07:10	elisabethR	non c'est pas vrai?	elisabethR	Chat
14	15:07:41	SandrineC	T'as quoi a me raconter sur les OGM ?	SandrineC	Chat
15	15:07:42	elisabethR	alors que penses tu des OGM?	elisabethR	Chat
16	15:08:19	SandrineC	tu m'as volé ma phrase.	SandrineC	Chat