A Role-Based Approach for the Support of Collaborative Learning Activities[1]

José Antonio Marcos
University of Valladolid

Alejandra Martínez
University of Valladolid

Yannis Dimitriadis
University of Valladolid

Rocío Anguita
University of Valladolid

ABSTRACT

The analysis of the interactions that occur among participants in computer-supported collaborative learning (CSCL) experiences has become a major research topic in this field. Interaction analysis (IA) methods and tools aim to enhance collaboration among participants, providing support for basic functions such as awareness, regulation or evaluation. The importance of these functions depends on the roles played by the participants in a collaborative experience. For this reason, IA tools need to interpret and manage the information needs required by the participants' roles as well as to recognize the dynamic role transitions that usually occur in authentic learning settings, in order to adapt their outputs to the needs of these changing roles during the development of collaborative activities. We are working in the definition, developing and validation of a conceptual framework for characterizing roles in collaborative learning contexts that aims at supporting IA tools in achieving these goals. In this paper we present two experiences carried out in the same authentic learning context that illustrates the use of this framework and forms part of a longitudinal validation process of the framework. The first experience shows how this

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framework supports the definition of IA indicators and values for detecting role transitions in a dynamic way, identifying a limited set of emergent roles. The second experience describes a static adaptation of an interaction IA tool for supporting the pre-defined information needs specified in the framework for several static roles.

Keywords: *Computer supported collaborative learning, interaction analysis, framework, roles*

INTRODUCTION

The increasing use of Information and Communication Technologies (ICT) and the emergence of socio-constructivist theories of learning converged at the beginning of the nineties in the interdisciplinary research field called Computer Supported Collaborative Learning (CSCL) (Koschmann, 1996). The learning theories underlying CSCL shifted the focus of the study from the products obtained from a learning experience to the processes followed by the learners to produce them. In collaborative learning, the study of the process implies the analysis of the interactions which occur among participants during the experiences (Dillenbourg et al., 1995). During the last years, a number of methods have been proposed to support this interaction analysis (IA), such as conversational analysis and action-based-analysis (Soller et al., 2005). These IA methods can be supported by the so-called IA tools, that implement fully or partially the method, enabling automated or semi-automated interaction analysis processes respectively. The elaboration of these IA methods and tools is a research priority in CSCL (Dimitracopoulou, 2005; Soller et al., 2005).

By providing a better understanding of the collaborative processes, IA may support different functions, such as the self-regulation of students, or the evaluation of learning experiences by teachers. These functions are oriented to different types of users, which have different needs depending on diverse aspects related to the context, the specific task, the educational level of the participants, and the IA purpose. For example, Petrou and Dimitracopoulou (2003) identify different needs of a teacher in asynchronous and synchronous scenarios, and therefore suggest various types of support, while Dimitracopoulou (2005) shows how it is possible to discriminate different meta-cognition and visualization needs for students and teachers in a CSCL environment.

Following this idea, in the CSCW (*Computer Supported Cooperative Work*) field we can find some proposals of awareness systems that adapt their functionalities to the different participants' roles (Dourish and Belloti, 1992; Drury and Williams, 2002). These approaches consider that the key issue is to provide exactly the right amount and type of information to each participant in a given role performing a specific task. Additionally, in CSCL there exist a number of research studies that show how the pre-assignment of appropriate roles to the participants facilitates their interaction and also produces educational benefits, improving the overall collaborative experience (Mizoguchi and Inaba, 2004; Strijbos et al., 2004; Strijbos et al., 2005).

From these experiences we can state that IA tools would benefit from considering these role-based proposals, in order to improve the collaborative processes they support. Besides, from the aforementioned works, we can see that it would be very useful to identify *the roles* that may appear in collaborative learning processes and what are their *IA needs*, i.e., the most appropriate information and how to present it to these roles. This is not only a pre-established and static task, but it is also necessary to take into account the dynamism of learning in real contexts, which can produce transitions between roles during the development of collaborative tasks (Edwards, 1996). Then, the problem faced in this article consists in helping the teacher to characterize the roles that participate in a collaborative learning activity, in order to facilitate the dynamic detection of role transitions during its development and to achieve the adaptation of the output of the IA tools to the needs of these evolving roles, in an automatic or semiautomatic way. Overall, our research aims at contributing to leveraging IA research in CSCL, which is currently too much focused on research prototypes (Soller et al., 2005), by supporting its adoption by real users in authentic learning contexts.

Thus, we have proposed a *framework for the structured description and characterization of roles.* The framework faces the lack of a common taxonomy of roles in CSCL (Marcos et al., 2005) and the need for describing dynamic aspects, such as the aforementioned shifts between roles that usually take place in real contexts. This framework is an evolving proposal, whose previous versions were presented in Marcos et al. (2005) and Marcos et al. (2006). We plan to continue evaluating and refining the framework with its application to various real case studies.

The socio-constructivist and situated foundations of CSCL require that this validation process is based on authentic learning scenarios in order to achieve relevant results (Koschmann, 1996). In this paper we present two of these validation experiences, which were aimed to assess, on the one hand, how the framework supports the pre-established needs of teachers and learners in a collaborative experience and, on the other hand, how the framework supports the detection of role transitions in a dynamic way. These experiences also serve to illustrate how the framework can be applied to a concrete learning situation.

The rest of the article is structured as follows: The next section introduces our proposal of a conceptual framework to describe and characterize roles in CSCL contexts. The third section presents the two experiences of the application of this framework in an authentic learning setting. One of them assesses the capability of the framework to support the dynamic detection of roles. The second experience focuses on the characterization of roles' information needs interpretable by an IA tool, which adapts its outputs to the needs specified by the framework. The article ends by presenting the main conclusions and an overview of our future work plan.

A CONCEPTUAL FRAMEWORK FOR DESCRIBING ROLES IN CSCL

This section presents the main features of our proposal of a framework for the structured description of roles in CSCL activities. This framework faces the lack of a common taxonomy of roles in CSCL (Marcos et al., 2005) and the need for describing dynamic aspects that usually take place in real contexts. Besides, this framework aims to enable IA tools to adapt their functionalities to the different roles played by participants in collaborative activities. This adaptation requires a description of these roles so that IA tools can interpret and manage computationally this information. The framework is an evolving proposal, based both on theoretical and practical foundations. The next subsection explains the process followed to define the framework, whose main aspects and dimensions are described in the second subsection.

Theoretical and Practical Foundations of the Framework

The need for a new framework to support the definition of roles, as well as its initial structure, was based on a review of related work in the literature with respect to the concept and classifications of roles (including CSCL, CSCW, e-learning, classroom-based research, group dynamics, and adaptive hypermedia environments) (Denis, 2004; Mizoguchi and Inaba, 2004; Jones et al., 1995; Lee, 2000; Linder, 2001; Linjse, 2000; Lund, 2003; Marin and Pérez, 1985; Shank, 2004; Singley et al., 1999; Tinzmann et al., 1990; Tongdeelert, 2003). During this review process, we detected a lack of a common vocabulary to describe roles, multiple definitions and different classifications, highly dependant on the context of their application. This diversity pointed out to the need for providing a framework, so that teachers could use it to define and characterize the roles they want to consider in their educational contexts. In addition, the review led us to identify the two first aspects that should be included in the framework: *role's definition* and the *context of application*. The framework's overall structure was complemented with two additional aspects, directly related to the framework's goal: *interaction analysis needs* of the role during the development of the collaborative activity, and *indicators* to identify it. These aspects take into account the dynamism of learning activities. On the one hand they permit to identify transitions between roles during the activities, while on the other hand they enable to adapt dynamically the interaction analysis outputs according to the evolving needs of the participants in their new roles, as specified using the framework.

Starting with a first proposal based on these theoretical roots (Marcos et al., 2005), the framework has been continuously refined by means of its application to a set of case studies in authentic learning settings from our university. Additionally, the framework has been tested by external experts in the area, within the Kaleidoscope Network of Excellence on Technology-Enhanced Learning (Kaleidoscope, 2007), who have used it to define roles in their usual learning scenarios, and have provided a high value feedback to validate and refine the framework. The next subsection provides a detailed description of the framework structure.

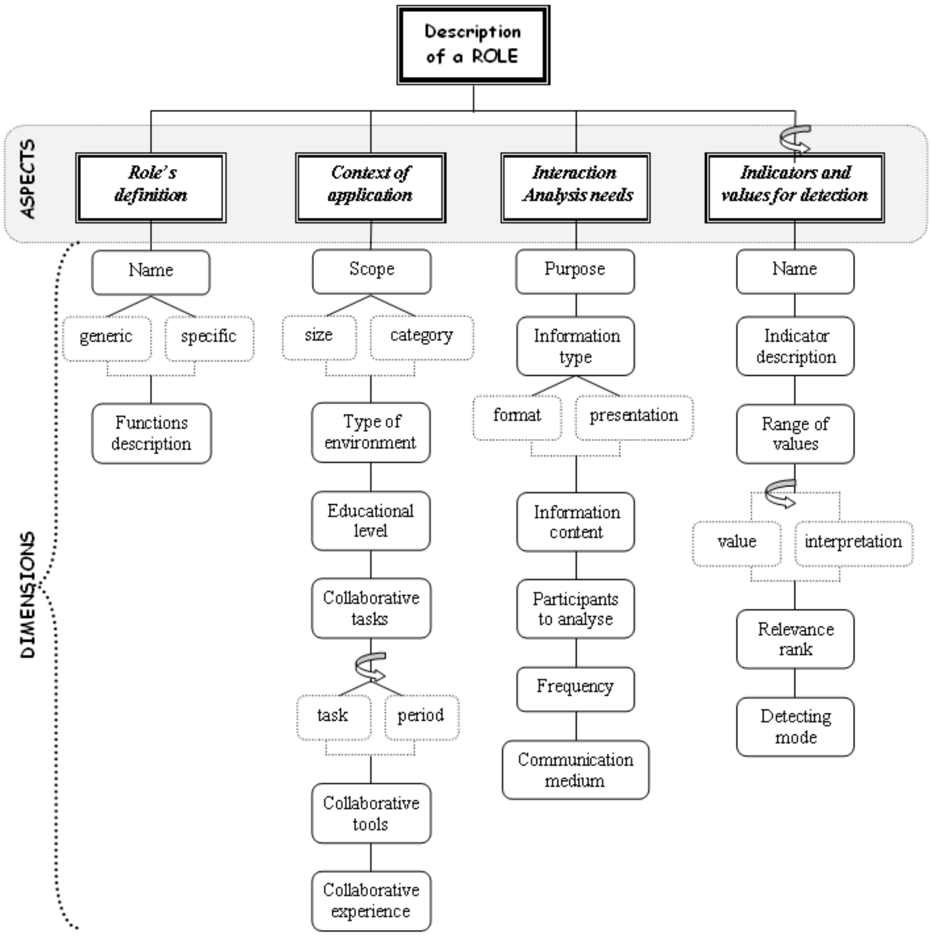

Figure 1. Structure of the framework for the description and characterization of collaborative roles. Semi circled arrows denote those parts which can be repeated.

Description of the Framework: Aspects and Dimensions

The description of a role in the framework includes four aspects: *definition*, *context of application*, *IA needs*, and *indicators for its detection*. Figure 1 shows these aspects, and the dimensions associated to each one of them.

The *role's* ***definition*** includes its name and the description of its functions. In relation to this aspect, the literature review discussed in the previous section showed us that the authors usually consider two levels for the description of roles. The first one refers to the actors or stakeholders that can be identified in educational settings, such as teachers, students, designers, etc. The second level defines the functions played by these actors in the educational environment, such as coordinator, facilitator, etc. For this reason, the *role's name* in the framework is composed by two levels (which we will call *generic* name and *specific* name). The *generic name* specifies the actor, such as a human, an agent or any combination of them (e.g., teacher or student) (Linder, 2001). The *specific name* is related to the role's functionality, depending on diverse facets such as the task or the participatory aspects of the collaboration (e.g., teacher-facilitator, student-writer, student-isolated). The *functions description* is a characterization of the role in terms of activities, duties and responsibilities in the learning activity (e.g., teacher-facilitator: "a teacher performing a minimal pedagogical intervention in order to redirect the group work in a productive direction" (Chen, 2006).

The theoretical review discussed in the previous sub-section showed us that the description of a role is highly influenced by its **context,** and thus, that the framework should include it as a separate aspect, defining as its dimensions the main characteristics that have shown up in the literature review with respect to the classifications of roles. These dimensions are the following: the *scope*, that specifies the *category* of the group being considered (e.g., small group, large group, community) as well as the actual *size* of this group, the *type of environment* (e.g., synchronous, asynchronous, distance, face-to-face blended), the *educational level* of the students (e.g., university, K-12 students, etc.), the specific *collaborative tasks* carried out by the participants and the *period* when they were or are to be performed (e.g., collaborative edition, between date1 to date2), the *collaborative tools* used to develop the activity (e.g., BSCW), and finally, the *collaborative experience* level of the participants (e.g., none, elementary, advanced). As mentioned beforehand, these dimensions are based on the classification of roles found in the literature, and they have been refined by the application of the framework to different case studies. For example, the *scope* dimension was initially defined by the *type of group* (small, large, or community), following the suggestions by several authors that considered this dimension in their definition of roles (Strijbos et al., 2004). The need to specify the *actual size of* the *groups* as part of this dimension was based on the external experts' feedback, as they pointed out that this size could have an influence in the work carried out in concrete activities and thus, it can be related to the role played by the participants in the experiences.

The description of **IA needs** specifies the IA information required for a role in a certain context. These requirements involve the *purpose* pursued with the provided information (i.e., social-awareness, regulation, evaluation), the *information type* that specifies the output *format* (e.g., numerical or graphical) and the *presentation* complexity of this information (e.g. elementary sociogram, bar chart, advanced three-dimensional graph, list of specific SNA indexes), the *information content* to provide (e.g., individual intra-group collaboration during a time period, inter-groups collaboration though different time periods), the *participants to analyze*, that indicates the participants included for the analysis (e.g., all participants, only some selected roles, only some selected groups), as well as the *frequency* and type of *communication medium* which will be used to communicate the information to the user (e.g., by the teacher in the classroom or by mail).

Finally the specification of **indicators and values for detection** is meant to enable an IA tool to identify a possible change of role during the activity. Each indicator related to the detection of a role includes five aspects: the *name* that identifies the indicator (e.g., closeness centrality), the *indicator description* that explains the generic aspects of interaction it represents and its relation with the functions of this role (e.g., "Closeness centrality denotes the proximity of a node to the rest of nodes in the network. This index can be interpreted as a measurement of the influence of an actor in the overall network"), the *range of values* that describes the correspondence between the different *values* that the indicator may take and their *interpretation* with respect to the described role (e.g., closeness value=100%, interpretation= he/she can be regarded as a prominent student for all the rest), the *relevance rank* that states the weight of the indicator for detecting this role, specified as some proportion (e.g., 60%) or as a priority rank (e.g., first, second,….), and finally, the *detecting mode* that permits to choose how and when the indicator is calculated during the development of the activity (e.g., in a specific moment, or between milestones).

As already mentioned in the first section, the framework presented here has been evolving during the last two years, based on the evaluation of a series of authentic learning experiences. In this article, we present two phases of this longitudinal evaluation process. With the first one we evaluated the possibility of identifying role shifts dynamically, based on the indicators and values specified with the framework for a set of roles. The second one shows how the framework was applied in the same scenario to evaluate its capacity to successfully adapt the IA output to different pre-established and static roles, based on the descriptions of these roles made with the framework. The next section presents these experiences and the results obtained from them.

THE FRAMEWORK IN USE: A CASE STUDY

The experiences described in this section are part of a case study that has been taking place since February 2005 in the course of "ICT (Information and Communication Technologies) applied to Education" at our University. The case study involves four classes. Each course is divided into two main phases. First, a *theoretical phase,* during which students have to analyze different aspects of the subject matter and elaborate three reports collaboratively; and later, a *practical phase*, during which students have to create a *Webquest*, which could be eventually used in a real school.

The setting is a blended one, where face-to-face activities are interleaved with technology-supported in-site or distance activities. Students collaborate mainly using *Synergeia* (ITCOLE, 2005), a tool that provides a workspace for sharing documents among all actors implied in the course. Students did not have previous collaborative learning experiences using computers, while teachers were more experienced in the use of interaction analysis tools for evaluation.

Table 1 shows the main characteristics of the *context* of this case study, according to the six dimensions defined in the framework for this aspect, namely: *scope*, *type of environment*,

Dimensions		
Scope	*Category*	*Size*
	Large group	**44** students distributed in 10 groups
Type of environment	**Blended** *(Technology supports in-site or distance activities)*	
Educational level	**University** *(A course of ICT applied in Education)*	
Collaborative tasks	*Period*	*Task*
	01-02-2006 // 31-03-2006 ***Theoretical phase***	Students analyzed diverse aspects of the subject and elaborated collaboratively three reports (subtasks)
	01-04-2006 // 02-06-2006 ***Practical phase***	Students created a *Webquest*, that could be used in a real school
Collaborative tools	**Synergeia** *(This tool provides a workspace for sharing documents among all the actors in the course)*	
Collaborative experience	*Student*	*Teacher*
	None	**Advanced**

Table 1. Specification of characteristics related with the context of this experience.

educational level of the participants, *collaborative tasks* developed, *collaborative tools* used, and *collaborative experience* of the participants. Scope and period shown in the table are related to the course in which we carried out the second experience presented in the next section.

In this context we have carried out two experiences with a focus on assessing the capability of the framework to support the dynamic identification of role shifts, and the application of an IA tool for supporting the information needs specified with the framework for several predefined and static roles.

We employed Social Network Analysis (SNA) (Wasserman and Faust, 1994) as a specific IA method appropriate for the study of participatory aspects of learning (Martínez et al., 2006) and structural properties of individuals learning in groups (Cho et al., 2002; Harrer et al., 2005). SNA focuses on the study of the interrelations among individuals and introduces structural variables to measure them.

To support this IA method, we have used SAMSA (Martínez et al., 2003) as the IA tool in order to produce the desired social network indicators. SAMSA builds social networks representing the interaction among the users of a CSCL environment, and computes a set of social network analysis indexes that measure individuals' participation and groups' collaboration structures. In this case study the relationships were built from the indirect links between an actor that creates an object in the Synergeia shared workspace and those actors that access this object in order to read it or to modify it.

In order to evaluate these experiences, we have triangulated the information collected from different sources of data, using the Mixed Evaluation Method, already applied for formative evaluation in other authentic CSCL settings (Martínez et al., 2006). This method defines the combination of different data sources and analysis approaches oriented to support the formative evaluation of participatory aspects of collaborative learning in real classrooms.

An Experience to Assess the Dynamic Detection of Roles

The first experience was carried out in order to assess the capability of the framework to support the dynamic detection of role transitions during a collaborative activity. In this case social network indicators and values produced by SAMSA were used to detect two roles related to teachers using IA, according to the framework shown in Figure 1.

Description of the Experience. The framework for the description of roles was used for the definition of *teacher-guide* and *teacher-collaborator* roles, and for specifying the social network indicators and values needed for the dynamic detection of these roles. Before describing these roles and values, it is necessary to present the indicators that were selected to identify them. These were: *degree centrality (CD(i))* and *closeness centrality (CC(i)). CD(i)* is the most common measurement for the study of participatory aspects of learning. It measures the activity of an actor in the network, which gives an idea of his/her level of participation in it. Also, it is an index of the actor's prestige (Wassermann and Faust, 1994). *CC(i)* specifies the proximity of an actor to the rest of actors in the network. This index can be interpreted as a measurement of the influence of an actor in the overall network. In the case of relationships that consider the direction of the link, two degree and closeness indexes are defined. For example, for *CD(i): indegree (CDi(i)),* or the number of links terminating at the node; and *outdegree (CDo(i)),* or the number of links originating at the node. Sociograms were also selected for the visualization of the detected roles in a very intuitive way. The sociograms represent the actors as nodes and the relationships among them as lines in the graph. The teacher-guide role was defined as a leader that conducts the activity, detects participation problems, and intervenes in order to improve the collaboration. For this reason, his/her SNA values are the highest among the actors in the network, and he/she has a central position in the sociogram. Table 2 shows the concrete values associated to this *teacher-guide* role.

On the other hand, the teacher-collaborator role was defined as a teacher who monitors the development of the activity but does not guide it. He/she participates only in specific moments, for example for reading the reports elaborated by the students. For this reason, his/her values for the selected indicators have to be lower than the majority of the actors in the network, and her position in the sociogram should not be a central one. Next subsection shows how we detected these transitions for the teacher, supported by the descriptions provided by the framework.

The activity of the participants was analyzed during the overall collaborative learning experience. Using SAMSA as the IA tool, and the specifications discussed in the previous subsection, we performed a study of participants' roles every four weeks. The results obtained appear in the next subsection.

Results: Evolution of the Teacher Role During the Collaborative Activity. During the elaboration of the first report, in the theoretical phase, the role of the teacher-guide was

Role: **Teacher-Guide**		
Indicators		
Indegree $C_{Di}(i)$	*Description*	Number of links terminating at this actor.
	Values /Interpretation	A high value indicates a high actor's prestige into the group
	Relevance rank	First
Incloseness $C_{Ci}(i)$	*Description*	Specifies the proximity of an actor to the rest of the actors in the network
	Values/ Interpretation	A high value indicates a high influence of the actor in the overall network
	Relevance rank	Second
Actor position in a sociogram	*Description*	A sociogram represents the actors as nodes and the relationships among them as lines in the graph
	Values/ Interpretation	A centered node in the graph indicates a prominent actor for the rest of participants
	Relevance rank	Third. Only for visual validation

Table 2. Specification of the indicators and their values for the *teacher-guide* role.

detected. Her indexes C_{Di}(teacher) and C_{Ci}(teacher) were the highest of participants (29 and 10.57 respectively). Moreover, the sociogram associated to this phase (Figure 2(a)) shows how the teacher was the most centred node. Thus, we could conclude that the teacher was the leader of the activity in this phase.

The values of these indexes related to the teacher decreased during the next weeks. At the end of the theoretical phase, her indexes were lower (C_{Di}(*teacher*)=19.00 and C_{Ci}(*teacher*)=13.17) than some of the students indexes (C_{Di}(x08)=39.00, C_{Ci}(x08)=13.73; C_{Di}(x00)=36.00, C_{Ci}(x00)=13.62; C_{Di}(x21)=28.00, C_{Ci}(x21)=13.39; C_{Di}(x20)=22.00, C_{Ci}(x20)=13.45). Thus, the teacher was still one of the most important actors, but other participants had begun to acquire some autonomy.

Following this tendency, after the first part of the practical phase we could detect clearly that the teacher had lost her role of *guide* and she had become a *collaborator* in the activity. In this period her *indegree* and *incloseness* indexes show a notable decrease (C_{Di}(teacher)=14.00 and C_{Ci}(teacher)=8.77, respectively). More than 50% of the students presented higher values in these indexes (with C_{Di} values ranging from 132.00 to 21.00 and C_{Ci} values from 10.39 to 8.82). The sociogram associated to the practical phase (Figure 2 (b)) also shows how the teacher is not a centered node anymore.

These results were confirmed by triangulation with different sources of data and analysis methods, including questionnaires, focus groups of volunteers, and classroom observations, following the aforementioned *Mixed Evaluation Method* (Martínez et al., 2003). This process corroborated the change of the teacher's relevance during the experience. On the one hand, 79% of the students confirmed in the Web-based questionnaire

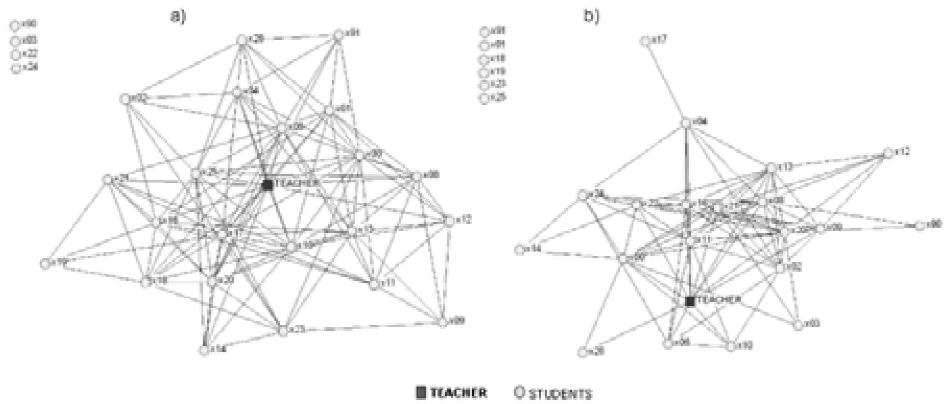

Figure 2. Sociograms representing the participants interactions: (a) During the elaboration of the theoretical first report. (b) During the first part of the practical phase.

the initial role of the teacher as a guide and leader and justified her posterior evolution towards a less central role, losing its relevance within the group. For example, one student stated that "*the teacher is a mediator during the collaborative activity. He is more important at the beginning because we did not know the course and the activities to perform. Later, we have work more independently in our group.*"

On the other hand, the reports elaborated by the observer during the course also confirmed this initial relevance of the teacher in the classroom and the posterior decrease of relevance for the students. During the first three observed sessions, and according to the notes of the observer, the teacher was almost overwhelmed answering questions from the students, while during the last three observations the teacher was more relaxed. The students collaborated more into their groups and performed fewer questions to the teacher.

Discussion. In conclusion, we can state that the social network indicators and values defined with the framework supported the detection of the teacher's specific role transitions during the collaborative activity using IA. At the beginning of the activity the teacher was the leader, i.e., the most relevant participant. However, during the evolution of the activity this relevance decreased, thus becoming a collaborator. This transition was validated by triangulation with collected information from other data sources.

Future experiences within this process of the framework cyclic refinement may imply the need to increment the number of supported roles, as well as the definition of adequate indicators and values to identify dynamically these participatory roles.

Once a role transition is detected, an IA tool could adapt its output to the specific needs of the emergent role during the collaborative activities. This adaptation has been already tested in this same scenario, where the output of SAMSA was adapted to pre-established and static roles. The next subsection describes this experience.

Assessment of the Adaptation of an IA Tool to Support the Roles' IA Information Needs

The second experience focused on the evaluation of the adaptation of the output of an IA tool to the predefined information needs of certain roles. More concretely, we dealt with the static adaptation of SAMSA output to the *student* and *teacher* roles according to their IA needs specified by means of our framework

Description of the Experience. The framework for the description of roles was also used for specifying the static IA needs of the student and teacher's roles. Table 3 shows these needs, according to the six dimensions defined in the framework for the 'IA needs' aspect: purpose, information type and content, participants to analyse, frequency of feedback and communication medium. The information requirements specified for the *teacher* role include more complex data than the IA information for *students* because the students of this course did not have previous collaborative learning experience while the teachers were more experienced in this area.

Both received the same elementary graphical information, sociograms. In order to facilitate the understanding of the sociograms, the report delivered to the students included a previous section with the most elementary concepts about how to interpret a sociogram. This is a key aspect to achieve students' reflection and regulation about their collaborative activity. Besides, information for teachers included numerical data based on some SNA indicators. The degree centrality ($C_D(i)$) and closeness centrality $C_C(i)$, already explained previously, and the degree centralization $C(i)$ were selected. The $C(i)$ is a network index that gives an idea of the dependency of the network activity on a small number of actors.

After the information was delivered to the students, we carried out interviews with thirty of them and with the teacher in order to collect their opinions about the information provided for their regulation and validate the success of this approach. These interviews included five aspects: level of difficulty to understand the information, interest and utility, reliability with respect to the work mediated by the Synergeia workspace, how the provided information could affect the work within their own group and finally proposals of improvement of the information that was given to them. This information was triangulated with other sources of data, including focus groups of volunteers (held twice after delivering them the information about regulation) and observations in the classroom (eight sessions).

Results: Supporting teacher and students' IA information needs. This section shows examples of the different types of information provided to the participants in the experience in order to support their IA needs specified in Table 3. Regarding the graphical information provided to both roles, Figure 3(a) shows an example of a sociogram sent to each member of one of the groups (group 5). These sociograms allowed the members of each group to visualize graphically their activity within the group during the development of the theoretical final report. For example, it is not difficult to interpret that learner *"x15"* is an isolated node of group 5, and does not collaborate with the rest of group members.

	Teacher	Student
Purpose	Evaluation, Regulation	Self –Regulation
Information Type *(format and presentation)*	• Numerical - SNA indexes: degree, closeness, centralization • Graphical - Sociogram	• Graphical: Elementary sociogram and main concepts about how to interpret it.
Information content	Individual participatory aspects:	
	• within the group • with the rest of participants in the course • comparative by phases (theoretical vs. practical)	• within the group • with the rest of participants in the course
Participants to analyze	• all the participants	• all the participants
Frequency of feedback	Milestones:	
	• 07.04.2006 (related to theoretical phase) • 08.06.2006 (related to practical phase)	• 07.04.2006 (related to theoretical phase)
Communication medium	• By mail	• Teacher provided feedback in the classroom

Table 3. IA needs specified for the teacher and student roles and their values for this experience.

Figure 3(b) shows a second sociogram delivered to all the participants. This sociogram shows the individual activity of each student with respect to the rest of participants in this course (each group is differentiated by the form and tone of the nodes representing its members). For example it is possible to observe that the aforementioned learner *"x15"* is linked to four members of other groups, but he/she does not collaborate with the members of his/her group. This situation could indicate some problem into his/her group.

As mentioned beforehand, the IA needs specified for the *teacher* role also included numerical information based on SNA indexes. Table 4 shows an example of the numerical information delivered to the teacher, obtained from the activity of members of group 4 during the last phase of the course. It is possible to observe that student *"x13"* has an CCi(i) value of 100. This means that all members of her group read some of her documents using the Synergeia workspace, and therefore, he/she can be regarded as a prominent student for his/her colleagues.

The teacher also received comparative data about the activity of each participant within his/her group and with learners of other groups. Table 5 shows the data obtained from two groups. It can be easily seen that the members of *group 10* did not collaborate among them, but they collaborated with members of other groups. The teacher can use this information to identify group breakdowns. Concretely, in this case, the teacher offered the possibility to change the composition of the groups by showing them this type of dysfunction.

Information referred to individual and group evolution in the collaboration mediated by Synergeia was sent to the teacher for final evaluation. Table 6 shows an example

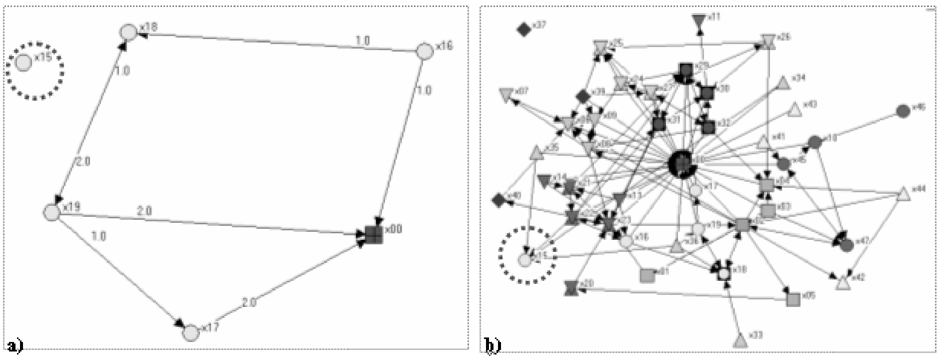

Figure 3. Sociograms representing participants' interactions during the task of elaboration of the theoretical final report: (a) Within the Group 5, including the teacher (a square node). (b) With the rest of participants in all groups.

of the data obtained from members of two groups and the teacher in the milestones specified by the framework. This information allowed the teacher to verify the progress in the collaborative activity of the different groups. For example, it is possible to observe in the table how all the members of groups 4 and 7 improved during the practical phase their initial indexes results obtained during the theoretical phase.

The participants in the collaborative activity were interviewed after the IA information was delivered to them. The results obtained were very positive. 100% of the participants answered that the information received had been easy to understand and 86% coincided that this information had been interesting and useful, emphasizing the reflection and debate that began in the group after its reception. The information provided was reliable for 86% of the participants, which considered the information reflected well their work group mediated by Synergeia. 14% of students did not see their activity properly reflected, mainly because they had used magnetic disks to exchange information instead of using Synergeia. Besides, 100% of participants proposed improvements to the information delivered to them. For example, 33% of the participants suggest adding the relations of each actor with himself, in order to understand better their activity. Another 33% suggest analyzing comparatively more larger periods of time. Finally another 33%

Table 4. SNA indexes obtained from members of group 4 during the practical phase of this course.

Actor	Indegree ($C_{Di}(i)$)	Outdegree ($C_{Do}(i)$)	Incloseness C_{Ci}(i)	Outcloseness C_{Co}(i)
x11	2	2	75.00	42.86
x12	7	9	75.00	42.86
x13	13	4	**100.00**	50.00
x14	0	7	25.00	100.00
Centralization: 333.33% (indegree); 155.56% (outdegree)				

		Within the own group		With other groups	
	ACTOR	Indegree ($C_{Di}(i)$)	Outdegree ($C_{Do}(i)$)	Indegree ($C_{Di}(i)$)	Outdegree ($C_{Do}(i)$)
Group 8	x29	1	6	3	3
	x30	6	1	2	1
	x31	2	8	2	3
	x32	2	5	5	3
Group 10	x37	0	0	0	0
	x38	0	0	1	3
	x39	0	0	0	5
	x40	0	0	2	3

Table 5. Indegree and outdegree into the group and with other groups.

propose to analyze separately the interactions during the laboratory hours, and out of these hours. We plan to include these proposals in our next experiences, as part of the formative refinement of the method and the tools.

Discussion. This experience has shown how an IA tool can adapt its output to support different roles' information needs. In this case we have used SAMSA for supporting teacher and students' IA information needs, which have been specified using the proposed framework for the structured description of roles in learning activities. This is a static adaptation in the sense that the roles' IA needs were defined before the beginning of the activity, and they did not change during its development. However, the next validation experiences should include the dynamic adaptation of the output, once the IA tool detects a role transition during the activity, as it has been shown in the experience reported previously.

The participants of this experience have assessed it positively. We have obtained this conclusion based on the collected information from different data sources as interviews, observations or focus groups. They state that the information provided was easy to

Table 6. Indegree and outdegree in the different phases of activity.

		Practical phase		Theoretical phase	
	ACTOR	Indegree ($C_{Di}(i)$)	Outdegree ($C_{Do}(i)$)	Indegree ($C_{Di}(i)$)	Outdegree ($C_{Do}(i)$)
Teacher	x00	358	51	86	0
Group 4	x11	0	4	5	0
	x12	2	2	1	0
	x13	26	15	0	11
	x14	1	39	0	6
Group 7	x24	7	22	5	0
	x25	9	7	2	2
	x26	18	42	5	6
	x27	21	29	3	9

understand, reliable and useful for the self-regulation of their work. Besides they have suggested a number of possible improvements that can help us to design next experiences into the cyclic of refinement of the framework.

CONCLUSIONS AND FUTURE WORK

IA tools can improve the collaborative processes they support by taking into account the participants' roles, in order to adapt their output to the needs of these roles during the collaborative activities. For achieving this aim, IA tools need to interpret and manage the information needs of these roles, as well as to recognize the dynamic role transitions that usually occur in authentic learning settings. We have described our current proposal of a framework for the structured description and characterization of roles that aims at supporting IA tools in achieving these goals. This framework is an evolving proposal based on the evaluation of a series of authentic learning experiences.

This article has presented two of these experiences performed in authentic learning scenarios using IA methods. The first scenario served for identifying dynamically a limited set of emergent roles, while the second one served for adapting the IA results to the pre-established and static roles' needs corresponding to teachers and learners, as part of the validation process of our framework.

The first experience described in this work shows that the structured description of roles proposed in the framework provides appropriate information to describe and identify a limited set of roles. The fact that the indicators and values to detect these roles are described in computational terms allows IA tools to interpret and manage the information. This opens a space for the automatic or semi-automatic adaptation of IA tools to CSCL.

A static adaptation of IA tool based on the teacher and student roles' needs specified in the framework has been also presented in a second experience performed in the same learning scenario. Students and teachers have assessed positively the specific information provided to them. On the one hand, students stated this information helps their work regulation. On the other hand this information also helps the teacher to identify collaboration problems, as the aforementioned group breakdowns.

Overall, these results aim to contribute to the evolution of the IA field in CSCL, which is currently more focused on the developing of research prototypes, and therefore, far from offering solutions for real users, as stated by Soller et al. (2005).

The next iterations of the process of cyclic refinement of the framework will include its application to other authentic CSCL scenarios, where the dynamic identification of roles and the dynamic adaptation of the output provided by the IA tools to the users will be integrated. Additionally, we will increment the number of roles to identify and support by the IA tools. This implies further work in the recognition and definition of adequate indicators to identify these roles.

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REFERENCES

Chen, W. "Supporting Teachers' Intervention in Collaborative Knowledge Building," *Journal of Network and Computer Applications* (29:2), 2006, pp. 200–215.

Cho, H., Stefanone, M., and Gay, G. "Social Information Sharing in a CSCL Community," in *Computer Support for Collaborative Learning: Foundations for a CSCL Community. In Proceedings of the 2002 Conference on Computer Support for Collaborative Learning,* Lawrence Erlbaum Associates, 2002, pp. 43-50.

Denis, B. "Roles and Compentences of the E-Tutor" *in Proceedings of Networked Learning Conference,* Lancaster University, U.K, 2004.

Dillenbourg, P., Baker, M., Blaye, A., and O'Malley, C. "The Evolution of Research on Collaborative Learning," in *Learning in Humans and Machines. Towards an Interdisciplinary Learning Science* H. Spada and P. Reinmann (eds.), Elsevier Science, Oxford, 1995.

Dimitracopoulou, A. "Designing Collaborative Learning Systems: Current Trends and Future Research Agenda," in *Proceedings of the 2005 Conference on Computer Support for Collaborative Learning,* International Society of the Learning Sciences, 2005, pp. 115–124.

Dourish, P., and Bellotti, V. "Awareness and Coordination in Shared Workspaces," in *Proceedings of the ACM Conference on Computer Supported Cooperative Work*, ACM Press, 1992, pp. 107–114.

Drury, J., and Williams, M. G. "Framework for Role-based Specification and Evaluation of Awareness Support in Synchronous Collaborative Applications," in *Proceedings of the 11th IEEE International Workshops on Enabling Technologies,* IEEE Computer Society Press, 2002, pp. 12-17.

Edwards, W. K. "Policies and Roles in Collaborative Applications," in *Proceedings of the 1996 ACM Conference on Computer Supported Cooperative Work*. ACM Press, 1996, pp. 11-20.

Harrer, A., Zeini, S., and Pinkwart, N. "The Effects of Electronic Communication Support on Presence Learning Scenarios," in Proceedings of the 2005 Conference on Computer Support for Collaborative Learning, International Society of the Learning Sciences, 2005, pp. 190-194.

ITCOLE Project, "About Synergeia", Retrieved May, 2007, from http://bscl.fit.fraunhofer.de/ Jones, B., Valdez, G., Nowakowski, J., and Rasmussen, C. "Designing Learning and Technology for Educational Reform," Washington, EEUU: the North Central Regional Educational Laboratory. 1995.

Kaleidoscope Network of Excellence, "Interaction analysis - Supporting Participants in Technology Based Learning Activities," Retrieved June 2007, from http://www.noe-kaleidoscope.org/pub/network /communities/jeirp/activity.php?wp=32 Koschmann, T. "Paradigms Shift and Instructional Technology", in CSCL: Theory and Practice of an Emerging Paradigm, T. Koschmann (ed.), Lawrence Erlbaum Associates, Mahwah, NJ, USA, 1996, pp. 1-23.

Lee, M., "Collaborative Learning in Three British Adult Education Schemes," *in Proceedings of Adult Education Research Conference,* University of British Columbia, Vancouver, Canada.

Linder, R., "Expertise and Role Identification in Learning Environments. Information Technology for earning, Education and Training," ISO/IED JTC1 SC36, Information Technology for Learning, Education and Training, Retrieved May, 2007 from http://old.jtc1sc36.org/doc/36N0065.pdf, 2001

Linjse, P. "Didactics of Science. The Forgotten Dimension in Science Education Research," in Improving Science Education: The Contribution of Research, Open University Press, Buckingham, UK, 2000.

Lund, K. "Human Support in CSCL," in *What we Know about CSCL and Implementing it in Higher Education,* J.W. Strijbos, P. A. Kirschner, R. L. Martens (eds.)Kluwer Academic Publishers, Norwell, MA, 2004, pp. 167-198.

Marcos, J., Martínez, A., and Dimitriadis, Y. "Interaction Analysis for the Detection and Support of Participatory Roles in CSCL," in *Proceedings of the 12th International Workshop on Groupware,* Springer Verlag, 2006, pp. 155-162.

Marcos, J., Martínez, A., Dimitriadis, Y., and Anguita, R. "Towards Adaptable Interaction Analysis Tools in CSCL," in *Proceedings of the Workshop on Representing and Analysing Collaborative Interactions at the 12th AIED International Conference,* Amsterdam, The Netherlands, 2005, pp. 70-74.

Marín, M., and Pérez, G., "Roles of Teacher as the Classroom Leader,(in Spanish)" *in Social Pedagogy and Sociology of Education*, Publications of National Open and Distance University, Madrid, Spain, 1985, pp. 228-248.

Martínez, A., Dimitriadis, Y., Gómez-Sánchez, E., Rubia-Avi, B., Jorrín-Abellán, I., and Marcos, J. "Studying Participation Networks in Collaboration Using Mixed Methods in Three Case Studies," *International Journal in CSCL,* (1:3), 2006, pp. 383-408.

Martínez, A., Dimitriadis, Y., Rubia, B., Gómez, E., and de la Fuente, P. "Combining Qualitative Evaluation and Social Network Analysis for the Study of Classroom Social Interactions," *Computers and Education* (41:4), 2003, pp. 353-368.

Mizoguchi, R., and Inaba, A. "Learners' Roles and Predictable Educational Benefits in Collaborative Learning: An Ontological Approach to Support Design and Analysis of CSCL," in *Proceedings of Intelligent Tutoring Systems 2004,* Springer Verlag, 2004, pp. 285-294.

Petrou, A., and Dimitracopoulou, A. "Is Synchronous Computer Mediated Collaborative Problem Solving 'Justified' only When by Distance?" in *Proceedings of the 2003 Conference on Computer Support for Collaborative Learning,* Kluwer Academic Publishers, 2003, pp. 14-18.

Shank, P. "Competences for Online Instructors," Learning Peaks LLC, 2004, Retrieved May, 2007 from http://www.learningpeaks.com/instrcomp.pdf

Singley, M., Fairweather, P., and Swerling, S. "Team Tutoring Systems: Reifying Roles in Problem Solving," in *Proceedings of the 1999 Conference on Computer Support for Collaborative Learning*. Lawrence Erlbaun Associates. 1999, pp.538-548

Soller, A., Martínez, A., Jermann, P., and Muehlenbrock, M. "From Mirroring to Guiding: A Review of the State of the Art Technology for Supporting Collaborative Learning," *International Journal on Artificial Intelligence in Education* (*15)*, 2005, pp. 261-290.

Strijbos, J. W., Martens, R. L., Jochems, W., and Broers, N. J. "The Effect of Functional Roles on Group Efficiency: Using Multilevel Modeling and Content Analysis to Investigate Computer-Supported Collaboration in Small Groups," *Small Group Research* (*35*:2), 2004, pp. 195-229.

Strijbos, J.-W., Laat, M. D., Martens, R., and Jochems, W. "Functional Versus Spontaneous Roles During CSCL," in *Proceedings of the 2005 Conference on Computer Support for Collaborative Learning,* International Society of the Learning Sciences, 2005, pp. 647-656.

Tinzmann, M., Jones, B., Fennimore, T., Bakker, J., Fine, C., and Pierce, J. "What is the collaborative classroom?" North Central Regional Educational Laboratory, Oak Brook, IL, USA, 1990

Tongdeelert, P. "A Proposed Collaborative Computer Network-Based Learning Model for Undergraduate Students with Different Learning Styles," *The Turkish Online Journal of Distance Education* (4), 2003.

Wasserman, S., and Faust, K. *Social Network Analysis: Methods and Applications.* Cambridge University Press, Cambridge, U.K., 1994.