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Collaborative Learning, the Use of NICTS and Interaction among Science Teachers: Necessary Skills and Problems

Aprendizaje colaborativo, uso de las NTIC en interacción entre profesores de ciencias: habilidades requeridas y problemas

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Abstract

This study analyzes the practices of a group of high school science teachers in the development of a training seminar using the Computer-supported Collaborative Learning (CSCL) approach. The pedagogical model, the tools used in collaboration, and the development of group dynamics are all described. The analysis is carried out using categories based on the concept of social infrastructure, which permits the identification of some of the skills required as well as problems that arose during the teachers' synchronous and asynchronous interactions.

Key words: CSCL, teacher-training, social infrastructure, collaborative tools, synchronous and asynchronous interactions.

Resumen

En este trabajo se analizan las prácticas de un grupo de profesores de ciencias de bachillerato, en el desarrollo de un seminario de formación desde el enfoque del aprendizaje colaborativo asistido por computadoras (CSCL). Se describen el dispositivo pedagógico, las herramientas colaborativas utilizadas y la dinámica desarrollada. El análisis se hace con categorías basadas en el concepto de infraestructura social, las cuales permiten identificar algunas habilidades requeridas y problemas surgidos en el curso de las interacciones sincrónicas y asincrónicas de los maestros.

Palabras clave: CSCL, formación de profesores, infraestructura social, herramientas colaborativas, interacción sincrónica y asincrónica.

> So that information circulating on computers via the networks can be enriched and transformed into knowledge, it must be accompanied by a change in the teacher's role: from being a supplier of knowledge in the classroom, to being a mediator and facilitator of learning in an interdisciplinary context.
>
> G. Waldegg (2002).

Introduction

The emergence of the paradigm of Computer-supported Collaborative Learning (CSCL, its acronym in English) (Koschman, 1996) has prompted research and development on educational proposals that recapture the socioconstructivist principles on which it is based.

The project "Work and collaborative learning with information and communication technologies in science" (Tactics)[2] is supported by the Department of Educational Research (DER) of the National Polytechnic Institute (Mexico) and the University of Montreal (Canada). It is based on the CSCL approach and is designed to visualize the process of cross-content learning in science (physics, chemistry and biology) among high school students from Mexico and Canada, through the use of new Information and Communication Technologies (NICT) (Waldegg, 2002; Juárez and Waldegg, 2003). During the operation of the project, the limited use of technology by teachers to communicate and coordinate work with and among students was presented as a problem because it involves a misunderstanding of the difficulties students face, and thus, the impossibility of giving them timely and adequate support. It can also be associated with the need for greater mastery of the principles of CSCL and for greater familiarity with the tools for collaboration.

To encourage a greater use of technology to improve the understanding of the CSCL foundations, we designed a 40-hour seminar for teachers, with a semipresencial modality, i.e., some face-to-face sessions, and the rest through asynchronous (forum) and synchronous (*chat*) interactions.

The contribution of this work is the analysis of teachers' practices, beginning with categories based on the concept of social infrastructure and the identification of some skills and problems encountered during the teachers' interactions in a CSCL process, and is part of preliminary analysis of the seminar mentioned above.

I. Background

CSCL is more than just "teamwork". Based on the socioconstructivist concept of learning there is necessary, before individual appropriation—intra-psychological—the socialization of knowledge in a cognitive dynamic group—interpsychological (Vigotsky, 1988, Leontiev, 1984). For that reason the fundamental principles of CSCL are expressed in terms of commitment (Lave and Wenger, 1991; Wenger, 2001), trust and responsibility toward one another for one's own learning, and for that of the rest of the group (Slavin, 1994).

Most research and development in this paradigm is centered on students' learning in the conditions most favorable for achieving it, and the tools to use (Lipponen, 2002); however, Koschman (1996) emphasizes the need to develop tools to support the teacher interested in working from the CSCL approach. In their research conducted with math teachers, Guin and Trouche (2005) emphasize that only half use the new information and communication technologies (NICTS) with their students in the classroom, and based on an extensive review of articles analyzed on the subject, say that of those, only 5% study the role of the teacher and the conditions of adopting technology in the classroom. Dunlap, Neale, and Carroll (2000) describe the problems faced by teachers in distance-learning collaboration processes, associating them with the organization of teaching, physical and temporal dispersion, and the individualistic culture in which teachers

are immersed. Fisher, Felps and Ellis (2000) found that the causes of most problems in a situation of distance teacher-training are attributable to technology and curriculum-design flaws. They consider that the group dynamic is in part similar to that developed in a face-to-face situation, but differs in the forms of commitment and in the need to give, from the beginning, an explicit explanation of the rules and guidelines that allow the consolidation of the group. The study by Russell and Schneiderheinze (2005), on problems of teachers when they adopt a techno-educational reform in the classroom, says that efficiency in the adoption of such reforms is hampered by the difficulty of teachers in understanding the potential a forum offers them in their professional development because of: limitations in solving the problems of their immediate school environment; concepts about teaching and learning; and the compatibility of these with the suppositions of the reform. Finally, Bielaczyc (2001) analyzes learning communities from the viewpoint of *social infrastructure*, which identifies the support structures (cultural, activity and tool) that help or hinder the desired interactions within CSCL environments.

II. Theoretical elements

Currently many of the works done with the CSCL approach are based on, or integrate, elements of the *theory of communities of practice* and *situated learning*, either as a global vision of the aims and strategies of training in schools (Brown, Collins and Duguid, 1989), as a framework for the introduction of NICT in learning communities (Scardamalia and Bereiter, 1994) or science education (Roth 2002a, 2002b).

Its principles are used to characterize *learning communities*, as communities of practice within schools are sometimes known. These communities are characterized by the diversity of skills and technical aptitudes among their members, by the shared goal of achieving collective knowledge and skill development, by the importance given to *learning to learn,* and finally, by the existence of mechanisms for sharing what they have learned.

Learning communities form the context of the overall concept of social infrastructure (Bielaczyc, 2001), which explicitly uses collaborative learning as a didactic foundation, and the use of NICTs as a central part of the support for the interaction, negotiation and creation of shared meanings among members of a community.

When Bielaczyc defines the categories for use in analyzing the social infrastructure, that is, the *support* structures for the desired interaction between collaborators in the use of technology in the classroom, she uses the concept of *communities of practice* and incorporates some aspects relative to the type of schoolwork, for example, the consciousness and intentionality of the teacher in promoting attitudes and ways of performing tasks within the group processes in an educational situation.

To identify and analyze the interaction support structures, we have first a crucial aspect: the *culture in the classroom.* It has two categories, the overall philosophy, which allows teachers and students to act in a certain way and makes possible the group identity, and the rules established between the members of the group. It insists that these rules determine what is permitted and what teachers and students are expected to do—that is, specify the overall philosophy.

A second aspect is *activity*, which is materialized in two categories: the adaptations to the classroom which the teacher established for the execution of the work with and without technology, and the relevant learning activities, i.e. preparation of the support structure for students' interaction—within teams and between teams—according to the teaching outline adopted. Here the teacher's role is more explicit based on the specific actions required in the beginning, during and at the end of the collaborative process.

A third and final aspect is that of *instruments*; in this the accent changes to the relationship between teacher and students and among students. It focuses on the uses that these, as end users, give to the Groupware[3] and to the modifications that make the tool. Bielaczyc (2001) considers two types of modifications, some expected and foreseen by the interface (for example, changing parameters) and the unanticipated results of the familiarity and ingenuity of users with the tool and with the task.

In our case, where the teachers participate in the learning community as members rather than facilitators, it is possible to analyze the support structures of the interactions in the Tactics seminar, based on the following aspects:

- Appropriation of and compliance with the norms established by the group (cultural level)
- Coordination of actions, management of roles in the process and consistency of participation with the context (activity level).
- The skills with which to manage the tools that make possible the execution of the tasks (level of the instruments).

III. Structure of the seminar

3.1. Profile of participants

The seminar was composed of eight teachers from four Mexican schools participating in the Tactics[4] project, and three researchers of that project, making a total of 11 participants. The teachers' involvement was voluntary and in addition to their conventional workload.

Eight of the participants have access to the Internet from home; three of them have it exclusively on the Tactics computers in their schools. Although some researchers have more time, and have used their knowledge of Internet tools and

facilities in more areas, the entire group has had experience in Internet use and its basic services, particularly Email.

Concerning the use of instant messengers (IM), it was the first time one of them had used it; four had used it only for personal purposes, and the rest had used it for academic, personal and entertainment purposes. Eight of the participants had already used the services of E-groups,[5] three had not been acquainted with this environment, five belonged to more than one E-group, and two had had the experience of creating them.

3.2. Technology used

Since it was necessary for participating teachers to work in an environment similar to that used by students, and as far as possible, to use the same tools, the organization of the seminar was designed so that the conventional sessions were minimal, and most of the work was done through asynchronous (forum) and synchronous (*chat*) interactions.

To carry out academic meetings and academic forums virtual, two free Internet devices were used: a software for groups in the web environment, and an instant messenger. The web-group software is called *e-groups*, a free Internet software offered by the Yahoo![6] website. This program was chosen because it permits the administration and storage of the teachers' participation. MSN Messenger was used as well because of the facilities it offers for recording and retrieving full-text *chat* sessions.

Before the seminar began, an *e-group* was created, and members were enrolled in it. There were created folders in which to put the presentation documents, plus folders for the intermediate and final products (summaries of the chat, conclusions from the forum, etc.) The teachers were urged to open additional folders as required.

3.3. Tasks

The seminar was built around three fundamental tasks: (a) individual reading of texts, (b) the contribution of questions, opinions, answers and multiple comments in the forum, and (c) production of group conclusions on the subject addressed synchronously in the forum. These tasks were performed over a period of two weeks. The initial themes covered the essentials of collaborative learning, and based on these, the evaluation of the work developed with the students, the development of proposals for the improvement of the collaborative structure, and the coordination of the project was done.

3.4. Data Collection

Data collection was performed by compiling the seminar's key documentation; the initial, semistructured interviews and the final ones; and by gathering the material produced in the synchronous sessions (by recording in a file which the instant

messenger itself generated) and the asynchronous sessions (for the recovery of the folder contents and the *e-group's* message logs).

The data collected in the first two activities served to interpret and compare aspects of conventional school culture and those of the seminar. The data collected in the third activity were used to identify the skills required to perform the tasks and problems emerging in the teachers' practices.

IV. Interactions in the seminar

The analysis was centered on teachers' practice while performing tasks because, as noted above, the forms of participation reflect the appropriation of the culture generated by the community, and indicate the current level of mastery for the tools. The results are grouped according to the structures supporting the interaction, as defined above.

4.1 Support structures for the implementation of teachers' asynchronous interactions

As an initial step, the first *chat* was conducted; in it the purposes of the seminar and the ways to address the various tasks within it were reviewed. The forum was then installed. This is the asynchronous mechanism in which the teachers would participate. It was expected to focus on a specific theme, with exchanges of viewpoints, criticisms, negotiations and agreements, in such a way that the group would have homogeneous elements that would allow their arriving at group conclusions in the synchronous sessions. As well, the role of secretary was established; this person was in charge of preparing to make a summary of the participations, before the synchronous sessions.

4.1.1. Appropriation of, and compliance with established norms

This type of activity was not unknown to the teachers, since they had supervised their students' work, but it was the first time they had performed it as protagonists.

Participation in the forum began after the first *chat*. At first, people stuck to the rules. The forum began with a series of questions from one of the teachers in the initial *chat*, and along with the answers to these questions, comments and new uncertainties related to the topics covered in the readings were expressed. However, as the process continued, it became clear that most participants had forgotten the rules; this was shown not only by the low rate of participation, but also because the new contributions were not generally related to prior or simultaneous input from other group members.

In the interviews, some teachers referred to what had happened, describing it as a difficulty in time management, since at the beginning there seemed to be enough for individual participation; but they had not thought about other people's reading (initially copious) input and the drafting of an appropriate response to it, based on

individuals' reading texts or their experiences as Tactics teachers. Here, compliance with the rules was overwhelmed by the limited experience of the participants in this type of interaction, and by the expression of disagreement and criticism in some of the participations.

4.1.2. Coordination of actions, management of roles and consistency of participation with the context

Although individual participation was in short supply, there was always some, and the synchronous meeting always took place on time, since participation increased as the date of the next *chat* session approached. However, this did not prove coordination in the assignments, but rather an attachment to the conventional classroom culture, where the achievement of objectives on predefined dates is important, as opposed to the role of participation as a basis for learning and as a basic cultural trait in such communities.

The work of the forum secretary could not be sustained because of the low rate of participation; some secretaries exchanged their role for that of *participation motivator*, a practice consistent with the Tactics culture, but which scarcely complied with this forum's obligations.

The *e-group*, as a context of group interactions, determined some forms of participation; for example, there was no rule establishing individual participation as a unique form. However, this happened even in schools where two or more teachers were participating, since they did not transfer the work method of the local Tactic-student teams (corresponding to Jigsaw II)[7] to the forum conditions. This was due in part to the fact that participation took place through individual email accounts.

At the face-to-face meeting at the end of the seminar, one participant, recognized for expertise as a biology teacher, summed up the difficulties of the group's forum participation paradoxically, saying, "We are a reflection of our students" (RCC-70105. p. 5).[8] This statement implies, among other things, the need for a thorough review, by the group, not only of the activity's supports, but also and particularly, of the culture shared by the participants. An interesting aspect is that the initial contents of the seminar approached the philosophy and characteristics of cooperative learning, where group participation and commitment are central to achieving the goals of joint production of knowledge and development of group skills; however, it was difficult to bring these concepts to fruition in the development of the forum.

4.1.3. Skills for managing tools

The heterogeneity of participants in the mastery of the instruments was evident in actions such as retrieving the participation in the section on *e-group* messages, and creating new folders in the file section defined by the user. In both cases the task was performed with the support of more-advanced participants. The *e-group* interface may seem complicated if one is not familiar with following different depth

levels in a tree structure, such as that describing the services of this software, and if one has no experience in creating, editing and deleting folders and files.

4.2 Support structures for the implementation of teachers' synchronous interactions

The synchronous or chat session is the mechanism by means of which is performed the task of stating group conclusions on a topic previously discussed in the forum, and its prospects for introducing it in the next cycle with students. This involves exchanges of viewpoints, reviews, negotiations and agreements in a short time. To speed up the task, the roles of moderator and secretary were defined, the length of time the roles would be filled, and the way of electing those who would fill them in the following session. It can be stated that participation in synchronous meetings was accepted better by the teachers, and its dynamics displayed a greater evolution than did the asynchronous form in a short period.

4.2.1. Appropriation of and compliance with established norms

In synchronous interactions the role of technology became more evident as actual support structure for these, and for the appropriation of and compliance with the norms established by the group as the infrastructure which made them possible. The participation of the teachers could be seen as guided by the norms, but motivated by learning and practicing this type of synchronous distance interaction.

Dealing with the difficulties of organization for carrying out the initial sessions and the limitations of the technology, which from the beginning impeded its fluidity, caused the participants to insist on the assumption of the roles defined, in addressing the issue without deviations, and keeping in mind the objectives set for that session.

The participations were individual, but the teachers of one of the schools were able to work out a plan so as to have all the material in the same format (on a CD). However, the reading was individual, and there were no interactions between the teachers prior to the synchronous sessions. In general, even though most had read the texts, and although they participated actively in these sessions, the lack of asynchronous interaction limited the group's taking advantage of it as a learning resource, since more time than expected was used to clarify personal positions or interpretations of a concept or a text.

The dynamics of each session were unique; however, as it became evident in the interactions, the possibility of achieving the common goal depended by and large on compliance with the implicit and explicit rules.

4.2.2. Coordination of actions, management of roles and participation's consistency with the context

Teachers' synchronous participation underwent an interesting evolution: in the first *chat* sessions, the participations were numerous, but the limitations of the

technology did not permit them to pursue real dialogues, or else these dialogues were lost among the new input from other teachers, so that the answer to a particular question might be given immediately, or might appear minutes after the first response had been seen in the instant-messenger dialog window. This made it difficult to follow; but even with these limitations, the discussions or answers to a question came to have five levels of interaction, as shown in Table I.

Table I. Example of sequences of a synchronous interaction (Chat 2, pp. 10 and 11)[9]

Sequences following a theme in the dialogue between participants Meeting: November 4, 2004										
	Initial Sequence		**Second Sequence**		**Third Sequence**		**Fourth Sequence**		**Fifth Sequence**	
Lines	541	542, 543	544	545						
Begin ↳	Am8	The moderator helps to negotiate and the facilitator conducts, helps and gives the necessary tools for the student to create his/her own growth.	Acm	That is the teacher's responsibility.						
Lines			546	547, 548	551	552	573	574	592	593
			Hdt	If in the constructivist approach the subject learns through the interaction of the subject with the object, is the role of the teacher to be the mediator between the two?	Am8	Then the new role of the teacher is that of facilitator.	Hdt	Would the vision of teacher as facilitator relate more with sociocon-structivism?	Acm	Yes, the vision of the teacher as facilitator is attached to socioconstruc-tivism.

Interestingly, although there was initially defined a moderator and a secretary, these did not fully exercise their role; above all those who functioned as secretaries faced two problems: the first, concerning when to begin the summary, and the second, how to overcome the limitations of the instant messenger (the maximum number of characters per message). The last was accomplished by dividing the summary into several segments, but that solution did not keep new participations from getting inserted between the segments.

As the roles of moderator and secretary became increasing clear and the issues and forms of participation were pinpointed, contributions generally improved; the number of entries per participant evened up. An example is the comparison of two teacher's participations. The first came from a school in the country's interior, and had minimal experience with web devices; in this case, participation advanced slightly, from 7.5% to 8% during a one-month interval. The other teacher was from

a school in Mexico City, and was familiar with the Internet; the number of operations in that case decreased from 11.2% to 7.2% during the same period.

While the coordination of actions, based on the assumption of roles and the restriction of time and forms of participation improved the process, teachers still had to overcome the characteristics of this type of synchronous distance interaction. The IM group as a context for academic activities competed with the immediate contexts out of which each of the teachers carried out his/her participation. Some people were at their schools, but others were at home, or were using a public Internet service. These immediate contexts affected the fluidity of participation, based on the extent to which stimuli demanding their attention were introduced.

Specifying the group's culture in synchronous interactions was shown as a process and a product of group learning; the complexity of managing the roles and of adapting to new participation conditions implied, for the teachers, the development of new skills.

4.2.3. Skills for handling tools

In the teachers' activities there was a clear perception of IM as an infrastructure that enabled or hindered the interaction. This tool is designed primarily for interactions between two people (at least in the Windows version), and its audio and video functions are lost when a third member is added. With more than two persons, the text-messaging function still works, but there are limitations on the maximum number of participants. For example, in our case, we always tried to get all the participants to interact; with nine participants communication was stable, but with more than nine, automatic exclusions were generated by the program, and prevented the return of members to the discussion window, although they still appeared as active members in the moderator's invitation window for the session.

Messenger limitations created difficulties for carrying out the task, especially in the initial sessions, because the attention of most group members turned toward attempts to reinstate the excluded members. Once this had occurred, it was the reinstated members who increased the distraction by asking for information about what had happened during their absence.

The group's heterogeneity in the management of the messenger and their limited experience in this form of interaction impeded the use of the tool's other capabilities, or its use in other ways—for example, having teams work in secondary windows, leaving a main window just for presenting each team's conclusion. The experience of those who had had previous contact with the messenger helped the rest of the group use it in the conventional way, as if it were a two-way chat, and although the same dynamic motivated students to overcome some of these obstacles, initially the CSCL philosophy was not manifested as a basis for possible uses of the messenger.

Conclusions

Although the seminar is essentially similar to a conventional one, it introduces elements new and different from those experienced by most teachers' in their training. If the activities, the ways in which they are carried out and how the tool is adapted to perform a group task are indicative of the internalization of culture by members of the community, work will be necessary in order to achieve fully the sense of belonging within the group, taking into consideration the factors of distance, synchrony and asynchrony, and the use of text as a basic form of interaction.

Although participants were not strangers to this type of interaction (since they had participated in Tactics, as expressed in one of the interviews: "looking over the shoulder of their students"), it is evident that being a protagonist implies more practice for employing NICTs in accordance with the CSCL learning philosophy.

Addressing an academic task with synchronous and asynchronous tools showed the need to develop or reinforce some of the teachers' skills, for example: working with explicit roles, respecting the time limit for participation, being able to concentrate for long periods on subjects in contexts different from the scholastic, speed reading, and writing messages that follow the thread of a discussion.

Reflection on what happened in this seminar includes analyzing which of the teachers' conventional practices can be useful in this type of work, and how some of them constitute an obstacle in such an environment; for example, individual participation in writing, and participants' criticism of what was written are not common in the Mexican school culture, but were presented here as two of the main forms of participation.

For some of the teachers it also implied reflecting on their own performance concerning what they expected from their students in similar tasks in the Tactics context. This reflection had a positive influence on the planning of activities for the next cycle.

Finally, we consider that the analysis of teachers' practices in this type of experience—still embryonic—opens a field for research in teacher-training. It is a valuable experience that permits the examination of the analysis categories having to do with the teacher's practice in learning communities, and allows for better perspective from which to evaluate the CSCL support media currently available.

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[1] Dr. Guillermina Waldegg died on August 17, 2005, in Mexico City, while this article was in process of publication. The Online Journal of Educational Research dedicates this issue to the memory of this Mexican researcher, in homage to her career of research on science teaching in Mexico.

[2] Research project supported by the National Council of Science and Technology (CONACYT), Key No. G33909-S.

[3] *Groupware* is a software that facilitates communication, participation and the coordination of activities between members of a group whose participants do not usually share a physical space.

[4] The Mexican high schools that participated were Cuernavaca High School No. 1; Jojutla Preparatory School of the Autonomous University of Morelos State; Pachuca Technological High School No. 8; Madrid School of Mexico City.

[5] *E-groups* is a device provided free by the Yahoo company on the Internet, and permits communication, coordination and administration of tasks between the members of the group. Its services include creating, editing and eliminating the group members' folders and files; interrelation between members by means of a space for synchronic interactions and a message board—based on the participants' email. It also has an agenda, surveys, and a database.

[6] http://mx.yahoo.com

[7] Jigsaw II is a teamwork technique which operates based on a topic divisible between the number of members (usually three members per team), each of whom takes a subtopic and becomes an

expert to interact with students of other teams that share the same subtopic. Once they have become experts they return to their base group and are committed to teach the rest of their companions their own sub-theme so as to develop an understanding of the initial theme. For that, at random, any member can present an examination whereby to obtain the evaluation of all team members.

[8] Through this code, the intervention of the teachers participating in the seminar sessions is represented; in this case the first three initials refer to the presencial or face-to-face meeting, and the numbers 70105 refer to the date the session was completed.

[9] A transcription of Chat 2, as well as those of other synchronic interactions, is found in *Archivos del seminario para profesores. Seminario Tactics-México 2005.* (2005).