Supporting JIGSAW-type Collaborative Learning

Tania Gallardo, Luis A. Guerrero, César Collazos[δ], José A. Pino, Sergio Ochoa
{tgallard, luguerre, ccollazo, jpino, sochoa}@dcc.uchile.cl
Department of Computer Science
Universidad de Chile
Blanco Encalada 2120, Santiago, Chile
Phone: +56-2 689-2736

ABSTRACT

JIGSAW is a well-known technique for collaborative learning. Students typically use it in a face-to-face setting without computer support. This paper describes Web-based tools for both the preparation of the collaborative learning activities and the execution of the activities. The teachers design and prepare collaborative learning activities and the proposal is they do it in a collaborative way. The system has tools to help teachers do these tasks while, at the same time, they can practice collaborative work and get hands-on experience. Most of these tools are re-used to support students to collaboratively learn. The tools are to be used by students in the same sequence and in the same phases as originally described for the unsupported JIGSAW technique. They also work organized as groups and pairs in a face-to-face setting. These tools are not intended as a replacement of the traditional JIGSAW technique. The teachers may find these tools useful as a support for various teaching/learning tasks.

[δ] On leave from FIET, Universidad del Cauca, Colombia.

1. Introduction

JIGSAW [1] is a method intended to provide collaborative learning environments. Its development began in the 70s by E. Aronson at University of Texas and University of California. Hundreds of schools have JIGSAW in their classrooms with much success (see http://www.jigsaw.org). JIGSAW is a face-to-face method, without technological support. It emphasizes interaction among workgroup members. This paper concerns a groupware tool to support JIGSAW-type collaborative learning.

In general, collaborative learning is a complex enterprise. Research about it has many methodological and theoretical perspectives [2]. In fact, it may take up to three years to implement collaborative learning (CL) activities within classrooms, taking into account the cultural change and new roles involved [8].

In collaborative learning, small groups of students work together to maximize both their own and their classmates' learning [9]. This type of activities fit into the constructivist learning strategies. They mean a paradigmatic change with respect to traditional or conductist educational approach. There are changes in roles and responsibilities for students and teachers involved in the teaching/learning processes.

On the other hand, technology may provide tools to improve communication and information management and this could have a positive impact on educational processes. This should change our attitudes about knowledge and way of thinking [4].

However, there are challenges when trying to introduce computers to support CL in class-rooms. One of them is to make the teacher accept her role of cognitive guide or facilitator for the process in a natural way. Another challenge is to develop suitable CL tools.

We have developed a software application to support teachers who use this educational approach. We also developed a computer tool supporting students' collaborative work. Teachers can use this tool as well to collaboratively design the activities to be done by the students.

Teachers may use these tools to make students work on a previously designed activity with JIGSAW. The tools do not pretend to replace the students' face-to-face work in the classroom. Instead, they are intended to support various teaching/learning tasks. In particular, the tools are useful to allow the teacher to monitor activities. The teacher can use this monitoring to improve the technique and eventually to implement successful CL activities in a relatively short time span.

The rest of this paper is organized as follows: section 2 presents the foundations of our methodology and describes the design and preparation of collaborative environments; it also describes the computer system intended to support teachers during preparation of student activities. Section 3 presents the JIGSAW method and how it can be supported by technology. The results are analyzed in Section 4. Finally, the conclusions and proposals for future work are presented in Section 5.

2. Creating Collaborative Learning Environments

Research on Computer-Supported Collaborative Learning (CSCL) has been extensively done because it may generate useful tools to ease students' learning and knowledge building [12,15]. Nevertheless, creating CL environments is not easy and consequently, developing technological supports for them is not simple either. Any CSCL tool should be embedded in an educational methodology; otherwise, it could not achieve its main goal: to maximize individual learning based on group work.

Students doing CL obtain new knowledge guided by a teacher, who has a dynamic role in this process, including session design, preparation, guide and evaluation. If students and instructors communicate through computer-mediated learning environments, teachers must learn new student support mechanisms [11].

A methodology to carry out the design of CL activities is presented in the next sections. It should support teachers in pre-instruction decision making.

2.1. Design and preparation phase

The creation of CL environments has a first stage consisting of designing and making the activity itself. Interactions among teachers include discussions, resolutions, consensual or voted decisions and communication concerning the session design. Guzdial claims that simply providing a space for discussion and definition of a subject not always leads participants to an appropriate discussion [6]. Therefore, teachers must carefully define the context in which learning will occur. Pre-instruction decisions are concerned with defining such context (work groups, roles and materials), the activity or collaborative session to be done in the classroom and the evaluations to measure performance and achievements.

Some of the activities to be performed in this stage are: contents definition and discussion; discussion and definition of general and specific objectives of the activity; activity proposals (brainstorming); choosing an activity (vote); definition of a methodology for the activity; *ad-hoc* material gathering; definition of the success criteria; individual and group evaluation design; work group definition; specification of roles within collaborative groups.

2.2. Process support using technology

The following opportunities of support and intervention are identified:
– Help the teacher's session preparation with tools oriented to material organization.
– Make available documents and information generated during the previous stage.
– Provide shared workspaces.
– Provide individual workspaces to be used before or after joint work. These workspaces may be shared afterwards.

One of the advantages of the computer support is that teachers work collaboratively and experience various roles and organized activities. Teachers also dominate technology by

achieving a collaborative objective supported by tools.

The main disadvantage is that a large initial time investment is needed in order to learn the tools and organize a collaboration scheme. Teachers may organize themselves in groups to "use CL to learn CL" to partially overcome this problem [10].

2.3. The tool

The developed Web-based system has several components. It has a chat tool allowing participants to communicate through various channels. It also provides a collaborative editor, with three main parts (see figure 1):
1. *Private workspace*. This space allows storing personal work and notes. It can not be accessible to the other participants.
2. *Public workspace*. The user uses it to make information available to the group.
3. *Shared workspace*. This space shows work contributed by the whole group. It includes paragraphs with attributes (author, date of creation, associated notes, etc), and functions which can be applied over them.
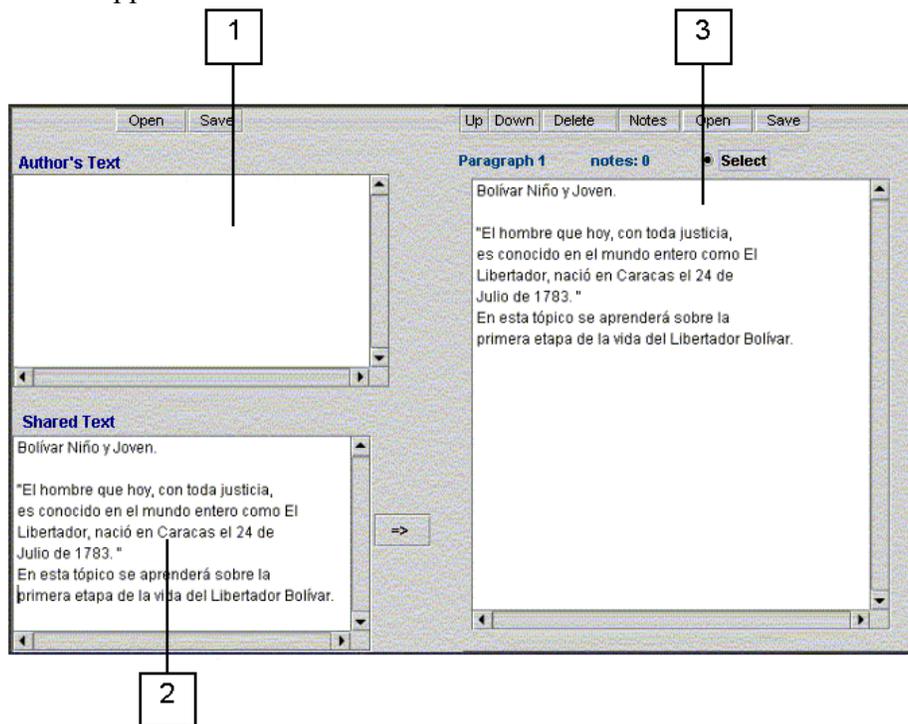
Figure 1. Collaborative editor interface

Teachers may prepare a technology-supported collaborative activity with this tool. Our proposal is they do it in a sequence of five phases:
1. Authentication and registration of participants
2. Definition of objectives and contents.
3. Definition of the activity.
4. Specification of the activity development methodology.
5. Evaluation specification and definition of success criteria.

When using the system, the teacher must log in and choose the session in which she wishes to work, or create it if it does not exist yet. She then has access to a work desk with these available tools: conversation rooms (chat), a collaborative editor and system configuration tools.

2.4. Collaborative edition

The teacher may edit text in a private or shared way at any time. When sharing a text piece, it becomes part of the joint document as a new paragraph. Paragraphs may be selected for later action over them, such as attach a note to it, save, modify its position within the document or delete it.

Moving from private to shared workspaces and backwards allows teachers to get at the end of the work session a document with personal notes and another joint one for the preparation of the activity. The chat tool is always available for discussion. The tool then has these characteristics:

− It supports teachers to design and build a CL session.
− It provides ways to communicate and do individual and collaborative work.
− It allows teachers to achieve a collaborative goal *acquiring* technology.
− It allows teachers experience collaborative work: various roles, information flow, information input and output, and communication.

Next, we present how the tools explained above could be re-used in order to support students to collaboratively learn, using the JIGSAW technique.

3. JIGSAW

The JIGSAW technique has six phases: creation of cooperative groups, preparation pairs, practice pairs, cooperative groups (action), monitoring, and evaluation. The following tasks must be done for the first phase:
− *Groups creation.* They must have at most 4 students, with different genre, skills, race.
− *Assign a leader.* The leader should preferably be experienced in group work.
− *Lesson partition.* The number of parts must agree with the number of group members. Each part should be numbered.
− *Distribution of materials.* Each student should have access to only his part of the lesson.
− *Individual reading.* Assign a time period for reading and investigating assigned material.

The second phase builds preparation pairs or "expert groups". Each pair has a subject to study. The students must read and summarize their material. They must also plan how to teach it to the rest of their own initial group.

New pairs of students are formed in the third phase. Their objective is to practice how to teach the assigned material. Typically one student listens the material presented by the other and suggests improvements. Then, the roles are interchanged.

The JIGSAW fourth phase involves work by the original cooperative groups. The cooperative goal is that all students know all parts of the educational material. The students must teach and learn.

While students work, the teacher moves from group to group. Her job is to observe the work and assist the students in their processes (fifth phase). At the end of the session, students' learning must be evaluated using an individual test on all lesson topics (sixth phase).

3.1. Technology-supported JIGSAW

JIGSAW success is due to a large extent to the face-to-face communication among students during group work. If the communication *bandwidth* is reduced then the learning process will be negatively impacted. Thus, the face-to-face communication should be maintained when supporting the technique. However, computer-based tools can help as follows:
1. The study material can be in digital form, easing its handling. The teacher can split it in parts and make it available to students through Internet.
2. There are tools to create and organize data. These tools are an important support to the discussion, and to prepare and present results: spreadsheets, text editors, etc.
3. Computer-supported tests ease the evaluation.
4. Monitoring the students' work can also be made easy using a computer-based tool (as we explain later).

Some of the advantages of supporting JIGSAW with technology are timesaving, better organization, access to results as they are being produced, easy maintenance of a materials repository, and incentives to students by technology usage. Disadvantages are: initial larger time investment to explain tools usage; very young students may have problems using the tools; and additional time from teachers to manage tools.

3.2. Proposed system

The following assumptions are made concerning computers and groups:
– *Group size*. Large courses should be split in small ones of up to 20 students.
– *Number of computers*. There must be one computer for every student.
– *Physical layout*. Group members must seat in circle with computers in the middle.

The system has a collaborative editor, a chat, a wizard and two viewers. The students have access to three user interfaces, according to the phase in which they are working. Both students can work on the same document when they are in JIGSAW phase 2. The practice interface allows each student make contributions and corrections to the generated document while in phase 3. The presentation interface shows the work done and lets students make annotations.

The system provides a communication tool (chat) in a way similar to the teacher's tool for design and preparation. The wizard is a simple messaging tool controlled by the teacher

supporting her interventions while monitoring activities. The pair and group viewers allow the teacher to monitor the students' work at any phase. The student user interface lets students log in, constitute groups, access study material through a viewer, run the preparation and practice editors and the presenter. Notice the context and steps sequence supported by the system are the ones specified in JIGSAW. The teacher's interface includes the wizard and material viewers.

3.3. The collaborative learning session

It will be described how students can be supported by technology to achieve a common goal with the JIGSAW technique.

3.3.1. Phase 1: Collaborative groups (I)

Each team must have a computer. The first step is to identify each member and to assign the group with a unique name (figure not shown). Once students have logged in, the teacher presents the lesson, the objectives and the topics to be studied. The contents is shown on screen, thus each group can see it (Figure 2). Then, the material is automatically distributed among the group members (Figure 3). After the material is assigned, the group is split in order to let each student do individual research about his subject. Students may see documents prepared by the teacher, but they may also search other material, e.g., in the WWW. Thus, at the end of this phase, each student has an individually prepared document with the topics assigned within the group.
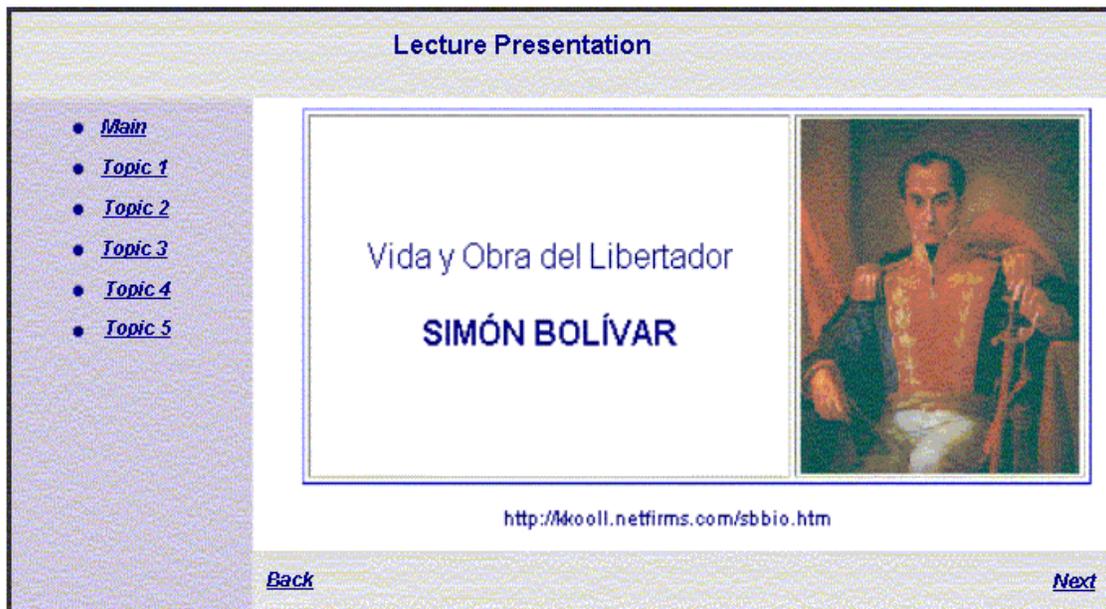

Figure 2. Lesson presentation

Figure 3. Work material assigned to members

3.3.2. Phase 2: Preparation pairs

Pairs of students are formed during this stage. The students must leave their previous groups and join their new partners in front of computers (one computer for each pair). They must log in the system again (similar to screen shown in figure 4). Each pair has the same material piece assigned by the teacher. The students can then access that material from their computer screens using a collaborative editor (similar to screen shown in figure 1). Each student writes his own text and shares it with his partner. The result of this activity is a joint document. The goal of this JIGSAW second phase is to let each student to improve his own document (created in phase No. 1). This document will finally be presented to the group during phase No. 4.

3.3.3. Phase 3: Practice pairs

New pairs are formed. Two of the previous pairs studying the same subject exchange partners. Each pair has again a computer available. The two members of each pair must log in the system (Figure 4).
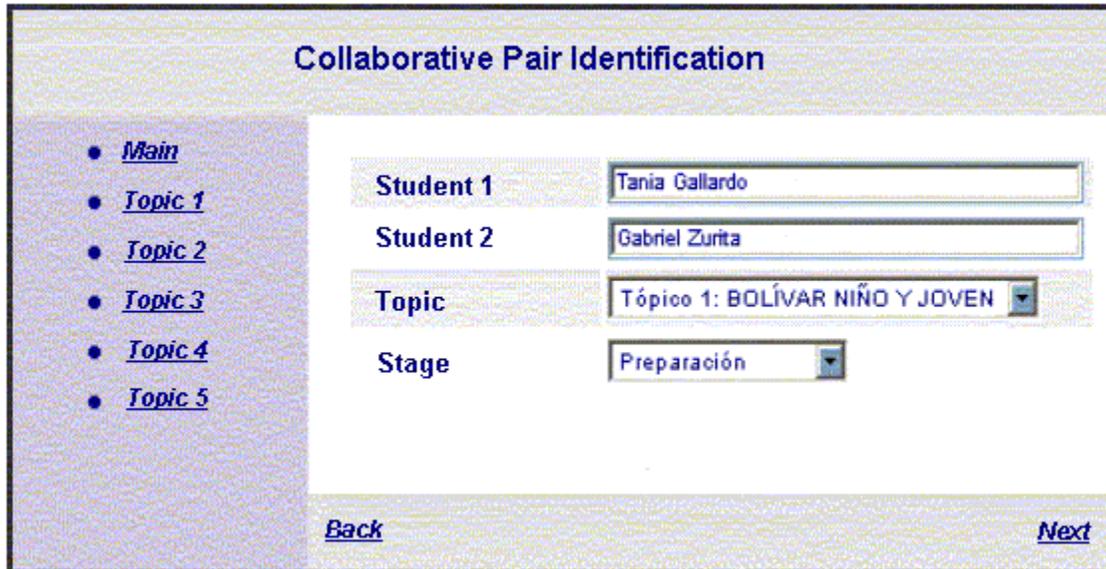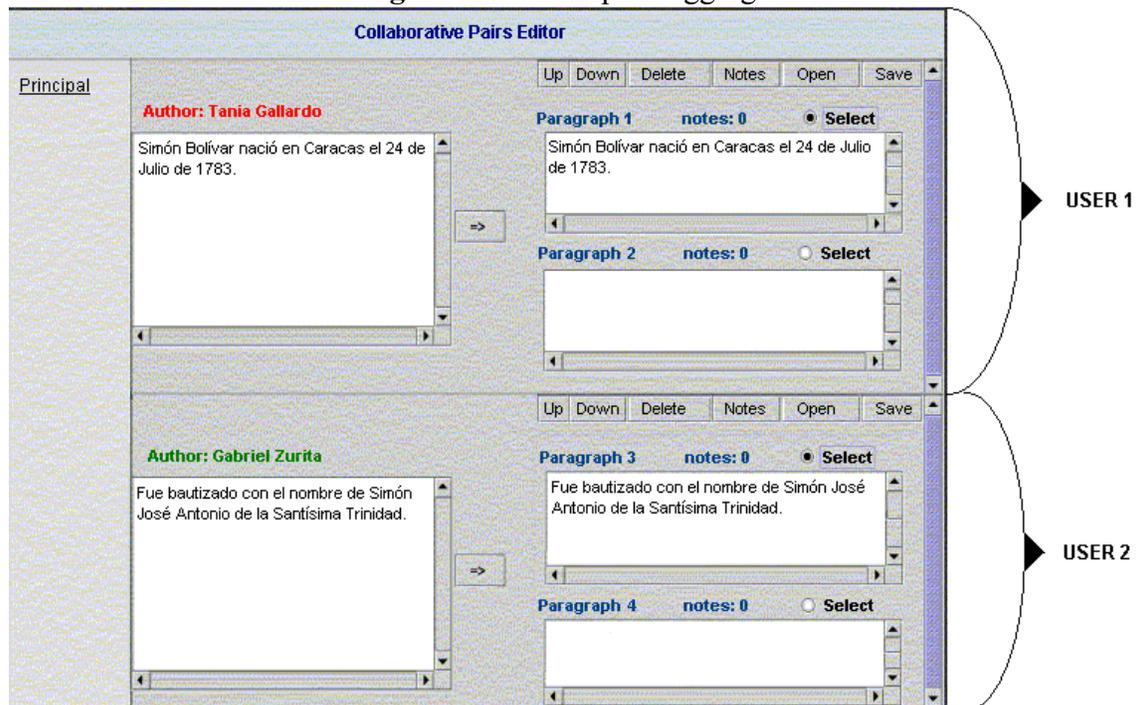
Figure 4. Practice pair logging in

Figure 5. Practice-pairs collaborative editor

Using the collaborative editor, each student can make contributions to the shared document prepared in the previous stage. Figure 5 shows a screenshot of this editor. Please note the screen is split in two halves, each referring to one student's document. This user interface allows two students to work in the same computer, thus sharing documents created in the two previous phases. The goal of this phase is that each student practices presentation of his document to the group. One student presents his subject to the other; the second student must help the first one by criticizing his presentation. Afterwards, they interchange roles. The user interface shown in Figure 6 not only provides document presentation but also

copy and paste services.

3.3.4. Phase 4: Collaborative groups (II)

Once students have completed their work in the practice pairs, they return to their original groups and present their work to their mates. They must log in the system as a group for the last time (not shown) and then, take turns to make the presentations (teach and learn). The system helps by retrieving the result obtained in the practice pair and displays it as a hypertext (see upper part of screen in figure 6). During each presentation, there may appear discussions, interesting questions and new concepts. All of these can be annotated with the presentation tool, identifying the contributor (see lower part of figure 6).
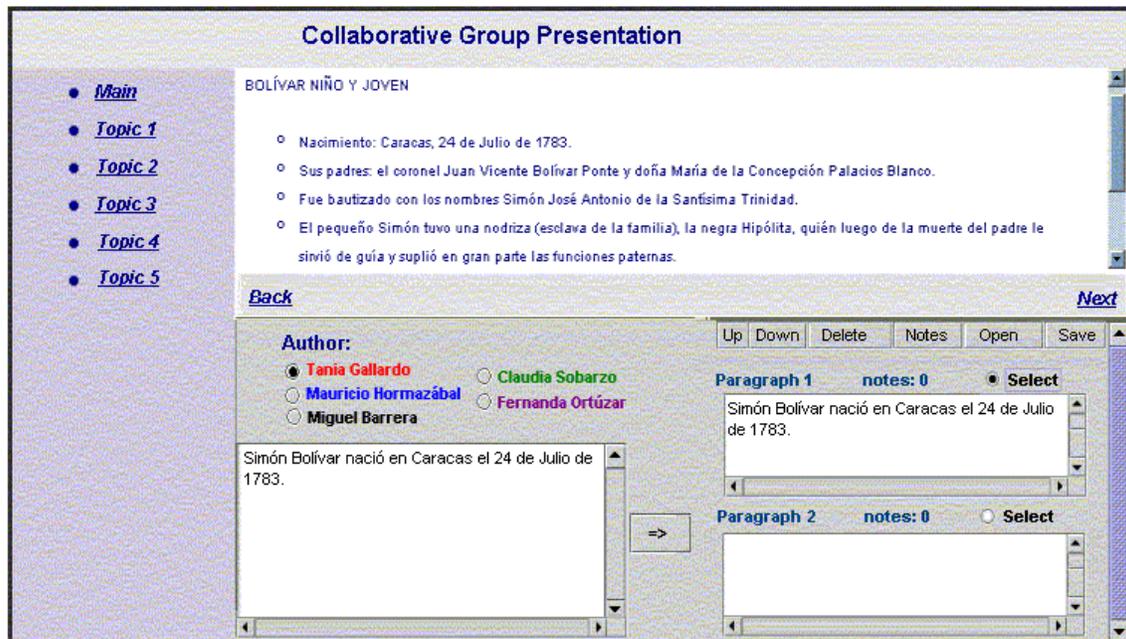

Figure 6. Results presentation for each topic

When students finish presentations, the teacher closes the lesson. She then evaluates groups work, gives feedback to the students and closes the collaborative session. She can also evaluates each student in an on-line previous prepared test (phase 6).

3.4. Information flow

Let us assume the following configuration of collaborative groups:

```
Gi : member doing task i within group G.
G = {A,B,C,D}, i={1,2,3,4,5}.
P [xy]i : document written by students x e y on subject number i during preparation phase.
P'[xy]i : document written by students x e y on subject number i during practice phase.
```

Then the information flow is as shown in Figure 7. It can be observed that going from preparation to practice phases both work threads receive the same input data. Students in the practice pairs have the possibility to enrich their own work with the work done by all other students doing the same task. This is interesting because this can not occur in unsupported JIGSAW: in that situation each student takes individual notes which may be

shared only with his pair mate.

The computer-supported JIGSAW has made possible the following achievements:

– To support a technique known for over 30 years, moving it to a scenario where the computer is the main tool used by teachers and students.
– Reuse the basic tools of the system proposed in Section 2.3 (chat, collaborative editor). A familiarized teacher will find easy to guide her students' activities.
– Cover basic needs of a collaborative learning group: face-to-face communication, work persistency, accesses to information sources, etc.
– Keep basic face-to-face interaction for JIGSAW-type learning.
– Enrich work done by practice pairs with contributions of other similar pairs.
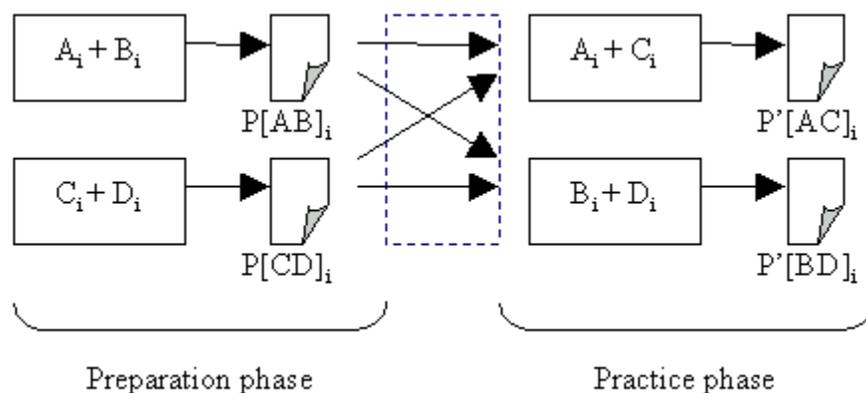
Figure 7. Information flow between preparation and practice phases

4. Discussion

There are very few successful computer-based efforts to support JIGSAW. Despite its introduction more than 30 years ago, its application in classrooms is largely unsupported today. Miyake *et al*. [13] developed a tool called ReConote, intended for relation making. During the first phase, students review current literature about a course in cognitive sciences. The students are grouped in small "expert groups" according to their interests. Then, they must present their results to the rest of the audience. The audience must start establishing relations between what they already know and the new material with the help of the tool. Finally, they must write a report. Muhlenbrock and Hoppe [14] analyze interactions two or more people solving a problem. They provide mechanisms for an automatic analysis of the collaboration, visualization and feedback processes. JIGSAW is used as an interface design mechanism.

Our approach is different from the previous works since the technique is supported as such. Our goal is not to replace the traditional technique, but to support it. The ideal use scenario for our tools would be with a group of apprentices who have already worked during some time using JIGSAW (without computer support) as a technique for collaborative learning. In this case, the teacher can tell her students they will use the same technique in the

laboratory, but now they will do it with computer support. Groups then will work in a way similar to the usual one. Since all relevant information gets stored in the intranet, the teacher can reconstruct a significant part of the process. For instance, she may see the individual documents prepared during the first phase, each student's documents after the second and third phases, and finally, the group presentations. Besides, she knows which students belong to each group and which the study and practice pairs are. Moreover, if the test (phase No. 6) is done using these tools, she may review the questions and track which parts of the process were not properly done. This may give her enough monitoring information (phase No. 5) to be able to change traditional CL activities in order to improve them. Therefore, the tools may provide the teacher with strong support for monitoring and intervention, supplying information that may be impossible or very difficult to obtain otherwise. In the not ideal case of students who have not had a previous experience with JIGSAW, the system may still be useful, stimulating students with the technology.

5. Conclusions and future work

The tool was tested in a controlled environment. It must be tested in real environments to get results on its effectiveness. The tool supposedly can help teachers to design and prepare a CL session allowing both individual and collaborative work. The system is also extensible, in the sense that other activity-specific tools can be included. If teachers use the system in a collaborative way, they gain experience with the technology and they are in a better position to guide their students afterwards.

Acknowledgments

References

1. Aronson, E., & Patnoe, S.: The jigsaw classroom: Building cooperation in the classroom, New York, Longman, 1997.
2. Arnseth, H., Ludvigsen, S., Wasson, B., Mørch, A., Collaboration and problem solving in distributed collaborative learning. Procs. of the Euro CSCL2001, Maastricht, The Netherlands, 2001.
3. Collazos, C., Guerrero, L., Vergara, A.: A guide for the implementation of a collaborative learning model in the classroom (In Spanish). ITINERANTES Journal, Popayán, Colombia, No.1, pp.111-119, 2002.
4. Clark, R.E.: Reconsidering Research on Learning from Media. Review of Educational Research, Vol. 53, No. 4, pp. 445-45, 1983.
5. Dillenbourg, P., Baker, M., Blake, A. and O'Malley, C.: The evolution of research on collaborative learning. In Spada, H. and Reimann, P. (eds), Learning in Humans and Machines, 1995.

6. Guzdial, M.: Information Ecology of collaborations in educational settings: Influence inquiry in the classroom. Procs. of CSCL'97 Conference, Toronto, Canada, 1997.
7. Johnson, D., Johnson, E., Smith, K.: Increasing College Faculty Instructional Productivity, ASHE-ERIC Higher Education Report No. 4, School of Education and Human Development, George Washington University, 1991.
8. Johnson, D., Johnson, R., Holubec, E.: Circles of learning, 4th ed. Edina, MN:Interaction Book Company, 1993.
9. Johnson, D., Johnson, R. y Holubec, E.: Cooperation in the classroom. 7th ed., Interaction Book Company, 1998.
10. Kessler, C.: Cooperative language learning: a teacher's resource book. Englewood Cliffs, NJ:Prentice-Hall, 1992.
11. Lakkala, M., Muukkonen, H., Ilomaki, L., Lallimo, J., Niemivirtia, M., Hakkarainen, K.: Approaches for analysing tutor's role in a networked inquiry discourse. Proceedings of the Euro CSCL2001, Maastrich, The Netherlands, 2001.
12. Lehtinen, E., Hakkarainen, K., Lipponen, L., Rahikainen, M., Muukkonen, H.: Computer supported collaborative learning: A review. The J.H.G.I Geisebers Reports on Education. No. 10, Dept. of Educational Sciences, University of Nijmegen, 1999.
13. Miyake, N., Masukawa, H., Shirouzu, H.: The complex jigsaw as an enhancer of collaborative knowledge building in undergraduate introductory cognitive science courses. Procs. of the EURO CSCL 2001, Maastricht, The Netherlands.
14. Muhlenbrock, M., Hoope, U.: Computer supported interaction analysis of group problem solving. In C. Hoadley & J.Roschelle (Eds), Procs. of the Conference on CSCL-99, pp.398-405, Palo Alto, CA, 1999.
15. Scardamalia, M., Bereiter, C.: Technologies for knowledge-building discourse. Communications of the ACM, 36, 37-41, 1993.
16. Webb, N. M., and Palincsar, A. S.: Group processes in the classroom. In D. C. Berliner and R. C. Calfee (Eds.), Handbook of educational psychology (pp.841-873). New York, NY, USA: Macmillan Library Reference, 1996.