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Collaborative Virtual Environments as Means to Increase the Level of Intersubjectivity in a Distributed Cognition System

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Abstract

Virtual environments are able to extend the space of interaction beyond the classroom. In order to analyze how distributed cognition functions in such an extended space, we suggest focusing on the architecture of intersubjectivity. The Euroland project—a virtual land created and populated by seven classrooms supported by a team of researchers—was analyzed with the aim of tracking down the process and the structure of intersubjectivity. Participants were located in different cities in two countries—Italy and the Netherlands. At the end of the project, the initial empty virtual world was filled with virtual artifacts borne from the intersubjective process. A group of ten 13-year-old students was observed throughout the project. Seven videotapes were collected in the classroom. By analyzing the videotapes, a set of episodes revealing intersubjectivity was captured and discussed. Intersubjectivity first concerned only participants and tools located in the classroom. Later, partners at a distance and the various communication tools available entered the architecture of intersubjectivity. Finally, intersubjectivity revealed not only information, but the reciprocal perception of the roles and awareness of a joint project. From the episode analysis, recommendations for teachers' use of virtual technology were drawn. (Keywords: intersubjectivity, virtual community, distributed cognition.)

INTRODUCTION

Distributed Cognition (DC) has reached a considerable degree of credibility in the psychological and educational literature. Since it was first introduced by Hutchins in the mid 1980s, DC has been recognized as enlarging the unit of analysis of human action—from individual cognition to the inclusion of the social dimensions, artifacts, and structure of the environment within which human action takes place. By adopting such an analysis unit, DC dissolves the traditional divisions between the inside/outside boundary of the individual (cf. Harnad, 2005), the culture/cognition debate, (e.g. Dakers, 2005; Derry, 1996), and focuses instead on the interactions between the distributed structures of the learner and the learning world (Rogers, 2004; Rudestam, DiStefano, & Silverman, 2004). We contend that technology is an integral part of that world—an artifact which is able to play an important role in sustaining and empowering DC.

Many studies have examined the role technology can play as part of the DC system (Dieterle & Dede, & Schrier, 2007; Kim & Baylor, 2006; Pea, 1993). Dieterle and Dede (2007), for example, called for teachers to use wireless handheld devices in learning experiences in class, understanding the strengths and limitations of these devices. They claim that these media can induce learning styles as, for example, "learning based on collectively, seeking, sieving and synthesizing experiences rather than individually locating and absorbing information from a single best source" (Dieterle & Dede, 2007, p. 51). Pea (1993) made the point that new technologies can support human activities by serving as experimental platforms in the evolution of intelligence, by opening up new possibilities for distributed intelligence. Kim and Baylor (2006) suggested that computer based environments that provide pedagogical agents as learning companions can create a more interactive social environment making learning part of a social process. In short, teachers are encouraged to make efficient and effective implementation of technology in their classroom in order to support the computer mediated DC functions technology affords (Petrina, 2007).

Still, however, the extent to which a classroom can be part of an extended virtual environment has been inadequately explored. Although virtual environments are recognized as an effective educational tool (Bricken, 1991; Renninger & Shumar, 2002), it is not clear how virtual environments may impact the DC system. We propose to analyse changes in the intersubjectivity architecture between constituents of a classroom system as a way of understanding the impact of the classroom as an active part DC.

In the following, we first give a brief introduction of what we mean by intersubjectivity and why we think it informs and enhances the conceptual architecture of DC. Later, we conceptualize technology as a particular type of artifact operating within this architecture. Finally, we present a project where the artifact of technology is embedded within a complex project aimed at building an educational virtual environment. There, technology becomes a cultural artifact emanating from the joint action of many actors (students, teachers, experts, researchers) in their use of, and understanding of each other via, the virtual environment—an intersubjectivity that is both informed by, and amplifies, the conceptual framework of DC.

Intersubjectivity

Intersubjectivity has always been considered an important dimension of learning. Piaget (1937/71; 1980) recognized intersubjectivity as an important dimension in the perspective-taking and decentration processes. Vygotsky (1930/1971; 1978) wrote that intersubjectivity was a process occurring between people, particularly between a competent adult and a less competent child, where the social interaction between the two generates new understandings beyond the mere combination of each individual's point of view (Wells, 1993). Thus, for Piaget, the processes of the individual work on the social information derived from reciprocal interaction, requiring coordination between individuals in terms of mutual understanding and joint attention. For Vygotsky, building intersubjectivity meant going beyond individual understanding, as happens

when zones of proximal development are activated, to a level that is fundamentally social. Thus, intersubjectivity is the skill of constructing new understanding within a social environment by combining different perspectives among social members (Grossen, 1988; Grossen & Perret-Clermont, 1994).

It is important to note that intersubjectivity markedly contributes to the success of face-to-face interaction (Bruner, 1996), collaboration at a distance (Ligorio, Talamo, Pontecorvo, 2005), as well as participation in communities of learners (Brown & Campione, 1990) and communities of practice (Wenger, 1998). That is, intersubjectivity, by virtue of the introduction of mediated communication and collaboration within virtual environments, has the effect of extending the community beyond the school walls, blurring the borders of the educational community, and making the learning context richer. This richness is conceptualized as a social and interactive process, occurring as a consequence of the attempt people make to understand each other (even overcoming limitations such as language, attitude, gender, and age). As individuals within a learning system strive for deeper and better understanding of each other, the transactions within the group reach more complex levels of intersubjectivity, leading the system to richer patterns of social comprehension and awareness. Thus, the complexity intersubjectivity takes on, is not necessarily more elaborate because of the patterns borne from the interactions per se, but rather because of the mutuality of understanding propagating between members of the system. Thus, mutuality of understanding becomes the raison d'être of learning within groups, and also the most important index of learning among a group's members.

It is important to underscore that the need for mutual understanding implied in the concept of intersubjectivity is central to DC (Hutchins, 1995). Participants in joint action are able to manage the flow of information by deciphering each other's mental state of information as well as the state of information contained in the tools they use. In the case of the cockpit scenario described by Hutchins, for example, some of the relevant information was located within the individual pilots; other information, such as the update of certain values, was located between the pilots, and finally some information was in the physical structure of the cockpit itself. Without an intersubjective orchestration of all these elements, the activity would not have been possible. Thus, we suggest that, in schools, knowledge is placed within individuals, between individuals, and within the tools the individuals use. When the classroom is part of a virtual space, the remote nature of participant action renders communication among group member mediated by several means, many of which are the tools built into sophisticated internet-based software.

The Role of Humans and Artifacts

The DC process is a phenomenon that, despite the label, does not concern only aspects of cognition. The social dimension is quite relevant as well, and actually deeply shapes the DC process. In the context of a socio-constructive perspective, various members of the social group are involved, as well as many resources and tools (Duffy, Lowyck & Jonassen, 1993). Social organization can be read as a sort of architecture of cognition at the community level. In other

words, the cognitive properties of a society (its memory capacity and ability to manage and retrieve information) can be understood by looking at what information is present, where it is located, and how it can move within the society (Roberts, 1964). Thus, we consider schools as a complex social organization, and we attempt to study the movement of information as well as the role played by humans and artifacts in sustaining such movement.

According to Cole and Engeström (1993), tools (resources) available within the environment determine the way cognition is distributed. The tools, shaped by the culture, are the means through which people gain access to, and interpret their world. Therefore, educational environments should aim at triggering "a process of tuning into the affordances of the environment" (Resnick, 1996, p. 43) and developing new understandings. In fact, "cultural mediation has a recursive, bidirectional effect; mediated activity simultaneously modifies both the environment and the subject" (Cole & Engeström, 1993, p. 9). Some authors (Salomon, 1993; Salomon & Perkins, 1998) argue that the changes occurring in the learners, and the changes occurring in the environment, are strongly related on the basis of socially distributed understandings. Thus, we believe that computers and internet spaces should be considered as artifacts, as well—able to sustain this function by mediating learning activities as well as learners' cognitive processes. Furthermore, we also see teachers as pedagogical agents playing a role comparable to an artifact. In fact, the bi-direction spiral is even more evident when looking at the role teachers play within a learning context. From one angle, teachers coordinate and orchestrate the DC process; from another, since they are unavoidably immersed in the learning context itself, teachers are concomitantly part of the distribution net of cognition and knowledge. Thus, they coordinate the relationship between internal (psychological and cognitive) and external (material or environmental) structure, and they regulate the processes through time in such a way that the products—i.e. the educational materials prepared by the students or coming from the past—textbooks, for example—transform the nature of events planned for later in time.

Based on these considerations, in this paper we will analyze a project where a complex virtual environment has been introduced into a classroom. We will outline how intersubjectivity develops as of a consequence of such a project and how intersubjectivity may inform the structure of a DC system that includes the classroom and the virtual environment employed within it.

THE PRESENT RESEARCH

In the present research, the activity described is part of a broader research project called Euroland—a project in which seven Dutch and Italian classrooms were involved virtually within an environment designed to teach students about each others' culture. Students interacted and shared information and tasks in order to construct the virtual environment. That is, the environment was built by the students, using software tools, to reflect, reciprocally inform, and mutually understand each others' respective cultures. In the present research, we analyzed the face-to-face and distance interactions among the students and teachers in one of the classrooms involved in the project.

Our analysis focused on the development occurring in the classroom as members participated in the project. In particular, we wondered how DC would be impacted by the inclusion of a virtual space and its remote partners within the classroom activity. Intersubjectivity was selected as the unit of analysis, because it permitted designation as an index of the changes occurring in the DC structure.

The Educational Scenario: The Euroland Project

Euroland has proved to be a successful project in primary education aimed at sustaining virtual communities composed by students and adults from different countries (Italy and The Netherlands in particular) (Ligorio, 2001; Ligorio & Van Veen, 2006). The educational aim of Euroland is to foster reflection on cultural issues and to sustain a sense of belonging to the European community. Euroland is oriented toward the construction of a final, visible, and tangible product, achievable only through interdependency among the various groups of students. The final product is the virtual world itself, with three-dimensional (3D) "cultural" houses and meeting spaces; comments, notes, and descriptions attached to the objects; and a database filled by the participants with educational material participants saw fit to include. Within this large scope, many sub-tasks are involved. For instance, national cultures are explored by studying various gastronomic habits and local recipes, and comparing national music and traditions expressed in paintings and art. Similarities and differences between countries are tackled by organizing virtual journeys or by performing collaborative games.

In order to elicit collaboration, mutual interdependency (Salomon, 1993) is created by asking students from one country to build and decorate the cultural houses for the other country. Thus, in the present research, the Italian classes built the Dutch cultural houses, and the Dutch classes built the Italian cultural houses. This type of organization forced the students to put their intermediated products online. In this way, the virtual environment was not a mere "window" for the display of products, but rather a space for real negotiation and collaboration at a distance.

Participants

The present research focused on the specific group of participants from Rome—the participants in charge of building the virtual Dutch house of art. This group was composed by 10 students of about 13 years old from a junior secondary school in Rome, their two teachers, one technician and a researcher. This is not a typical arrangement of participants in Italian schools, but was made possible because of the nature of the project. Thus, two teachers—an art and English teacher—agreed to collaborate on the project and combined their expertise. The art teacher was in charge of coordinating the analysis and selection of the materials to be included into the Dutch house of art; the English teacher helped the students communicate with the Dutch students via English. The technician contributed as expert on computer software and was in charge of maintaining the computer lab. The researcher acted as a participant observer, monitoring the implementation of the educational project. All of the adults

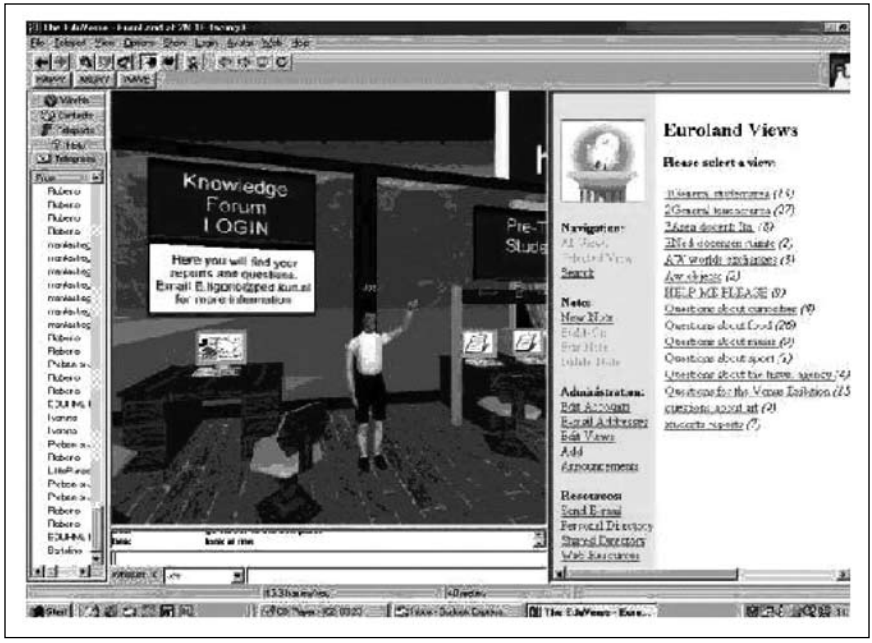

Figure 1: Computer screen with AW and FK running at the same time.

actively participated in the project, although the researcher and the technician were not always present when school activities about the project were performed in the classroom.

The 10 students participating in the project were randomly sampled from an 8th grade class, agreeing to participate as an optional school activity. The students interacted with the other students and adults participating in the project from schools located in the other Italian and Dutch cities attached to the project.

The Task

The target group from Rome was responsible for building the house of Dutch art. To accomplish this task, the collaboration with their Dutch partners was essential. The students collected information about Dutch painters, visited a museum, decided how to organize the data collected, and finally consulted with the Dutch students to solve problems, clarify doubts, give opinions, and ask questions. The virtual house of art was organized as a museum, with Dutch paintings displayed on the virtual wall, and links provided to the internet-based information about the paintings and painters.

The activity was scheduled for two hours a week, both in class and in the lab. The virtual learning environment organized for the project consisted of two software—Active Worlds (AW) and Web Knowledge Forum. AW allowed the construction of the 3D virtual worlds, composed of houses, roads, trees, and objects. Users could chat, navigate, build 3D objects, and virtually walk through, or fly over the terrain.

Knowledge Forum (KF) (Scardamalia & Bereiter, 1992) was implemented in the AW environment to support asynchronous discussion. At the center of the KF was a communal database that could be filled with notes written by students and teachers. Users could enter their own notes and/or build on and react to the notes of others. Including KF within the AW environment was simple. A 3D-object in the form of a computer activated a link to the KF. Figure 1 shows the computer screen with AW and FK running at the same time.

Both pieces of software used in the project were able to trace the changes implemented by the users by dating the notes composing the threads in the forum, keeping track of the modifications of the 3D objects, and recording the log-chats.

METHODOLOGY

DC calls for a methodology targeting the development of meaningful events (Hollan, Hutchins, & Kirsh, 2000). Therefore, events in the process of building intersubjectivity between participants and artifacts were selected. Within these events, data analysis was aimed at examining how intersubjectivity resides in the knowledge and skills of the participants, as well as the way the participants organized the tools in the environment.

Data Source

Our main data was derived from the seven videotapes recorded during a period of time that covered the entire project (nine months). Each of the first six interactions lasted about 20 minutes. The last videotape recorded the final discussion session about the project's outcomes and lasted one hour.

We also collected data on the virtual environments, such as notes posted in the web-forum and chat-logs recorded by AW. This data was used to support the analysis of the videos.

Data Analyses

As recommended by Goodwin and Goodwin (1996) and Suchman (1987), the videos were our main source of data. Each video was entirely transcribed using the Jeffersonian code (Jefferson, 1991).

The first analysis performed on the video was aimed at defining the type of activity included in each video. The activities taking place in each video are shown in Table 1 (see page 346).

In the first video, the classroom was engaged in doing benchmark lessons. A week later, the classroom was mainly engaged in reporting to the virtual world, the work done in the classroom. A week later, working in the virtual environment seems to be the main activity. At the fourth week, the classroom is discussing events and activities undertaken in the virtual environment. The fifth and sixth week, Euroland is completed and activity in the classroom concerns planning and re-planning of the 3D objects, as well as discussions about the project. During the last week, participants have a plenary discussion about the project.

Table 1: Description of the Activities Included in each Video

Number of videotape	Activity
1st	Benchmark lesson about Dutch art's history; planning the project; activity into Euroland.
2nd	Posting in Euroland reports of what happened in the classroom; planning next steps; classroom activities; working in Euroland.
3rd	Reporting about activities carried out in small groups; planning the virtual house of art; working in Euroland.
4th	Discussing the classroom about the life in Euroland; classroom activities; working in Euroland.
5th	Reporting about the construction of the virtual house of art; classroom activities; working in Euroland.
6th	Working in Euroland, small group-discussion on topic related to the project
7th	Final plenary classroom discussion about the general outcomes of the project

The inclusion of the virtual space into the classroom activities is a gradual process. Initial activities were, in fact, devoted to having a first overview of what the Dutch art is, and at exploring the possibilities offered by the available software. Later, the virtual space came to life and in-classroom activities and events occurring in the virtual space were gradually more and more interconnected.

After this general overview of how the project developed, episodes were singled out to reveal where the plot upon which intersubjectivity was built. The on-line activities occurring at that time were associated with those episodes allowing for a better understanding of how intersubjectivity was organized.

RESULTS

Our aim was to find evidence of how intersubjectivity was built and maintained across the diverse activities undertaken along the development of the project. We reasoned that changes in the structure of intersubjectivity would give us information about how exposure to an extended community with the task of filling in an initially empty space would shape DC.

The Benchmark Lesson

This video was recorded when the classroom was involved in the project after a few months—when the classroom had already performed a few activities connected to the project. Participants had already spent portions of their time: (a) searching documents on Dutch art, (b) visiting an exhibition about the Dutch art topic, (c) making preliminary contacts with foreign partners, and (d) mastering the skills necessary to build structures in the virtual environment. At the moment the video was taken, participants were attempting to finalize their task by making a decision about what masterpieces should be included in the vir-

Excerpt 1: Discussion about a Dutch Painting Contained in an Art Book

Art teacher: Rembrandt painted a lot of self-portraits during his life
Student: this is more beautiful (pointing to one picture)
Art teacher: it is very important, because the author
[has an introspective vision...
Student: more luminous]
Art teacher: this is when he is young
English teacher: it is more luminous when he is young

Excerpt 2: Art Teacher Lecturing

Art teacher: When he is young, right, I mean, look here how clear is the image of life, how meaningful is (:::) It is like we look at a series of photos about our life (…) it is life marks on the face. I mean, what life gave you, your experience, it is very important for a painter, instead of writing a diary, > did you get what I mean? <he did not write about himself, he painted himself!

tual world. The teacher proposes to analyze a book about many Dutch painters and to compare it with what the students saw in the book they viewed at an exhibition.

We selected a particular moment during which the art teacher was trying to lecture. The whole group was sitting around a table and the art teacher was holding the book (see Excerpt 1).

During this episode the main tool involved is the book. Everyone is looking at the book and the painting observed is at the center of the interaction. One of the students is giving an aesthetic assessment of the painting (*this is more beautiful*) and the adults are making their comments relative to the student's utterance. The flow of information starts from the book; the student provides a first selection based on what he likes; the first teacher adds information (*this is when he is young*); and, the second teacher makes explicit the relationship between the elements highlighted by the student (*it is beautiful and it is luminous*) and the information given by the first teacher (*this is when he is young*); in fact, she says "it is more luminous when he is young." In this episode, intersubjectivity is based on an artifact locally present (the book) and the information flow is activated by a student and enriched by the two teachers. The whole process is driven by the art teacher's intention to make meaningful the information delivered by the book. To accomplish this goal, the teacher anchors her talk to the student's remark and she organizes her benchmark lesson around it. In fact, in the continuation of the video, the art teacher finally begins to resume her initial intent—that of lecturing (see Excerpt 2).

Based upon the intersubjectivity plot above, the teacher can finally lecture. Although this is an activity not requiring any collaborative skill, the audience is very attentive. More importantly, such a result—that is, a return to the original intent of lecturing— only becomes possible by the collective interaction occurring a few seconds earlier. Thus, this type of intersubjectivity supports the teacher's activity, mainly aimed at making the information interesting and appealing to the students' interest before delivering the information via lecture.

Excerpt 3: Reading the Answer from the Dutch Partners

Researcher: Obviously this question made them think a lot
Art teacher: Think a lot. So, you see, it was
Researcher: a good question
English teacher: So Paolo, go on
Student 1: (reading in English) "To Michela and Martina we have disc.., di, discu-
English teacher: discussed
Student 1: "discussed your question in class. It is a class which is not really involved in the project but they were really interested in it. The students are forty years old-"
English teacher: oh, they are forty years old... It's ok?
Student 1: no, fourteen
English teacher: fourteen, go on
Student 1: "Maybe it is possible to create a special room in the house or maybe a wall special for the Flemish painters. And put e sign"
English teacher: PUT A SIGN, above it.
Student 1: "and explain that. These are painters who were, lots of years ago, e: Dutch painters"
Art teacher: I didn't understand, they don't want to answer..
English teacher: no, no, they did answer
Art teacher: And I didn't understand anything…!
English teacher: so..(translating) maybe it is possible to create a special room
Student 2: or a wall
English teacher: or a special wall
Art teacher: so, this is what we proposed
English teacher: only for Flemish painters and put a sign
Researcher: to indicate it
English teacher: To indicate that it is Flemish. It is they want not to mix, if I understood
Art teacher: ok
English teacher: So, students? Agree?
Student 1: "agree that , the Flemish painters have to be a part of the Dutch house of art."
English teacher: So they agree that there must be :
Student 2: A Dutch house

Questioning Inclusions: What Should Go in the Virtual House

The material analyzed in the classroom now has to be transferred into the virtual space. A selection is needed in order to keep the project coherent.

The class faces the problem of clearly defining what should be considered as Dutch art. In particular, the following question arises: *Can Flemish art, so labeled before the division between Holland and Belgium, be included into the art Dutch virtual house under construction?* This question is posted into KF with the explicit request to have an answer from the Dutch partners. The episode selected and reported in Excerpt 3 is when the roman group is reading the reply found in KF.

Excerpt 4: Discussion in Front of the Computer While Building the Virtual Dutch House of Art

Art Teacher: Let's see if we like it, in this way (*Student 1 is moving the mouse*)
Student 1: Also here?
Student 2: yes
Art teacher: there we can put a glass, or a wall. As we like
Student 1: Here a door is better
Student 2: No, a door is better
Art Teacher: oh, a door, yes, another door. A duplicate (*Student 1 builds a new door*)
Student 1: Hm!!
Art Teacher: oh, it starts to ...
Student 1: ... to have a shape
Art teacher: oh, here we need a glass. The same we did on the other side, isn't it? Exactly the same (*Pointing to the screen*)

The group is busy reading aloud the answer they found on the forum. During the reading activity, students' concerns are discernable relative to whether their messages are well understood. For example, students were concerned about whether their alternate country counterparts were: (a) actually interested in answering their queries (*they don't want to answer…*); or (b) suggesting a solution similar to what they already discussed (*this is what we proposed*). In fact, there are many reasons for possible misunderstanding. For example, the communication tool is an unconventional one; using a web-forum is rather unusual in a classroom; furthermore, the communication is taking place in English—a non-native language for all of the students in both countries; finally, the solution proposed concerns a 3D space and its objects (e.g. virtual rooms, walls, and signs)—objects that are not normally used when performing classroom activities. Thus, the readers are striving to make sure they understand what their partners are telling them. They use the artifacts as sources of two types of information: about the concept they are working on (how to consider the Flemish art) and about the intention of the partners. In other words, they are building an intersubjective state involving the partners at a distance and two types of artifacts are in use: English as a language for mediation, and the note in the forum.

The Affordance of the Software

The features of the software seem to play a relevant role in the process of building intersubjectivity. The virtual space composed of the two pieces of software mediates the communication and collaboration with the partners at a distance and, at the same time, influences the shapes and functions assigned to the 3D objects. Excerpt 4 reports an example of how the software seems to suggest what to build.

The suggestion coming from the Dutch partners was to build a panel or a wall to separate the space where the Flemish paintings will be exposed, but while building, the students found that a door may be a better solution. This suggestion seems to come from the affordance of the software. The inclusion of the

door gives the feeling of progress in the building. This feeling is shared by all participants. In fact, the prompt given by the teacher (*it starts to ...*) is quickly completed by one of the students (*... to have a shape*). They seem to follow the same thread of thoughts, revealing an intersubjective state that includes the participants in the action, as well as the actions possible with the software.

Another interesting point in this excerpt can be drawn from the first line. The architectural choices seem to be based upon aesthetic considerations (*let's see if we like it)*. Later, a criteria of appropriateness became more salient. As we already noted in the first excerpt, the teacher is tailoring for herself this type of role: She discerns what students select on the basis of aesthetics and adds more educational value. The aesthetic dimension seems to function as a lever the teacher uses (more or less intentionally) to drive students' attention toward the direction she wants.

Intersubjectivity Based on Swapping Roles

During the final discussion, much information could be retrieved about the participants' perception of the various activities performed. In fact, this discussion was aimed at eliciting students' and adults' assessment about the outcomes of the project and their points of view on what were the strong and weak points of such a project. In Excerpt 5, the group is discussing how the perception of their roles changed.

The researcher picks up a point raised earlier by a student—that the teachers were perceived like students. Later, a teacher recognizes her role as an "apprentice" about the use of the computer and technical matters (*we are pupils too*). A vision of flexible roles emerged together with a reciprocal understanding of what it means to play the role of the other. By swapping roles, participants not only exchanged information, but they also found themselves understanding the role of the counterpart. In other words, students know what it means to be a teacher and, at the same time, they feel that, in certain cases, they can act as teachers, as well. Similarly, teachers understand what it means to be students, and in certain cases, they felt as if they were acting as students. Teachers and students are aware the roles they played, still keeping aspects of their traditional roles (e.g., teachers teach and students learn); at this point, however, aspects of the role played by the counterpart are also included (that is, teachers learn and students teach) (Schwartz & Ligorio, 2004). Intersubjectivity, in this case, is based upon the comprehension of what it means to cover the role of a counterpart, together with the awareness that they could also actually play that role when needed; and, that the awareness of both serves to enrich each of them. This type of intersubjectivity seems to have a more psychological nature—that is, it is not based on the flow of specific information and does not rely upon or incorporate the use of a specific artifact. Rather, the intersubjectivity operates at a level of a reciprocal understanding of each participant's position—not only because specific competences are appreciated, but also because each participant had the possibility of playing the role of the other. The participation in a complex project like Euroland supported this type of intersubjectivity because it required new competences (i.e. connected to the software), which allowed the

Excerpt 5: The Whole Community Assessed the Project

English teacher: you said, two or three times... we in the classroom, we are the teachers, and when we go down (*to the lab for the project*), aren't we teacher?
Student1: no, you are always teachers but ...
Student2: in the classroom you're stricter
Student1: ... you are more open-minded
Student3: more understanding
Researcher: he said almost like students (*referring to student2*)
Student2: you have to learn from this experience, the same we do
Art teacher: oh, good
Student3: you know about Euroland more or less as much as we know it
Student1: the relationship is also different. How can I say? Perhaps when we are in the classroom your goal is to educate, to teach. There instead...
English teacher: perhaps, as he said, we in this case, doing an activity like this one, teachers in an activity like this, with the computer that implies many changes, a lot of media, we are pupils too.

students to be appreciated as experts. Therefore, teachers felt less compelled to act, as they commonly do, as the competent authority in charge of transferring information. This finally produced a reconceptualization of the relationship between students and teachers on new basis.

Awareness of Common Goals and Mutual Commitment

In the following excerpt, still from the final plenary discussion, the group is discussing what was learned during the project. There is common agreement about what should be considered the major outcome of the project: participants acquired knowledge and competences that are useful only when put in service of a common goal.

From this excerpt, a profound awareness emerges of a shared project. The joint project is perceived as the source of what was learned and also what makes meaningful what was learned. A peculiar definition of the individual contribution can be inferred from the excerpt. Participants contribute to the project

Excerpt 6: Sharing Ideas and Cognition

Researcher: In my opinion, .. do you know what? Now I'll tell you. We had a shared project. Isn't it?
Student1: the same goal
Researcher: That's it, each of us had his work, and everyone had his own different experience
Student2: Each one contributed with what he knew and..
Student3: and then you could see what came out. Every one in this project, in my opinion, I think so, in this project, a group-project, you have to put all you know, and you have to engage yourself, you cannot take this as a game, a recreation. You have to share all you know with other participants. And then, if it works like this, it always becomes a good job. If you really engage yourself and if everyone really cares.

with what they know; however, by contributing, the participants also believe that the project *and* the their own knowledge and competence is enriched. Thus, their general perception is that, if they keep contributing as they can, their contribution to the project will become richer; in short, a sort of constant and virtuous loop reciprocally feeds individual capacity and the common project.

The profound sense of a common enterprise and the importance of the individual commitment allow a higher level of intersubjectivity. Here at stake is the general sense of the project and the appreciation of individual contributions. In this case, intersubjectivity is based upon the awareness about the entire "system": the role of the project, a common goal and the division of labor between sub-groups, and the relevance of individual contributions.

CONCLUSIONS

In this paper we started from the assumption that exposing a classroom to a virtual environment, with a strong educational project behind it, could extend the process of DC. To verify this assumption, we selected intersubjectivity as an indicator of how DC is organized.

The classroom we observed implemented the project following indications from the community of learners (Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993; Brown & Campione, 1994) and the community of practices (Wenger, 1998). Therefore, activities performed both in the classroom and online were based on collaboration, and designed to produce interdependent groups, even those working at a distance. Specifically, the group of students we observed was in charge of building a virtual museum about Dutch art, such that Dutch students not only participated as an audience, but as real collaborators.

An analysis was performed on seven videotapes recorded in a classroom participating in the Euroland project. Episodes were selected from which the architecture of the intersubjectivity could be inferred. By comparing the episodes, we could understand the development of DC over time.

In the first episode, intersubjectivity seems to be rather confined to the class, in the sense that it does not concern the virtual space, nor the other remote participants. It is built around the book, which is the main artifact, and based upon a sort of layered construction on each of the comments of the participants in the exchange. The information flow starts from the book; it then propagates to the student's selection based on what the student likes; then, the teachers add value and new information to the selection. A shared understanding of the painting under observation is the ultimate goal.

In the second episode (excerpt 3), intersubjectivity has a larger scale. It strongly involves the partners at a distance (the information they give and their intentions). Consequently, the communication tools used become part of the architecture sustaining intersubjectivity. Relevant artifacts are embodied in the forum, the notes posted in there, and the use of the English language. The flow of information is from users at a distance, mediated by multiple artifacts. The ultimate goal is to gather an answer to a problem and to make a decision.

Over time, the relevance of the virtual space tends to increase. What can be done or not done with the software, and the consequences of certain technical choices, become part of the activity, as well. A new level of intersubjectivity appears between the intention of the users and the affordance of the software. This is evident in the episode where students and teachers are completing the structure of the virtual museum where they must decide whether to use a wall, a glass, or a door. The information flow, at that point, is between software and users, and the final aim is to obtain a product—a 3D object capable of meeting many requirements (aesthetic, functional, etc.).

In the last two episodes, intersubjectivity concerns the role participants played in the project and the value of the project itself. There is no more information moving from source to source. Instead, what is at stake is the relevance of what is done—the awareness of a joint enterprise, and the value of individual contributions and enrichment.

Through these levels of intersubjectivity, we can see how the system of DC evolves. Depending upon the intersubjectivity activated, different artifacts became central and different competences were appreciated. This implies that students learn not only educational content connected to the project, but also what to do with the knowledge they acquire; they also learn how to efficiently use various type of artifacts, and how to communicate through specialized media. This does not simply support competencies useful to the knowledge of society, it also contributes to the education of people able to pursue higher levels of thinking and metacognition.

Intersubjectivity and Implications for Virtual Technology Use

There is no doubt that sustaining the transaction between the different levels of intersubjectivity is not an easy task for teachers. However, findings born from the analysis above reveal that there are several points to keep in mind. First, our data reveal that technology—in this case, virtual technology—is valuable to use. However, when doing so, teachers have to arrange the introduction of such technology around a meaningful and interesting educational project. Students (but also teachers) need to see why they should work on such a project. We suggest, therefore, spending time planning the project in early stage—perhaps discussing it with colleagues willing to be involved. Secondly, the goals and aims of the project should be kept visible throughout the project's duration; this will help in maintaining high student involvement. Next, technology should be considered as embedded in the project, rather than a distinctive moment of the classroom's life. In practice, this means that references to the virtual space should not be confined to the moments the group is working in a computer lab. Even in the classroom, when performing activity with other artifacts and tools, or when exploring locations outside of school (such as a museum), the virtual space remains the final target. Data and information collected undergo thorough analyses and reorganization with the intention to be later posted in the virtual environment, so it can be shared with the virtual partners and used to build 3D objects or to develop ideas and carry on discussions.

Finally, students spontaneously select and highlight what they like, justifying their choices and referring to aesthetic or playful dimensions. Teachers pick up these elements and interweave them with the elements relevant to their opinion, connected to the educational material and goals. This seems to be a great strategy to keep the involvement high and to raise the level of intersubjectivity. Therefore, we suggest that teachers accept and elaborate information students define as interesting, in addition to the directions toward which students like to work. This strategy allows students to feel more integrated in the learning setting and plays an active role in the DC system. In other words, in an intersubjective system occurring in school, teachers work as mediators: they bring up students' ideas and preferences, re-elaborate them, and attach to them an educational value.

Distributed Cognition and Intersubjectivity: A Final Note

Finally, we found that many layers of intersubjectivity appeared and evolved. By tracking this evolution, DC was revealed to function in a learning context involving a virtual space. In fact, technology played the role of a complex artifact having multiple functions; information flowed in multiple directions; and, teachers and students derived an understanding and appreciation for each other's role. These are relevant aspects for DC and re-conceptualizing them as part of the process of building intersubjectivity helps enhance the relevance of DC in learning contexts. In fact, learning is a key process even in the cockpit scenario described by Hutchins (1995); thus, within an educational context where technology is infused into a learning system, participants learn how to construct new knowledge by combining their own knowledge and intentions, knowledge and intentions mantained by others, and knowledge and affordance pertraining to the tools they use. In short, participants do not simply learn technical skills such as how to use software or how to acquire information from a Web site; they learn by developing new levels of intersubjectivity between new elements. In this sense, intersubjectivity informs the learning process in a DC system.

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