Scaffolding through the network: analysing the promotion of improved online scaffolds among university students

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This article explores how to enrich scaffolding processes among university students using specific Computer Supported Collaborative Learning –CSCL- software. A longitudinal case study was designed, in which eighteen students participated in a twelve-month learning project. During this period the students followed an instructional process, using the CSCL software to support and improve the students’ interaction processes, in particular the processes of giving and receiving assistance. Our research analyzed the evolution of the quality of the students’ interaction processes and the students’ learning results. The effects of the students’ participation in the CSCL environment have been described in terms of their development of affective, cognitive and metacognitive learning processes. Our results showed that the specific activities that students performed while working with the CSCL system triggered specific learning processes, which had a positive incidence on their learning results.

Keywords: Computer Supported Collaborative Learning; Learning Processes; Peer Interaction; Qualitative research; Socio-cultural theory.

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Running heads (verso)  M. Pifarré

(recto)  Scaffolding through the network

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Introduction

The theoretical framework of our research is the socio-cultural approach of the teaching and learning process. The socio-cultural theory of learning highlights the relationship between the development of the subjects’ mental processes and the characteristics of the cultural, historic and institutional scenes in which they take part. Differences in social and cultural organisation produce variations in the development of individuals’ psychological processes. These processes do not mature spontaneously but rather their construction requires personal interaction. From this perspective, the social mediation of someone else, of cultural tools (instrumental and symbolic ones), and of entities and social organisations are the main variables that explain individual development (Salomon & Perkins, 1998).

There now exists a substantial body of knowledge which demonstrates the benefit of social interaction for learning, the role of language as a tool for collective sense-making, and the impact of computer mediation in these interaction processes. Computer collaborative learning is believed to have the potential to engage students in activities which are valuable in their learning processes.

However, it is not guaranteed that this high-quality discourse will always occur between interlocutors (Dillenbourg, 1999; Mercer, 2000; Arvaja et al. 2000). Recent research is interested in identifying what constitutes a productive collaborative activity and finding out more about the processes of collaborative learning which could lead to better learning (Dillenbourg, 1999, 2002). Actually, we need a better understanding of how the individual’s mental processes relate to social and situational factors that influence cognitive performance and learning. It is therefore crucial to integrate computer-supported collaborative networks and those research projects that support them into curricular courses for reasonably long periods of time, in order to investigate the main educational variables that can help a community of learners build knowledge together (De Jong, Veldhuis-Diermanse and Lutgens, 2001; Häkkinen, Arvaja and Mäkitalo, 2004).

The work presented in this paper falls within this line of research. We aimed at designing, implementing and evaluating a specific computer-supported instructional process in curricular courses at the University of Lleida (Spain). We used a CSCL software called KnowCat (Cobos, 2003) to support and improve the students’ interaction processes, especially the scaffolding processes among peers. We applied the CSCL system in three curricular courses over a one-year learning project and analysed the effect of the students’ participation in the CSCL instructional process on their learning processes and outcomes.
Research questions

The following two main research questions have been addressed in our study:

- What effect does the students’ participation in the CSCL instructional environment have on their learning processes?

  Our study analysed the quality of the students’ interaction processes and described their evolution. It was designed with a view to obtain information about the evolution of the quality of the scaffolding processes among university students. We intended to verify whether students developed affective, cognitive and metacognitive learning activities as a result of their participation in the CSCL instructional context.

- What is the impact of the students’ participation in the CSCL instructional environment on their learning outcomes?

Computer-supported collaborative learning

There is a consensus amongst researchers that collaboration involves the construction of meaning through interactions with others and that such collaboration can be characterised by a joint commitment to a shared goal (Littleton and Häkkinen, 1999). From this perspective, the role of the social context in collaborative learning is particularly emphasised, as learning is a process in which cognitive resources are socially shared in order to either extend individual cognitive resources or to accomplish something more than what individuals could achieve alone. A crucial point in successful collaborative learning is the joint attention in which processes relate to social negotiations to create a common ground (e.g. sharing perspectives, sharing common goals, awareness of common goal, explaining…) (Häkkinen, 2004). Thus, collaborative learning is not one single mechanism, but rather can be explained as series of specific activities that students perform when working together, which in turn may trigger specific learning mechanisms (Dillenburg, 1999; Kanselaar et al. 2001).

Recent research interests in collaborative learning focus on studies that seek to understand the characteristics of the context in which collaboration takes place, the processes of collaborative interaction itself and its contribution to learning (Baker, 2002). While emphasizing the role of social context in collaborative learning, in addition to the cognitive variables, recent research trends highlight the relevance of social, motivational and affective variables of collaborative learning. Social and cognitive factors are intertwined in the accomplishment of collective thinking (Häkkinen, Arvaja and Mäkitalo, 2004; Stahl, 2003; Dillenbourg, 2002; Crook, 2000).

Crook (2000) pointed out collaboration is motivated and requires intentional activity. He introduced the importance of the concept of ecology of collaboration, which refers to certain forms of productive joint engagement in learning and focuses on circumstances that will lead students to engage in collaborative activities. It also centered on how the circumstances for potential collaborations are enhanced. Crook argued that ecology is concerned about the immediate environments within which collaborative learning is supported –the artefacts, the technologies and the spaces for acting together.
The role of social factors is also stressed when collaborative learning is supported by technology. Several authors have claimed that a technology-based learning environment increases openness, choice and control of the learning task, while striving to achieve more adaptive, collaborative and situational learning. This creates new challenges for learners who study in these environments, especially those related with regulation of motivation and emotions and task actions (Järvela and Niemivirta, 2001; Järvenoja and Järvela, 2005). Järvenoja and Järvela (2005) have studied the importance of volitional processes to regulate the emotions implied in the learning situation and to complete the tasks needed to achieve the established goals. In the volitional phase the students have to regulate the sources of their emotional experiences. They identified five categories related with the sources for emotional experiences in computer-supported collaborative inquiry context -namely, self, task, performance, context and social.

Kreijns, Kirschner and Jochems (2004) have also emphasized that the effectiveness of an (a)synchronous distributed group for collaborative learning largely depends on whether a social space has emerged indicating the establishment of a learning community. Such social space is important since it facilitates and reinforces social interaction and, in turn, influences the effectiveness of collaboration. They argue that a social space that could promote social interactions capable to enhance computer-supported collaborative learning needs to include both the sociability of the CSCL environment – i.e., the design of the CSCL needs a sociability potential capable to facilitate the emergence of a social space- and social presence –in which the communication of socio-emotional cues are necessary in order for the other person in the communication to be perceived as “physically” present.

Besides the social variables, in educational research there is a long tradition of studying the importance of cognitive variables in collaborative learning. In the history of research into the cognitive processes that could explain students’ learning outcomes, the focus has been laid on two main traditions: neo-Piagetian ideas or socio-cognitive conflict (Doise and Mugney, 1984), and Vigotsky’s (1978) socio-cultural approach and the importance of language as a mediating tool for learning. From the latter perspective, and the theoretical framework of our research, the study of the importance of language in the scaffolding processes among equals while working together is like to become an important cognitive mechanism that may promote better individual learning (Webb and Farivar, 1999).

A scaffold has traditionally been referred to as intentional assistance provided to “another” for learning ends (Vigotsky, 1978; Mercer and Fisher, 1998). In a scaffold the student must construct, transmit and comprehend explanations. Many researchers show that the amount of learning by the individual who provides explanations seems to be related to the cognition necessary for constructing and presenting explanations. In this sense, this explanation can come at different levels of elaboration and complexity. The amount of learning by the individual who receives explanations seems to be related to variables such as how relevant, understandable and elaborated the explanations are. The students’ knowledge acquisition increases when the assistance provided is more elaborated and contains relative information about the task contents, about the process and about the main strategies for solving the task. Finally, highly elaborated assistance benefits both the students who provide and those who receive said assistance (Cohen, 1994; Webb, Troper and Fall, 1995; King, 1997).
The conclusions of these studies have led to the design of further educational research studies whose objectives are to enrich and to improve the scaffolding processes among equals, especially the processes that involve giving and receiving assistance to favour better learning. Among these studies, one can emphasise those which analyse the main variables for solving a task (i.e. the tasks of solving a mathematical problem, of writing an argumentative text, and the note-taking processes). In these studies, guidelines, questions, aspects to be considered, etc., are designed in order to improve the strategies for solving the concrete task (King, 1997). These guidelines have two objectives: on the one hand, to teach relevant strategies for solving the task in an explicit way, and on the other hand, to structure the collaborative learning situation in order to favour the emergence of productive interactions (Dillenbourg, 2002). These studies show that the scaffolding processes among equals are richer and that the interaction deals with relevant aspects of the task and its realisation.

To sum up, in the words of Häkkinen, Arvaja and Mäkitalo (2004:167) “while aiming to understand the diverse viewpoints on collaborative learning, we have to consider an extremely complex set of variables: cognitive, social, emotional, motivational and contextual variables interacting with each other in a systemic and dynamic manner.”

The evolution of technology and the explosion in the design of specific collaborative software has encouraged the building up computer-supported collaborative learning networks. Recent studies have revealed that CSCL environments can facilitate a natural setting for explanation, knowledge articulation, argumentation, and other demanding cognitive activities that can foster higher-level processes of inquiry-based interaction (Scardamalia and Bereiter, 1994; Häkkarainen, Lipponen and Järvelä, 2001).

Despite the benefits and positive results obtained by many CSCL experiments, educational research has also shown constraints and contradictory results, which Häkkinen, Arvaja and Mäkitalo (2004) have summarised in the following three points: a) computer-supported collaborative processes are over-generalised and simplified in many studies; b) there is an assumption that a high level of interaction will automatically happen in a CSCL-environment, although many studies report that discussion threads are short, participation rates are low and that the interactions deal with descriptive and surface-level knowledge instead of finding deeper explanations for the phenomena under study c) it is difficult to reach and maintain an adequate level of common ground between participants, which is essential in collaborative activities.

The possible benefits of CSCL environments and the constraints detected in the research show the need to find out more about the nature of collaborative learning processes and what promotes collaborative knowledge building in network communities. In this line of work, many researchers have shown the necessity to design some piece of research that analyses those features that may affect learning in the context of a joint activity (Salomon, 1998; Crook, 2000; Dillenbourg, 2002; Stahl, 2003).

Research Methodology

Our study took the form of a longitudinal case study conducted in an authentic university class environment. The purpose was to follow the scaffolding processes among students over a twelve-month (two terms) learning project. The study was conceived as a field study capable of deepening our understanding of the complex
factors influencing computer-mediated learning and teaching in university contexts. Thus, the analysis was initially planned on a descriptive level. Nevertheless, as we were addressing the changes occurring from the beginning to the end of a long-term learning project, we chose to demonstrate this fact by using a quantitative method, thereby adopting a coding scheme which would allow quantitative results to be stated. Furthermore, this research methodology would allow us to reach conclusions about our research question concerning the incidence of computer mediation on learning outcomes.

**Participants**

Eighteen university students participated in the research. They used CSCL software – KnowCat - during two terms, and in the context of three curricular courses of the Psychopedagogy degree, each course lasting for 12 weeks (4.5 hours per week). The university courses were: Psychopedagogy Intervention, Instructional Psychology and Learning Strategies.

**Procedure: Main characteristics of the instructional context to support and structure the computer-supported collaborative work**

*The CSCL system used: KnowCat*

The KnowCat system (acronym for “Knowledge Catalyser”) has been developed at Universidad Autónoma de Madrid (UAM) (Cobos, 2003). The main aim of this system is generating quality educational materials as the result of the interaction of students with the materials in an asynchronous and distributed way (Alamán and Cobos, 1999).

KnowCat organises knowledge in the form of a tree structure. The root of this tree is the main topic of the knowledge area, or KnowCat node. Each node of the knowledge tree represents a topic and contains a set of mutually alternative descriptions of the topic (a set of addresses of Web documents). The documents may receive votes and annotations. Moreover, a document author can submit a new version of his/her document at any time. An example screen of a KnowCat node is shown in the following figure.

----------Figure 1. Example screen of KnowCat-----------------------------

The left side of the screen shows the knowledge tree of the knowledge area “Psychopedagogy Intervention”. The right side shows the documents added to the topic “Mobility Impairment”. These documents are identified by their author’s name, arrival date and title. On the left side of the identification of each document are the icons that inform us whether a document has received annotations and a new proposal of a document version.

An annotation – or notes for short – reflects the knowledge of the note’s author about the information presented in the annotated document. In our work, we used these notes as explicit scaffolds among peers. We considered the following note types:
In synthesis, there are three main actions which the students carried out when they used the KnowCat system to construct knowledge collaboratively: (1) consult the different elements of knowledge in the system: documents, notes and the topic tree; (2) contribute to the system with new knowledge – new documents, new notes, new topics in the tree of community knowledge construction and, (3) give opinions about the knowledge elements in the system – voting service. With the voting service the community can express their agreement or disagreement about documents, notes and the inclusion of new topics in the topic tree.

Main pedagogical characteristics of the instructional context

Results of research into collaborative learning and CSCL show that some prerequisites for pedagogical and contextual settings must be taken into account in the design of successful collaborative learning environments. Among these prerequisites the following four can be highlighted, all of which have been taken care of in the design of our instructional process: a) the creation of common grounding; b) the design of open-ended learning tasks; c) the facilitation of a student-centred education in which the role of the teacher is to guide the student’s knowledge construction; d) the need to structure student’s collaboration (Arvaja et al., 2000; Stahl, 2001; Woodruff, 2001; Dillenbourg, 2002).

In order to assist the students in the use of the KnowCat system to construct knowledge collaboratively, and more specifically the KnowCat notes as improved scaffolds that could help their classmates to improve their documents, we designed a specific educational process in which the pedagogical prerequisites above were introduced as follows:

- We supported the creation of a common frame of reference before starting to use the CSCL system. Both the students and the instructor shared and exchanged ideas about the learning processes at university and the role of scaffolding processes. In particular, they were encouraged to reflect upon the note-taking processes as a learning tool at university. As a product of this debate, the instructor and the students jointly elaborated a guideline about the more relevant aspects to allow for in the note-taking processes. The guideline had two objectives: on the one hand, to help the students to think about how to elaborate, organise and personalise their ideas in the note-taking processes and, on the other hand, to act as a script that would guide and structure the writing of the students’ scaffolds – i.e. the notes of the CSCL system - in order to help their classmates to improve their written documents.
We used a student-centred approach (rather than lecture-dominated). The students actively participated in all the activities. We combined face-to-face meetings with asynchronous and virtual work. Face-to-face meetings were used to teach specific course contents and to support students in using the KnowCat system, which would help them reach the learning objective grounded at the beginning of the experience: to help their fellow students improve their learning processes. More specifically, in these sessions the instructor solved specific students’ problems when interacting with the KnowCat system and guided them with the KnowCat notes as scaffolds among equals. Both instructor and students would discuss in these sessions such aspects as: which types of notes were more effective to help a classmate to re-write a document; how to write an effective note; how to deliver some criticism to a classmate on his/her work in a polite way.

The collaborative KnowCat system was also used in well-structured activities in which students shared the project’s common values and pedagogical goals, and the collaborative tasks were coordinated in advance – i.e., the tasks and the timetable were agreed on previously between instructor and students.

The main procedure of the students’ work with the CSCL system was as follows: a) individually, students read some information about a specific topic course; b) the students wrote an individual report about the topic and submitted it to the KnowCat system. These reports contained a personal reflection on the content of the articles read or expressed a personal solution to a specific problem; c) students read a peer’s report and annotated it – i.e. giving assistance - in order to help a fellow classmate to improve on it. For each individual topic, the students had to annotate a minimum of one classmate’s report and write at least three notes. During the study, the students were strongly encouraged to annotate the reports of different classmates. Despite this recommendation, the students’ documents received a different number of annotations, but none of the students’ documents received less than three notes and, finally, d) the document’s author read the notes concerning his/her own report, taking into account their classmates scaffolds, re-wrote it and submitted it to the system again.

Data analysis

The method used for collecting and analysing the data consisted of three steps:

1) The analyses of possible changes in the students’ participation in the system: interaction processes.

Veldhis-Diermanse (2002) proposed to study the distinction between active and passive participation with regard to the students’ participation in a CSCL system. In our study, passive participation refers to reading notes and documents, while active participation refers to writing notes and documents. We focused our analysis on the active participation by counting the type of notes written throughout the study and analysing the evolution of the pragmatic value of the students’ note contributions.

The instructors of the course checked whether the students labelled the notes correctly in relation with their content. At the beginning of the study, the instructors revised all the labels and the content of the notes. Wherever they detected incorrectness, they contacted the student who wrote the note and together they decided how to re-label it.
This action was also part of the instructional process to assist students in using the KnowCat system effectively. During the study, the number of errors in labelling the notes decreased and instructors continued checking the labelling process by selecting and revising random notes.

2) The analysis of possible changes in the students’ learning activities when using the CSCL system.

A coding scheme was used to study possible changes in the content of the notes and in the learning processes required for the writing of these notes. The coding scheme was based on the categories developed by Veldhuis-Diermanse (2002) and was applied in subsequent studies such as Laat and Lally (2003). The scheme distinguishes three general types of learning activities (or categories) and nine subcategories: (1) cognitive activities – three subcategories are distinguished: debating ideas, using external information and experiences, and linking or repeating internal information; (2) metacognitive activities - three subcategories are distinguished: planning, keeping clarity and monitoring; (3) affective activities - three subcategories are distinguished: general reaction, asking for general feedback and chatting or social talk.

The coding process consists of two steps: (1) dividing the messages into meaningful units (Creswell, 1998); (2) assigning a code to each unit. We decided to segment the notes into units of meaning by using semantic features such as ideas, argument chains, and discussion topics, or by regulative activities such as making a plan, asking for an explanation, or explaining unclear information (Chi, 1997; Laat and Lally, 2003). We analysed the data with the help of nVivo software (Qualitative Solutions and Research, 2002)

3) The analysis of the impact of the student’s participation in the CSCL instructional context on their learning outcomes.

The results obtained by students in a test about the conceptual and procedural contents of each course helped us analyse the impact of the CSCL instructional environment on the students’ learning outcomes.

Results and discussion

Results on students’ interaction processes: students’ participation in the system

We analysed the type and the evolution of the notes that the students wrote and submitted to the system in order to help their classmates improve their documents during the courses.

----------Figure 2. Evolution of the students’ notes contribution during the study----------

Figure 2 shows the number of each type of notes written by the students throughout the two semesters. The students wrote a total of 547 notes during the study. These were distributed as follows: 47 “clarification” notes, 204 “support” notes and 296 “review”
notes. The breakdown for the notes included in the category of “review” notes are as follows: 166 “addition” notes, 88 “correction” notes and 42 “question” notes.

During the study, the type of the scaffolds written by the students fluctuated. The increasing number of “review” notes produced was particularly interesting. These notes had the explicit practical value of asking a peer to revise some information, adding relevant information that was missing from his/her document, or correcting or changing parts of the documents. These three possible actions behind the “review” notes could verify whether the student who wrote the note engaged in constructive cognitive and metacognitive activities. In the next section, the analysis of the content of the notes will provide more evidence for this inference and it will confirm whether the use of explicit tools of the CSCL-Knowcat to support scaffolding processes has fostered the development of higher cognitive and metacognitive processes.

Evolution in the nature of the scaffolding processes in a collaborative community has already been seen in previous studies. Fretz et al. (2002) showed the evolution of the scaffolds among secondary students using a specific tool to support modelling practices in science. In that study, the authors showed that the scaffolds of the specific software tool used encouraged the students’ use of evaluation practices.

Additionally, different studies using the CSCL system Knowledge Forum have shown how the number of build-on notes and revised notes increases with the time the student has been using the collaborative system and as such has been more actively involved in the knowledge building community (De Jong, Veldhuis-Diermanse, and Lutgens, 2001; Russell and Perris, 2003). Other studies have shown how the content of the notes also changes in the direction of higher cognitive and metacognitive processes (e.g. Veldhuis-Diermanse, 2002; Veerman, 2000; Newman et al., 1999). In the next section, we will focus on the changes in the content of the notes written by the students during the research project.

Results of the students’ learning processes developed in the CSCL system and their evolution in time: content analyses.

In this section, we will analyse the development of the students’ learning activities with KnowCat. To reach this objective, we carried out a detailed study on the content of the notes written by the students at two different time periods: one was made in the middle of the first semester with students who used the CSCL system, and the other, in the middle of the second semester. Both time periods correspond to two different topics, but share the same learning objectives and the same type of task: to construct knowledge from a theoretical topic. Furthermore, at both time periods the students showed a high level of active and passive participation in the system. To be precise, the students wrote 108 notes in the first period analysed and 87 in the second. We analysed 195 notes out of a total of 547, which amounted to 35.65 % of the total note contribution.

Figure 3 provides a general picture of the learning processes developed by the students in both semesters. The total number of notes and the meaningful units identified in these notes in the two selected periods of time are different; although the number of notes in the first semester is higher than the number of notes in the second (108 notes in the first period analysed and 87 in the second), the number of meaningful units identified in the second semester is higher than the number of meaningful units identified in the first
semester. Thus, within the 108 notes of the first semester 142 meaningful units were identified, while within the 87 notes of the second semester, 239 meaningful units were identified. These results suggest that the notes of the second semester were richer than the ones of the first semester because they were longer (in number of words) and each of them expressed different ideas, arguments and topics.

If we analyse the number of meaningful units of each learning processes category, we also found important differences between the two semesters. In the first semester, most students’ notes, 91 in all, concerned cognitive activities, while 38 out of 142 meaning units were coded as metacognitive, and only 13 meaning units were coded as affective (in percentage, these figures represent 64.08% for cognitive, 26.67% for metacognitive, and 9.15% for affective activities). In the second semester, we observed a large increase in metacognitive and affective activities, where 68 out of 239 meaning units were coded as metacognitive, 92 were cognitive and 79 were coded as affective (38.49% for cognitive, 28.45% for metacognitive, and 33.05% for affective activities).

The changing nature of the notes’ content during the two-semester period can be seen in detail in the different activities of the general categories – the subcategories of our coding scheme. Figure 4 shows the learning activities divided into subcategories.

With regard to the affective activities, our data show an increase in the number of the student’s affective activities as a result of their participation in the CSCL environment. Many studies have related how affective learning activities are of importance to the extent to which, and how, students develop learning activities (Vermunt, 1998; Järvelä, and Niemivirta, 2001; Kreijns, Kirschner and Jochems, 2004).

In our research, in the second semester notes, students reacted emotionally to fellow students’ work more frequently than in the first semester notes (“General” category in figure 4), for example, students used to start or finish second semester notes with statements as:

“Congratulations on your work”
“Good work”
“Nothing else… keep up the good work!”

Besides, in the second semester notes, students included statements asking for general feedback, responses or opinions by fellow-students (“Ask Feedback” category in figure 4), for example:

...Do you think my recommendations are enough?
... What is your opinion about...?
The value of positive feedback for collaborative learning is underlined in CSCL research. Accordingly, Wegerif (1998) stated that creating a sympathetic sense of community is a necessary first step for collaborative learning. When this exists, people feel that they can reveal their own feelings, assumptions and knowledge without the risk of being treated poorly by their fellows in a web-based environment. Following this argument, Hara, Bonk and Angeli, (2000) showed that positive feedback encourages people to participate in discussion and thereby engage in the group, actively contributing to the web-based learning environment. Mäkitalo et al. (2002) further confirmed that during deeper level discussions, supporting feedback became more frequent.

Particularly interesting in our study is the increase in statements which incorporate chatting or social talk, which indicates a “social presence” in the students’ notes (Tu, 2000). During the second semester, students used to start or finish their notes incorporating phrases such as:

- How are you?
- Hi, little girl!
- Don’t lose heart and keep going!

Recently, a number of educational researchers have recognised that the emergence of a social space is a positive indicator of the establishment of a community of learning, which affects the degree of social interaction in CSCL environments (Gunawardena, 1995; Tue and Isaacs, 2002). Kreijns, Kirschner and Jochems (2004) have confirmed that this social dimension of learning interaction is necessary for achieving the cognitive goals of collaborative learning.

In view of these arguments, the results obtained in our research verified that the learning atmosphere after using the CSCL for an extended period of time was more positive and more confident than the one at the beginning of the study. Students created a good work atmosphere and a social climate capable to enhance and foster online social interaction, which is the main vehicle to collaborate and learn together.

With regard to the cognitive learning activities, our data shows that this kind of activities is the most frequent in both semesters (64% in the first semester and 38 % in the second, figure 3). Cognitive activities can be described as the thinking processes to learn a content and to attain learning goals (Vermunt, 1998). In our work, mainly, the cognitive category refers to processes related with managing and contributing with information about the topic documents written by students. Accordingly, meaning units coded in this category are strongly task-oriented. One explanation for the cognitive activities being the most frequent relates to the design of the task environment in which students were asked to help their classmates to re-write and improve their documents about a topic course. It seemed logical then that the students’ contributions involved debating, contributing, referring or repeating information. Another explanation for cognitive activities being the most frequent stems from the formal character of collaborative learning, as it was a formal part of the course. The results are consistent with comparable studies of, e.g. Schellens and Valcke (2005) and Salovaara and Järvelä (2003). Like us, these researchers also detected considerable task-oriented communication in working in a CSCL environment.

The data referring to cognitive activities also shows differences between the two semesters. In the second semester, the debating category decreased in favour of the use
and link of external-internal information categories (figure 4). In the debating category, students expressed agreement or disagreement with opinions, ideas or information issued by another student. They could either back up, refutate or restrict such information. The students’ viewpoint was highly related with the document’s topic. Two examples of this category are shown below:

I agree with the ideas you present about the theoretical framework. I really have found interesting your arguments about the role of language in the teaching and learning processes.

I think your conclusions are right and they are well organised.

Hence, in using the external information and experiences category (“Use external Information” category in figure 4) students contribute, summarise or evaluate new relevant information found in information sources other than the discourse to support their ideas or elaborate their explanations or questions, as in the example below:

I think, in your introduction, you should incorporate the main aspects to take account in an educative intervention highlighted by the author Shuell (1996) (page 358 in Coll et al. article).

In the linking or repeating internal information category (“Link Information category in figure 4), students linked facts, ideas or remarks presented in the discourse. They explicitly referred to a contribution in the discourse. We understand internal information as information found in a student’s document or in other students’ notes. Referring to and linking database information is considered important because of increasing coherence in the database (Veldhuis-Diermanse, 2002). The example below belongs to this category:

You centred the value of the experience on the procedure and the instruments used but you didn’t mention anything about the importance of the language. Oral language is very important because...

To us, the increase in the second semester in the use of linking and external information categories reveals that students went more deeply into their fellow’s documents, not only by debating ideas -i.e. agreeing and disagreeing, but also by contributing with new information which shows an elaboration of earlier ideas and by reflecting on argumentation, reasoning and justifications of earlier information. The increase in these cognitive categories could reveal that students develop learning activities that researchers as Scardamalia and Bereiter (1994) and Veerman and Veldhuis (2001) relate to higher levels of knowledge construction. These activities influence the way in which acquired information can be transformed into knowledge, and the way in which knowledge can be transferred to other contexts (Laurillard, 1993).

As for the metacognitive learning activities, our data shows an increase in the number of the students’ metacognitive activities as a result of their participation in the CSCL environment. In educational literature, there abound references on the issue that the use of metacognitive learning activities is essential to explain successful learning because it enables individuals to bear on the overall cognitive activity, managing and controlling their cognitive activities in order to solve specific problems (Schraw, 1998, Flavell, 1992).

In our research we emphasized the use of the KnowCat notes as improved scaffolds among peers, and therefore in studying the students’ metacognitive learning activities, our main focus was analysing external regulative learning activities rather than analysing metacognitive knowledge (Flavell, 1992). External regulation can help students to run group processes, to make plans aimed at successfully carrying out the task, to monitor their learning processes and to assist each other for learning ends.
In both semesters of our study, the activities related to planning others’ work were the most frequent. In the “Planning” category (figure 4) were coded meaning units which students asked for a new approach or procedure to carry out the task or students presented or illustrated a new approach or procedure to perform the task, such as:

You could synthesise the positive and the negative aspects of the experience in a table, in this way the content would be more comprehensible and concise.

However, in the second semester we observed an increase in activities related to mutual regulation of the learning processes. The “Keeping Clarity” category increased significantly in the second semester. This category consisted in students asking for a better content structure of the classmate’s document and regulating their classmate’s work to key points. For example, asking the other to go further in his/her work, asking for explanations, clarification and illustration or formulating a key point.

... Do you think this point is the only necessary one? What other things would you considers indispensable? Could you develop these aspects further and give some examples?

Could you explain me how would you apply the proposed intervention technique? Give some examples.

Also in the second semester, our results show an increase in those activities related to monitoring the others’ and one’s own work, as seen below:

What have you learned from the article?

What learning strategies of those proposed in the paper would you use if you worked in secondary education?

... I also will take into account this aspect in my work.

Educational research has shown that among the main characteristics of effective scaffolds are those that help good behaviour – giving examples, asking for clarity and explanations, encouraging thinking for oneself and helping in the transition from other-to self-regulation (Wertsch, Minick and Arms, 1984; Rogoff, 1990; Mercer and Fisher, 1998). These features are included in the metacognitive activities developed by the students of our study. In our view, the metacognitive features included in the students’ notes reveal the improvement of these notes for the purpose grounded at the beginning of the study “scaffold to a classmate in their learning processes”. These results also show that the students gained an insight into the educational objective of the use of the KnowCat system: peer scaffolding.

Furthermore, educational research has pointed out the learning benefits obtained from the elaboration of an explicit scaffold, for both the student who provides the scaffold and the student who receives it. Therefore, the amount of learning achieved by the individual who provides scaffolds seems to be related to the cognitive and metacognitive activities necessary for constructing and presenting explanations (Webb, Troper and Fall, 1995; Ploetzner et al. 1999). Following these arguments, in our study we can assume that the positive effect of the instructional process mediated by the use of KnowCat system on the development of affective, cognitive and metacognitive learning activities may have a positive effect on the students’ learning. This aspect is covered in the section below.
**Learning outcomes**

At the end of each course students sat a test. In this paper we report and compare the results obtained by the students in the Instructional Psychology course (first semester) and the Learning Strategies course (second semester) because the contents of both courses had strong conceptual links. The tests were different from each other in order to facilitate data comparison, the questions of both tests had the same cognitive demands, the students had the same instructor in both courses and continuity between the contents of both semesters was emphasised. Two evaluators marked the tests.

We compared the scores obtained by the students in both tests. The paired t-Test of individual differences in the learning results reached levels of significance \([t(1,17) = 2.64, p=0.012]\). Students obtained better results in the second semester (M= 6.67 SD= 1.15) than in the first semester (M=5.06; SD=2.38). This proves that the computer-supported instructional environment had a positive impact on the students’ learning.

Besides, in the second semester, we calculated the Pearson correlation coefficient between the three types of learning activities developed by the students in their note contribution and the results of the test taken at the end of the second semester (Learning Strategies course). We observed a nearly significant correlation \((p=0.08)\) between the sum of affective, cognitive and metacognitive learning activities and the exam results \((r=0.41)\). When considered separately, there was no significant correlation between the affective, cognitive and metacognitive activities and the exam results.

The analysis of the students’ learning results provide a slight, but still promising, relationship between the students’ participation in the CSCL environment, the learning activities developed by the students in the instructional context and their learning results. These results support the hypothesis laid out in research on collaborative learning, that constructive cognitive and metacognitive activities involved in collaborative settings can foster better learning results.

In our view, the slight relationship between the higher-order learning activities developed by the students and their learning outcomes can be explained, on the one hand, by the low number of subjects who participated in our study: a larger population study would be needed in order to find irrefutable and statistically significant evidence of such relationship. On the other hand, this relationship is not easy to demonstrate, as many other researchers have shown that the powerful attributes of CSCL that may lead to deeper learning have not automatically resulted in positive learning outcomes (Stahl, 2001; Hakkarainen, Lipponen and Järvela, 2001, Dillenbourg, 2002). Following this argument, Kester and Paas (2005) have summarised the contribution of different computer-supported environments and concluded that, although interventions to enhance collaborative processes, such as grounding, discourse, argumentation, with the ultimate goal of achieving better learning successfully supported these processes during collaboration, their beneficial effects on learning were not always found.
Conclusions

In this paper we aimed at understanding the learning processes of students who participated actively in a CSCL system. To achieve such goal, our study applied a CSCL system to curricular courses during a single academic year to develop regular higher education activities such as writing documents about specific topics or solving practical cases. One of the main instructional objectives of the courses was to make explicit use of the document annotation option of the KnowCat system as improved assistance among peers.

Comparing the three steps considered for the data analysis in our study, namely evolution of the students’ notes contribution, content analysis of the students’ notes and the students’ learning outcomes, they seem to coincide in that the CSCL environment promoted the students’ development of higher-order cognitive processes which could have fostered deeper and better learning.

Furthermore, our work showed that the instructional application of the KnowCat system can favour and improve the scaffolding processes among peers, by influencing the quality of the students’ scaffolds. As mentioned above, at the end of the study the scaffolds written by the students imply their engagement in constructive affective, cognitive and metacognitive activities.

However, although it is true that students constructed knowledge, and that they developed higher-order cognitive processes, our study only found a loose connection between the students’ participation in the CSCL environment, the learning activities developed by the students in the instructional context, and their learning results. To conclude, our study showed to what an extent the powerful possibilities of a CSCL system could be used to enhance knowledge construction and higher-order thinking processes. Also, the constraints mentioned in our study could be the first step towards implementing CSCL systems that may support learning processes in new educational programs currently discussed in many European universities.

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References


Figure 1. Example screen of KnowCat.
Figure 2. Evolution of the students’ notes contribution during the study (frequencies)

Evolution in type of notes

SUP: Support notes; CLA: Clarification notes; Rev: Review notes.
Figure 3. Frequencies of meaningful units of each general learning process category.
Figure 4. Frequencies of meaningful units in the different learning process subcategory
### Documents on Mobility Impairment

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