Promoting Metacognitive Skills in a CSCL environment: implications for instructional and technology design

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Running Title: ***Metacognitive Skills in CSCL***

Abstract

This paper aims to better understand the development of students' learning processes when participating actively in a specific Computer Supported Collaborative Learning system called KnowCat. To this end, a longitudinal case study was designed, in which eighteen university students took part in a 12-month (two semesters) learning project. During this time period, the students followed an instructional process, using some elements of KnowCat (KnowCat key features) design to support and improve their interaction processes, especially peer learning processes. Our research involved both supervising the students' collaborative learning processes throughout the learning project and focusing our analysis on the qualitative evolution of the students' interaction processes and on the development of metacognitive learning processes. The results of the current research reveal that the instructional application of the CSCL-KnowCat system may favour and improve the development of the students' metacognitive learning processes. Additionally, the implications of the design of computer supported collaborative learning networks and pedagogical issues are discussed in this paper.

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Keywords: Computer Supported Collaborative Learning; Metacognitive Learning Processes; Awareness; Peer Interaction; Qualitative research.

1. **Introduction**

The evolution of technology and the explosion in the design of specific collaborative software has assisted in designing computer supported collaborative learning networks –henceforth, CSCL. 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 (Häkkarainen, Lipponen & Järvelä, 2002; Weinberger & Fischer, 2006).

Although CSCL could support communication and collaboration learning processes, both research and field observations do not always confirm that they actually work (Kreijns, Kirschner & Jochems, 2003; Häkkinen, Arvaja & Mäkitalo, 2004). Recent CSCL research focuses on studies that seek to understand the characteristics of the context in which collaboration takes place (Dey & Abowd, 2000), the processes of collaborative interaction itself and its contribution to learning processes (Baker, 2002). A few lines of research highlight the relevance and intertwining of social, cognitive and metacognitive variables in the accomplishment of collective thinking (Crook, 2000; Stahl, 2003).

In view of this, there is a need to do research to enhance the possible benefits of CSCL environments and alleviate the limitations detected. Likewise, many researchers have proved the need to analyse different learning features as a joint activity (Crook, 2000; Stahl, 2003). It seems then crucial to insert computer supported collaborative networks and research projects that support them with regular courses, and for reasonably long periods of time, in order to investigate both the main educational variables that can enhance successful and critical attributes of collaborative learners (Häkkinen, Arvaja & Mäkitalo, 2004; Naidu & Järvela, 2006) and also the critical design variables of CSCL environments that generate successful collaborative learning (Kreijns, Kirschner & Jochems, 2004; Johson, Hornik, & Salas, 2008).

The research study presented in this paper falls within this line of work. Our aim was to analyse a pedagogical hands-on activity for two regular courses over a one year project at the Universitat de Lleida (UdL, Spain), by using a specific and innovative CSCL software called KnowCat (Alamán & Cobos, 1999; Cobos, 2003) designed to support collaborative learning processes. Specifically, this research study focuses on the analysis of students' development of metacognitive processes in the context of joint learning activities supported by CSCL-KnowCat in higher education.

2. Background: the development of metacognitive learning processes in collaborative learning environments

Recent educational research focuses on the value of specific cognitive and the metacognitive processes that students acquire while working in electronic discussion groups on collaboration tasks (Schellens & Valcke, 2005; van Joolingen, de Jong, Dimitrakopoulout, 2007). In educational literature, there abound references on the issue that the development 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 (Flavell, 1992; Pintrich & Garcia, 1994; Schraw, 1989).

Metacognition is a complex psychological concept, but researchers agree that it concerns metacognitive knowledge as well as metacognitive skills. Metacognitive knowledge can be defined as knowledge concerning one's own metacognitive skills and products or anything related to them; it is a static and stable component of metacognition. Metacognitive skills concern the extent to which students can regulate their cognitive and affective learning activities and, therefore, their own learning; it is strongly related with task and context characteristics (Brown, 1987; Flavell, 1992).

Research on metacognition has produced information on how an individual uses metacognitive knowledge and metacognitive skills to become aware of his thinking and control over his own cognitive actions (e.g. Brown, Bransford, Ferrara & Campione, 1983; Flavell 1992; Schraw 1989). An emphasis on the social aspects of learning allows researchers to expand the theories of metacognitive processes and to view metacognition not only as an individual's activity, but also as an essential part of socially shared discussions. Others (both adults and peers) have a central role in the recent research on metacognition which has suggested that metacognition appears to be a part of the collaborative learning situation where metacognition regulation is considered also as a group level activity rather than an individual's performance (Goos, Gailbraith & Renshaw, 2002; Zimmerman, 2000).

The foundations of viewing metacognition as part of the collaborative learning situation could be grounded on the theoretical idea of socially shared cognition in which thinking and cognition are seen as a social practice. It is argued that thinking can be regarded as a socio-cognitive activity in which thinking and cognition can be shared through the learning environment among participants (Resnick, Levine & Teasley, 1993). A key feature of a social cognitive model of metacognition regulation is the interdependent roles of social, environmental, and self influences (Zimmerman, 2000).

The social environment is viewed by social cognitive researchers as a resource for self-enhancing forethought, performance or volitional control and self-reflection. From this perspective, the study of the importance of language in the scaffolding processes among participants while working together is likely to become an important cognitive mechanism that may promote better individual learning (Webb & Farivar, 1999).

A scaffold has traditionally been referred to as intentional assistance provided to the "other" for learning ends (Mercer & Fisher, 1998; Vigotsky, 1978). In a scaffold the student must construct, transmit and comprehend explanations. Many researchers verify that the amount of learning obtained from the individual who provides explanations seems to be related to the cognition needed to construct and present explanations. Such explanations can come from different levels of elaboration and complexity. The amount of learning by the individual who receives explanations seems to be related to such variables as how relevant, understandable and elaborated the explanations are.

Expanding on these ideas, it is hypothesized that in networked collaborative learning environments with an appropriate CSCL pedagogical model there are metacognitive processes which can be stimulated by peers (Hurme, Palonen & Järvelä, 2006). In recent design research on interactive learning environments, this notion of scaffolding has been generalized to refer to aspects based on software tools to assist learners in making progress on task solving (Reiser et al. 2001). In the design of interactive learning environments, two situations to assist learners in task solving may be found: a) a situation whereby a software program provides additional assistance to help a learner accomplish a specific task. For example, the software might provide prompts to encourage students to take steps, or supply a graphical organizer to help students plan and monitor their problem-solving process or offer representations that help learners track the steps taken in the problem-solving process; or b) a situation whereby students use software tools to provide each other with explicit assistance to accomplish a specific task. CSCL enables students to see online fellows' solutions and provide them with specific widgets for explicit assistance to improve on task and process solving or they can discuss online how to solve the task. The software used in our research study tackles the latter scenario.

Our study is grounded on the hypothesis that students could benefit from using networked technology since they are using their metacognitive knowledge and their metacognitive skills more actively in task solving. Furthermore, such skills are more visible to other CSCL community members, who can be given suggestions and assistance with a view to improving their own work.

The importance of developing metacognitive processes in CSCL as a variable to improve the quality of group work and the students' learning results has led software designers to introduce design tools for CSCL networks and support people to be conscious of group workspace. Gutwin & Greenberg (2002) highlight the need that groupware designers should promote awareness in three areas: what information to gather and distribute, how to present the information to the group, and, thirdly, finding out when the information will be most useful. The consciousness of shared knowledge -when students carry out a collaborative learning activity- may have a positive impact on group metacognitive activities by aiding in the construction and maintenance of group shared knowledge (Collazos, Guerrero & Pino, 2003).

Even though CSCL could engage students in collaborative learning activities, the role of metacognition in a collaborative framework supported by networked technology is not clear and as pointed out by some educational researchers there is not much research on how metacognitive learning processes evolve in natural contexts (Pintrich, 2000; Salovaara, 2005). The research study presented in this paper falls within this line of work. Our aim was to analyse a pedagogical hands-on activity for two regular courses over a one year project at the Universitat de Lleida (UdL, Spain), by using a specific and innovative CSCL software called KnowCat (Alamán & Cobos, 1999; Cobos, 2003) designed to support collaborative learning processes. Specifically, this research study focuses on the analysis of students' development of metacognitive processes in the context of joint learning activities supported by CSCL-KnowCat in higher education.

Our study departed from the following research question:

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

3. KNOWCAT: The computer supported collaborative learning system used

KnowCat, an acronym for "Knowledge Catalyser", was developed in 1998 and has been actively used since then at the Universidad Autónoma de Madrid (UAM). KnowCat is a distributed non-supervised system to structure knowledge. Its purpose is to enable crystallisation of collective knowledge as a result of user interaction without an editor managing the task. Furthermore, the system generates quality educational materials as the automatic result of the students' interactions with the materials, by catalysing the crystallisation of knowledge (Alamán & Cobos, 1999; Cobos, 2003).

KnowCat encourages communities to share their knowledge and, progressively, construct knowledge sites of reasonable quality (see the studies and results presented in Cobos & Pifarré, 2008, Diez & Cobos, 2007 and Cobos & Alamán, 2002). These knowledge sites, accessed through a specific URL, are organised around the following three knowledge elements: a) a knowledge tree: a hierarchical structure of topics which facilitates the organisation of the community knowledge; b) a set of documents contained in each topic which provides alternative descriptions of the topic and c) a set of annotations contained in each document which express explanations, comments and opinions about the content document. In Figure 1, we can see an example screenshot of the "Instruction" KnowCat site**.**

The users participate in the common task of constructing the community knowledge through the following main operations:

1) Adding documents. A document reflects its author's knowledge on a specific topic. Once a document is added to a topic of the knowledge tree, the document will compete against the others to become the best document on that particular topic. This competitive

environment is achieved by the Knowledge Crystallisation mechanism of KnowCat (see below for details).

2) Voting documents. A user can express with a vote the degree of satisfaction with a document.

3) Adding an annotation to a document. A user contributes an annotation (note, for short) to a document in order to make suggestions and/or give comments or opinions. In our study, we used these notes as explicit scaffolding messages –i.e. the assistance mentioned above. A note is composed by i) a text stating the type of assistance provided by the user to the author of the annotated document and ii) a note type. The following is a detailed explanation of the note types supported by KnowCat:

- “Clarification” note: used to clarify some parts of the document. This note type is normally made by the author of the annotated document.
- “Support” note: used to express satisfaction with the document.
- “Review” note: used to make suggestions about adding, removing, or changing some parts of the document, or to make comments on it. The note types for a review note are the following five:

“Addition” note: used to suggest additions to the document.

“Delete” note: used to suggest deletions to the document.

“Correction” note: used to suggest changes to the document.

“Criticism” note: used to criticise the document.

“Question” note: used to make open questions about the document.

4) Adding a new version of a document. The author of a document can contribute with a new version of his/her document at any time.

The Knowledge Crystallisation mechanism takes into account the user's opinions about the documents and the evolution of the opinions received to determine what documents are socially acceptable, in which case they remain in the knowledge site, and which of those are found unsatisfactory, in which case they are removed from the knowledge site (Cobos, 2003).

Whether or not a document is socially acceptable is determined by its "degree of acceptance" as calculated by the Knowledge Crystallisation mechanism. More specifically, the degree of acceptance of a document is formulated using the explicitly received opinions concerning the document: the received votes, how these votes were received, the received annotations and their respective types and the implicitly received opinions regarding access to the document.

[Here: Figure 1]

Figure 1. Example screenshot of the "Instruction" KnowCat site

As seen in Figure 1, the knowledge tree is shown on the left of the screen. The right side of the screen shows the documents for the selected topic "Learning Strategies: Conceptualization". The documents are identified by the author's name, arrival date and title. They are ordered according to their degree of acceptance, which is shown to the right of the identification heading of each document (on the green-red bar). On the left side of the identification heading of each document are the icons indicating whether a document has received annotations and whether a new version of the document is available. For example, the document identified by "RAQUEL L S … [19/11/2003] (PRACTICA 1. Estrategias de Aprendizaje) [Practical work 1. Learning Strategies])" shows the highest degree of acceptance on the selected topic, and this document has received annotations and a new proposal of a document version –as shown with the corresponding icons.

4. Research Methodology

Our study took the form of a longitudinal case study conducted in an authentic university environment. The purpose was to follow the students' collaborative processes over a twelve-month learning project, by collecting and analysing data during and at the end of the learning process. The study was conceived as a field study which would allow us to better understand the complex factors involved in computer-mediated learning in university contexts. The study analysed then changes in metacognitive variables from the beginning to the end of the learning project. To achieve this, we made use of a coding scheme which would allow comparison between initial (first semester) and final (second semester) quantitative results.

4. 1. Participants

Eighteen university students participated in the research. They used CSCL software –KnowCat– during a two-term period of two regular university courses in the Psychopedagogy degree. Each course lasted 12 weeks totalling 160 hours. The two courses were "Instructional Psychology" and "Learning Strategies". The contents of both subjects are closely related in that the contents of "Learning Strategies" could be considered as part of "Instructional Psychology". Two instructors participated in the study, both of them taught in "Instructional Psychology" and only one of them taught in "Learning Strategies". Both courses shared the same pedagogical methodology, explained in the next section.

4.2. Intervention: Main pedagogical characteristics of the CSCL-KnowCat 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, Häkkinen, Eteläpelto & Rasku-Puttone, 2000; Stahl, 2001; Woodruff, 2001; Dillenbourg, 2002). These pedagogical prerequisites were introduced in our study as follows:

- We supported the creation of a common frame of reference before using the CSCL system. Both students and instructors shared and exchanged ideas about the learning processes at university and the role of scaffolding processes. In particular, they were encouraged to create a social learning environment where students monitored and modelled each other's application of cognitive and metacognitive strategies as part of their normal learning practice. As a result of this debate, the instructors and the students jointly elaborated some guidelines to verify what the most relevant aspects in note-taking processes were. These guidelines aimed to: on the one hand, help the students think about how to elaborate, organise and personalise their ideas in note-taking processes and write an appropriate piece of writing and, on the other, act as a script that would guide and structure the writing of the students' scaffolds – i.e. KnowCat notes - in order to help their classmates to improve their written documents.

- We used a student-centred approach and goal orientation that focus on increasing learning, competence and performance as a tool to guide students toward the use of more self-regulatory processes. There is vast empirical evidence that confirms the role of goal orientation in promoting self-regulated learning (Pintrich, 2000).

- We combined face-to-face meetings (25% of course time) with asynchronous and virtual work (75% of course time). Two instructional objectives were achieved in face-to-face meetings both as master classes to teach specific course contents and as support classes to negotiate with students how to use the KnowCat features to reach the common learning objective set out at the beginning of the study, namely, help their fellow students improve their learning processes.

- The collaborative KnowCat system was also used in neatly-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 instructors 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 (document) about the topic and entered it into KnowCat. These reports contained a personal reflection on the content of the articles read, or suggested a personal solution to a specific problem; c) the students read a peer's report and annotated it –i.e. by giving assistance– in order to help a fellow classmate improve on it. For each individual topic, the students were asked to annotate a minimum of one classmate's report and write at least three notes (these three notes could be done on one or more documents). 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, d) the document's author read the notes concerning his report, taking into account his classmates scaffolds, re-wrote the report and entered it back into the system again, and finally e) the students voted for the best document on a topic.

4.3. Data analysis

Metacognition shares the properties of an event. An event spans in time and can be measured as an occurrence (Winne & Perry, 2000). Trace methodologies, which are observable indicators about cognition that students create as they engage in a task, are frequently used to evaluate this component of metacognition. In CSCL environments, one of the most common trace methodologies to analyse students' cognition while participating in a CSCL activity is the content analysis of the students' notes posted in the system (De Wever, Schellens, Valcke & Van Keer, 2006; Naidu & Järvelä, 2006).

In our study, a coding scheme was used to study possible changes in the notes and in the metacognitive processes required for the writing of these notes, from the beginning (first semester) to the end (second semester) of the learning project. The coding scheme was based on the metacognitive skills developed by Veldhuis-Diermanse (2002). This coding scheme analyses the regulation of group processes aimed at stimulating collaborative learning and establishes three categories of metacognitive skills:

- *Planning*, when students present or ask for an approach or procedure to carry out the task. This presentation is followed by an argumentation or an illustration.
- *Keeping clarity*, when students ask for an explanation, synthesis of information, clarification or illustration as a reaction to certain information of the document. They give an example and/or add a new point to a specific information
- *Monitoring*, when students monitor the original planning or aim. The students mention the work done by their classmates and propose how to improve on it. Either that, or when students reflect on their own actions or on certain contributions to the database.

The coding process consists of two steps: a) dividing the messages into meaningful units (Creswell, 1998) and, b) 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 & Lally, 2003).

Validity and reliability aspects were considered in the study. Two evaluators of our research group with experience in this type of coding participated in the segmentation and categorization process. In the first step, the two evaluators categorised 5% of the total notes separately. In order to develop the coding rules and achieve reliability, from those notes which the evaluators categorised differently, a common view was negotiated. In the second step, the two evaluators categorised 25% of the total notes separately. The Cohen's Kappa coefficient for both was as high as .87 (Lombard, Snyder-Duch & Campanella, 2005). The rest of the notes were coded by the two evaluators separately. We analysed the data with the help of nVivo software (Qualitative Solutions and Research, 2002).

4.4 Results and discussion

In this section, we analyse the development of the students' metacognitive skills with KnowCat. To this end, we carried out a detailed study on the content of the notes written by the students who participated in our study 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 both topics belong to a common discipline: Instructional Psychology, both shares the same pedagogical framework, 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 (Veldhuis-Diermanse, 2002). To be precise, we analysed 108 notes of the written notes in the first period and 87 in the second one. The number of meaningful units identified in the second semester was 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.

In our research we emphasized the use of the KnowCat notes as improved scaffolds among peers, and therefore in studying the students' metacognitive skills. Our main study focus was analysing external regulative learning which can help students 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.

When analysing the number of meaningful units referred to as metacognitive skills, we observed an increase of these skills in the second semester. Mean comparison test was run in SPSS software in order to analyse whether the improvement observed in metacognitive skills was statistically significant. Wilcoxon matched-pairs signed ranks test showed a statistically significant difference (95% significant level) between the metacognitive skills observed in the first and in the second semester of our study (n= 18, z = -2.46 p = 0.014). Table 1 presents the main descriptive statistics.

Table 1: Total frequencies of the different metacognitive skills, mean and standard deviation of the data in the two semesters

Metacognitive Categories	**1st Semester** n = 18			**2n Semester** n = 18			
	Total Frequency	Mean	Standard Deviation	Total Frequency	Mean	Standard Deviation	Wilcoxon Test
Planning	31	1.55	1.58	28	1.28	0.96	Z = - .466 p= .641
Keeping Clarity	3	0.17	0.38	17	0.89	1.13	Z = - 2.36 p= .018
Monitoring	4	0.17	0.38	23	1.28	0.75	Z = - 3.34 p= .001
Total Metacognitive Skils	**38**	**1.89**	**1.64**	**68**	**3.44**	**1.65**	**Z = -2.46 p=.014**

These results showed that metacognitive processes take place and increase in KnowCat collaborative learning project. Many studies report on how metacognition learning activities could be developed by means of a CSCL pedagogical environment (e.g., Järvelä & Niemivirta, 2001; Kreijns, Kirschner & Jochems, 2004; Hurme & Järvelä, 2005). In order to achieve an in-depth analysis into this area, our study pursues a detailed analysis of the characteristics of the metacognitive skills developed during the KnowCat collaborative learning project.

When analysing the results obtained by the students in the three subcategories of metacognitive skills, the data also showed differences between the two semesters. Though the activities related to planning the others' work ("Planning" category) were the most frequent in both semesters, this category decreased in the second semester and in contrast, in the second semester we observed a high increase in the "keeping clarity" and "monitoring" categories – see Figure 2.

[Here: Figure 2]

Figure 2: Percentage of each metacognitive learning processes in the two semesters of our study

Differences detected between the two semesters in the number of statements related to "planning" were not statistically significant by 95% ($z = -0.466$; $p = 0.641$). In the "Planning" category, students asked their classmates for a new approach or procedure to carry out the task or suggested their classmates a new approach or procedure to accomplish the task more effectively.

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 by 95% ($z = -2.360$; $p=0.018$). This category consisted in students both asking for a better content structure of their classmate's document and revising key points of their classmate's work. For example, encouraging the other to continue with his/her work, asking for explanations, clarification and illustration or formulating a key point.

Also in the second semester, our results showed a significant increase in those activities related to monitoring the others' and one's own work. Comparisons of the "monitoring" category between meaningful units written during the first and the second semester were statistically significant ($z = -3.337$; $p = 0.001$).

The results obtained in our study show that students increase the presence of metacognitive processes when working in the CSCL-Knowcat environment. While revising their own activity (write a document which describes adequately a specific topic with the help of interaction from peer documents and notes) in the collaborative learning environment, the students managed to monitor and supervise how their peers were working in the same task. From our point of view, these results give experimental evidence that KnowCat knowledge elements can support the development of metacognitive skills.

The increase in the number of metacognitive skills in students' active participation in networked learning –specially those processes that involve monitoring and controlling other's work- achieved in this study is a step forward in metacognitive research in that our results differ slightly from previous studies which reveal that there is a higher increase in metacognitive knowledge than in monitoring skills (Hurme & Järvelä, 2005).

Moreover, educational research has shown that one benefit of student's participation in a CSCL environment is the fact that it requires students to construct explanations which formulate their ideas or construct scaffolds which provide help to others during the collaborative task (Ploetzer, Dillenbourg, Preier & Traum, 1999). Different studies highlight the fact that among the main characteristics of effective scaffolds are those that foster good behaviour –giving examples, asking for clarity and explanations, encouraging thinking for oneself and helping in the transition from other- and self-regulation (Mercer & Fisher, 1998; Rogoff, 1990; Wersch, Minick & Arms, 1984). These features are included in the metacognitive skills developed by the students of our study because they improve significantly on “keeping clarity” and “monitoring” categories, in whose definition these features are included.

Furthermore, the results of the current study illustrate how the students' participation in the KnowCat instructional process might have an effect on the students' cognitive regulation particularly in planning actions and monitoring the learning processes. A growing body of research demonstrates the positive effects of CSCL on self-regulated learning. CSCL sets demands and provides unique tools for engaging in specific self-regulation processes and the positive incidence of these processes in the students’ learning results (Koschmann, Hall & Miyake, 2001; Paris & Paris, 2001; Salovaara, 2005). These effects are reinforced when collaborative learning is applied to open and well-defined complex tasks embedded in an authentic learning context –as we did in our study–**.** Solving these task types improves the effectiveness of social knowledge construction (Kreijns, Kirschner & Jochems, 2003).

Conclusions

In the next three sections we present the main conclusions of the research and related future work.

Strengths of the research and practical implications

In this paper we aimed at understanding the development of students’ metacognitive learning processes when participating actively in the CSCL system called KnowCat. In order to do so, our study applied the system to regular university courses during one academic year to develop teaching and learning processes in higher education. One of the main activities developed using KnowCat was to assist students’ construction of knowledge about a topic through reading and writing critical documents about specific topics. One of the main instructional objectives of the CSCL instructional process was to assist in developing high quality collaborative learning processes among equals. To reach this objective we made explicit use of the document annotation feature of KnowCat to improve assistance among peers.

The results presented in this study have corroborated that KnowCat can support the developing of metacognitive learning processes among peer interaction. From our point of view, the main design guidelines of KnowCat, which can be generalized to other CSCL systems, are:

a) Document-based collaboration: the KnowCat knowledge organisation into documents which are, in turn, organised in a table of contents has been useful as a mirror tool which provided students with different versions to solve the same task. Furthermore, the Knowledge Crystallisation mechanism controls the knowledge evolution and the quality of the knowledge elements in the communities' sites.

b) Opinion-based collaboration: the system supports different ways to express opinions from the users, specifically through votes and annotations. Empirical evidence has shown that the document's annotations improve task-related assistance among peers (content and strategies).

Limitations

It should be noted that the results of the current study are based on a limited number of subjects and therefore, the emphasis of the study is on qualitative findings. However, these results illustrate how the students' participation in CSCL-KnowCat instructional process might affect students' metacognitive learning processes.

The instructional process designed emphasised the students' competences related with analysis and review. These competences are explicitly included in Psychopedagogy studies. In order to generalise our results we are planning the instructional use of KnowCat in other educational contexts whose purpose is to learn contents of other disciplines in which analysis and review competences are not key but lateral issues.

Future research

In our study, the students' annotations were rather long; which means that each note included different ideas, explanations and suggestions. This makes it difficult for the reader of a note to extract all the knowledge included in a note aimed to improve on a document. In the study, the segmentation of the notes into meaningful units was an important and difficult task in order to extract all the knowledge of the notes for analysis purposes. From our point of view, it is convenient to assist users in creating shorter and more focused notes in order to help them use annotation options as interaction feedback strongly related to task solving processes.

To this end, we are planning to offer users the option of giving their opinion about a document with a new knowledge element categorized as "assessments". An assessment will represent a "weight assertion" and it could be comparable with a manually extracted meaningful unit. More specifically, an assessment will characterise a note by making its content more explicit both to the author's note and the annotated document author.

The results obtained in this study show that the students can benefit from knowing about others' learning processes. In other words, and as expounded by Gross, Stary & Totter (2005), members of work groups need information about one another, about shared elements, and about the group process (i.e. awareness of others).

We find it necessary to improve feedback of KnowCat in relation to interaction processes through graphical information capable to act as metacognitive mirror of interaction processes (Jermann & Dillenbourg, 2008). More specifically, we are considering an extension of KnowCat in order to provide its users at least the following awareness widgets (Gutwin & Greenberg, 1998): i) a radar view in the knowledge tree, which could give concrete information about where and what the on-line users are doing in the system, ii) detailed and structured action histories for the registered users, and iii) a graph which could show how the users annotate documents.

We are planning new research studies with students' groups from both universities: Universidad Autónoma de Madrid and Universitat de Lleida. In these studies the new knowledge element, “the assessments”, will come into play and we will study how they can help KnowCat users and in the Knowledge Crystallisation process supported by the system. Moreover, we foresee that the new awareness widgets will be available in ensuing research studies.

Acknowledgements

This research was partly funded by the Spanish National Plan of R+D, project numbers, SEJ2006-12110 and TIN2008-06596-C02-01; and by the AECID (Spanish Agency of International Cooperation for the Development) project number A/017436/08.

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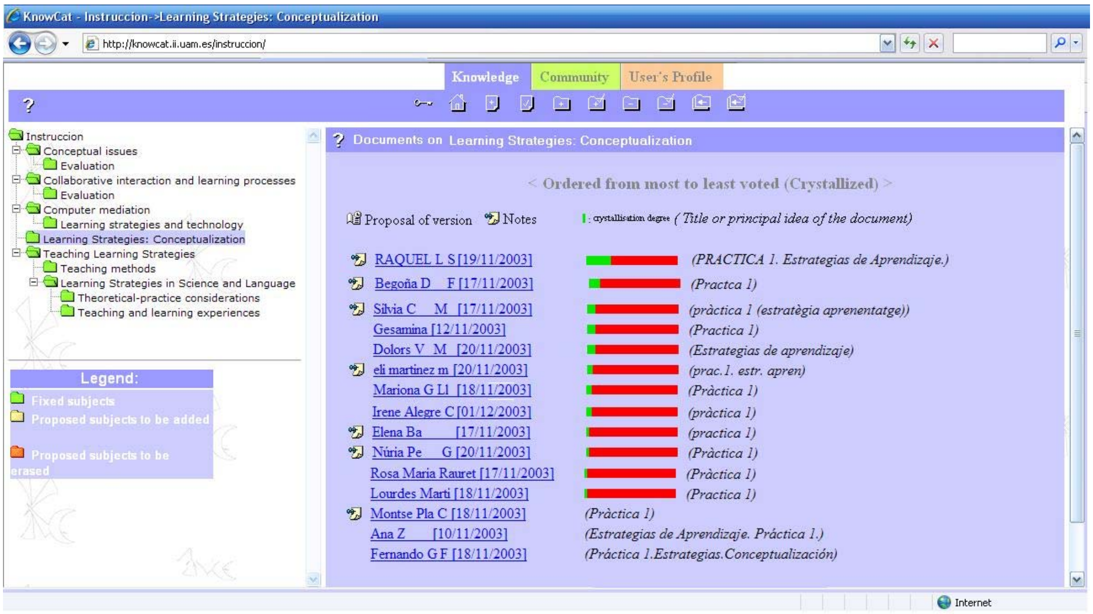

Figure 1. Example screenshot of the “Instruction” KnowCat site.

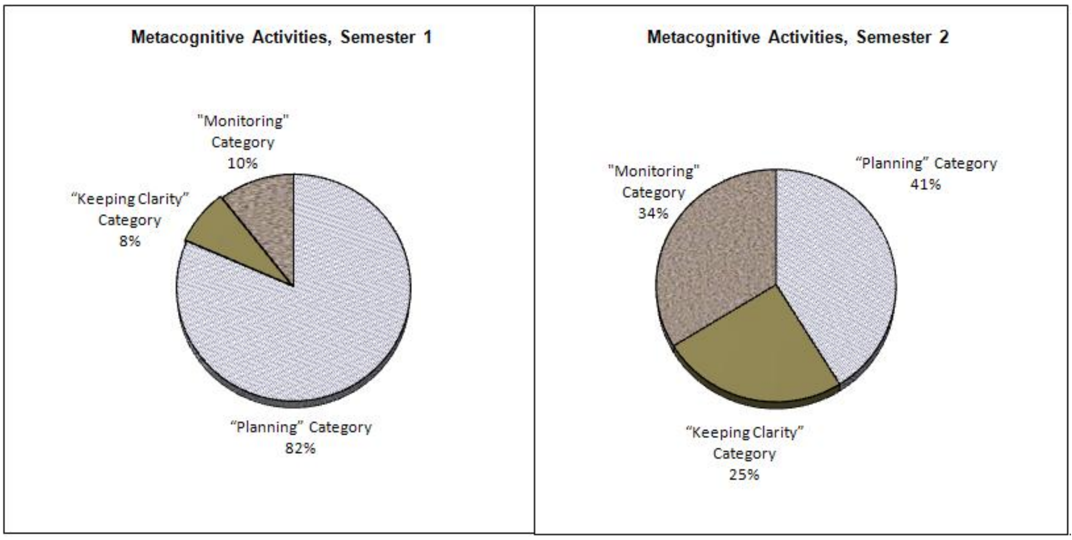

Figure 2. Percentage of each metacognitive learning processes in the two semesters of our study.