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Evaluation of the Development of Metacognitive Knowledge Supported by the KnowCat System[1]

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Abstract

The aim of this study was to examine the development of the metacognitive knowledge of a group of higher education students who participated actively in an experiment based on a Computer Supported Collaborative Learning environment called KnowCat. Eighteen university students participated in a 12-month learning project during which the KnowCat learning environment was used to support scaffolding process among equals during problem-solving tasks. After using KnowCat, the students were interviewed over their work in this shared workspace. Qualitative analysis revealed that the educational application of KnowCat can favour and improve the development of metacognitive knowledge.

Keywords

CSCL; Metacognitive Learning Processes; Knowledge Construction; Peer Interaction; Qualitative research.

Evaluation of the Development of Metacognitive Knowledge Supported by the KnowCat System

Metacognition is a complex psychological concept but most researchers agree that it consists of both metacognitive skills and metacognitive knowledge. Metacognitive skills concern the extent to which students can regulate their cognitive and affective learning activities and, therefore, their own learning; metacognitive skills are strongly related to task and context characteristics. On the other hand, 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 (Flavell, 1992). Therefore, metacognitive knowledge involves knowledge about cognition in general, as well as awareness of and knowledge about one's own cognition.

Educational researchers agree that metacognitive knowledge includes knowledge of strategy, task and person variables and interactions among these three variables (e.g. Flavell, 1992; Pintrich, Wolters, & Baxter, 2000; Weinstein & Mayer, 1986). A definition of each follows. Metacognitive knowledge of strategies consists of knowledge about cognitive strategies for enhancing learning and performance. This type of knowledge refers to the general strategies required in learning, thinking, and problem solving. These strategies are applicable across all or most academic disciplines or subject matter domains in contrast to strategies applicable to more specific disciplines or domains. Consequently, these strategies can be used across a large number of different tasks and domains, instead of being most useful for one particular type of task in one specific subject area (e.g., elaborating a conceptual map to gain thorough understanding of some information).

Students develop their knowledge of different learning and thinking strategies and their use. In other words, this knowledge reflects on the *what* (conceptual knowledge) and the *how* (procedural knowledge). However, this knowledge may not be sufficient if students were to prove their expertise in learning. Students must also develop some knowledge about the *when* and *why* (conditional knowledge) of using these strategies appropriately (Paris, Lipson, & Wixson, 1983). Since not all strategies are appropriate for all situations, the learner must develop some knowledge of the different conditions and tasks where the different strategies are most appropriately used.

Metacognitive knowledge about cognitive tasks refers to knowledge about learning. Hence, different types of tasks have different cognitive demands associated to them. For example, students may know that a recall task is more difficult than a recognition task and need to solve it by developing different learning and thinking strategies.

The third variable included in metacognitive knowledge is self-knowledge. Self-knowledge includes knowledge of one’s strengths and weaknesses. Pintrich, Wolters and Baxter (2000) argue that one of the hallmarks of experts is that they know when they do not know something and have to rely on some general strategies to find the appropriate information. This self-awareness of the breadth and depth of one's own knowledge basis is an important aspect of self-knowledge. Finally, individuals need to be aware of the different types of strategies they are likely to rely on in different situations.

These three variables of metacognitive knowledge –strategy, task and self-knowledge– do not operate in isolation whenever a subject solves a task. Knowledge about the ways in which the above-mentioned variables of metacognitive knowledge might interact with one another to influence the outcome of some cognitive performance is also necessary. These interactions have been articulated by a number of different authors (e.g. Brown, 1981; Pintrich & DeGroot, 1990; Meijer, Veenman & Van Hout Wolters, 2006).

More recently, educational research on this topic emphasizes the role of social aspects in the development of metacognitive learning processes. Socio-cognitive perspectives have allowed researchers to both expand on the theories of metacognitive processes and view metacognition not only as an individual’s activity, but also as an essential part of socially shared discussions (Goos, Gailbraith, & Renshaw, 2002). The others have given a central role to metacognition and suggest that it appears to be part of the collaborative learning situation where metacognition regulation is considered also as a group level activity rather than only as an individual's performance (Zimmerman, 2000). Social environment is viewed by social cognitive researchers as a resource to self-enhance forethought, performance or volitional control and self-reflection.

Expanding on these ideas, some research hypothesizes that in Computer-Supported Collaborative Learning –henceforth, CSCL–there are metacognitive processes which can be stimulated by others (Hurme, Palonen, & Järvelä, 2006). This research shows that CSCL enables students to either see online fellows' solutions and provide them with specific widgets for explicit assistance to improve on task- and process-solving or discuss online how to solve the task. In addition, learning in a hypermedia environment requires from the learner to regulate his or her own learning in order to construct higher and deeper levels of knowledge; that is, to make decisions about what, how and how much to learn, how much time to spend on it, how to access other educational materials, to realise whether he or she understands the material, how to modify plans and strategies to learn better and when to increase one's effort (Azevedo, Moos, Greene, Winters, & Cromley, 2008).

In this line of work, several studies have reported on how metacognition learning activities could be developed by means of a CSCL pedagogical environment (e.g., Hurme & Järvelä, 2005; Järvelä & Niemivirta, 2001; Kreijns, Kirschner, & Jochems, 2004; Newman, Johnson, Web & Cochrane, 1999; Scardamalia & Bereiter, 1994; Veldhuis-Diermanse, 2002).

Following these arguments, the present study hypothesizes that students could benefit from utilizing networked technology because they are using their own metacognitive knowledge and their own metacognitive skills more actively in task-solving and also because metacognitive skills are more visible to the other members of the CSCL community, who can make suggestions and provide assistance to improve on them.

The aim of the present study is to analyse the development of metacognitive knowledge in a collaborative framework supported by a specific CSCL environment called KnowCat in a group of higher education students. The study strives to give an answer to the following two research questions:

Firstly, how were students aware of their own and others' learning processes developed when participating in the KnowCat educational environment?

Secondly, which KnowCat knowledge elements have more incidence in the students' awareness of the development of specific learning processes?

The KnowCat System

KnowCat (an acronym for *Knowledge Catalyser)* was developed at the Universidad Autónoma de Madrid (Spain). The main aim of this system was to generate quality educational materials as the automatic result ensuing from the students' interaction with the materials (Alamán & Cobos, 1999; Cobos, 2003). More specifically, the system is based on a mechanism called *Knowledge Crystallisation*, which gives us evidence of the best contributions in the users' opinion through their interaction with the system.

KnowCat is in active use and has been tested and validated in several research studies at both Universidad Autónoma de Madrid (Spain) and the Universitat de Lleida (Spain). These studies corroborate that KnowCat enhances metacognitive activities by improving the development of high quality collaborative learning processes among equals (Alamán & Cobos, 1999; Cobos, 2003; Cobos & Pifarré, 2008; Díez & Cobos, 2007; Gómez, Gutiérrez, Cobos, & Alamán, 2001). In the research study presented in this paper, we are interested in analysing in depth *how* the different KnowCat knowledge elements support the students' development of metacognitive knowledge.

KnowCat facilitates the construction of community knowledge sites accessed through a specific URL using a Web browser known as *KnowCat sites* or *KnowCat nodes.* Each knowledge site is divided into three workspaces: i) community knowledge workspace, which displays the knowledge elements contributed by the users; ii) communication community workspace, which supports communication among the users through e-mail lists; and iii) personal user workspace as a workspace in which each user can see his/her own contributions to the knowledge site and can receive information about the interactions of other users related to his/her contributions.

More specifically, community knowledge (obtained in the community knowledge workspace) is organised around several knowledge elements. Firstly, the knowledge tree, which is a hierarchical structure of topics, displays the organisation of the knowledge site in several topics.

Secondly, each topic contains a set of users' documents that describe the topic. At any given time, all documents contained in the same topic compete with each other to be considered as the best description of the topic. This competitive environment is achieved by the Knowledge Crystallisation mechanism of KnowCat, which is supported by virtual communities of users (see further details below). At any time, the author of a document can add a new version of his/her document.

Thirdly, each document can receive annotations –or notes, for short–. A note is a review on the information presented in a document. The note format is free; however each note has a type that describes its purpose. The note types are the following: a) 'clarification' notes: to clarify some parts of the document; b) 'support' notes: to express agreement with the document; and c) 'review' notes: to make suggestions about adding, removing, changing some parts of the document, or making comments on it.

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.

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, that is, the votes received, how these votes were received, the notes received with their respective types (see the descriptions of votes and notes below); and the implicitly received opinions regarding access to the document.

Figure 1 displays an example screenshot of the community knowledge workspace of the *Psychopedagogy Intervention* KnowCat site.

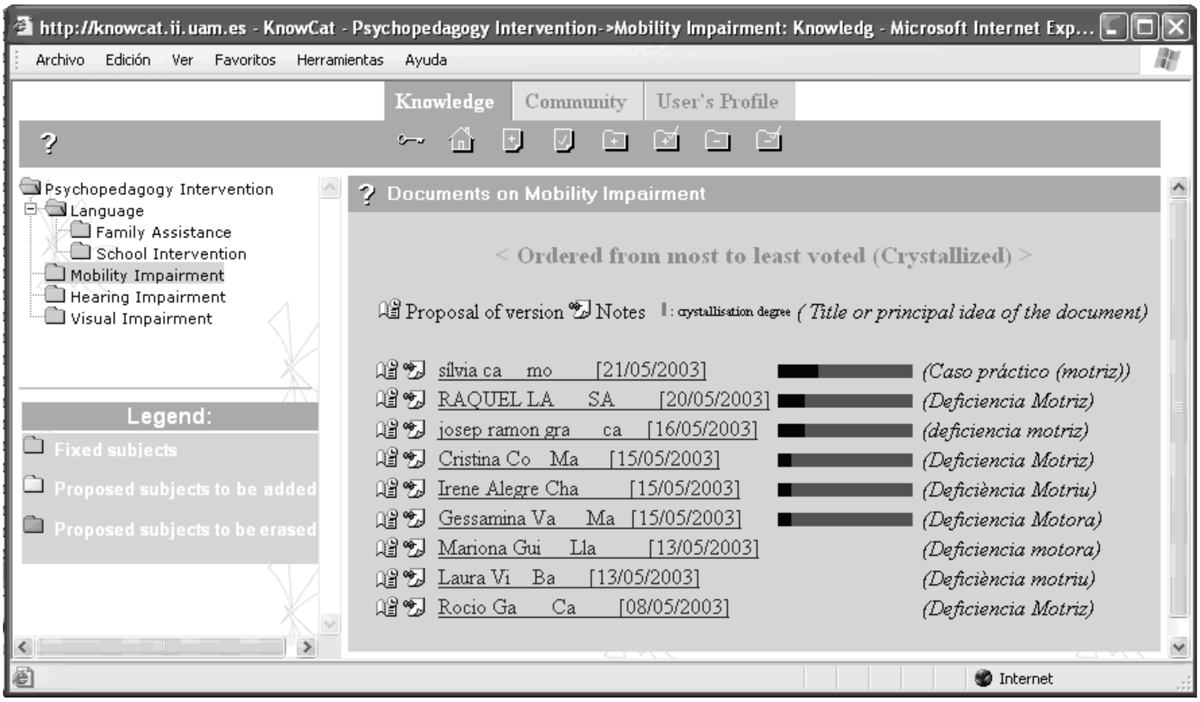

Figure 1. Example screenshot of the *Psychopedagogy Intervention* KnowCat node.

The main operations supported by KnowCat are:

a) Modifying the knowledge tree.

Users can collaborate in the collaborative construction of the knowledge tree. They can suggest adding, deleting or modifying topics of the knowledge tree.

b) Adding a new document to a selected topic.

The user contributes with a document (normally a Web page located in a Web server) related to a specific topic of the knowledge tree. From this moment on, the document can receive votes from other users, notes (normally from other users) and a revised version from the original author. As seen in Figure 1, the documents are identified by the author's name, arrival date and title. They are sorted according to their degree of acceptance, which is shown to the right of the identification heading of each document (the black-grey bar). On the left of the identification heading of each document are the icons indicating whether a document has received notes and whether a new version of the document is available. For example, the document identified by "silvia ca mo … [21/05/2003] (Caso práctico (motriz) [Practical case (mobility)])" shows the highest degree of acceptance in the topic called "Mobility Impairment", and this document has received notes and a new proposal of a document version –shown by means of icons.

c) Displaying the content of a document.

A user can display the content of a document by clicking on its identification. The document is then displayed on the right half of the screen.

d) Voting a document.

A user can express with a vote his/her degree of agreement with a document. There are two types of voting mechanisms available in KnowCat: i) a value from a range (1-5, with 1 representing the lowest value and 5 the highest) and ii) with the single value "1" to denote agreement with the document. The latter is by far the most popular voting mechanism in the system and has been validated as the most useful way of expressing agreement with a document.

e) Adding an annotation to a document.

A user contributes a note to a document in order to make suggestions and/or give comments or opinions. In our study, we use these notes as explicit scaffolding messages –i.e. the assistance mentioned above.

f) Displaying the content of a note.

When the content of a document is displayed, it is possible to access the list of its received notes on the left half of the screen.

g) 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. This operation is available as a sub-case of the ’Adding document’ operation.

h) Displaying the content of a new document version.

Once a new version of the content of a document is displayed, it is possible for users to select to display the new version.

Research Methodology

This case study was conducted in an authentic university class environment. Its main purposes were i) to study the collaborative learning processes evolved by students over a twelve-month CSCL project and ii) to analyse the metacognitive knowledge variables developed by them.

Previous CSCL research revisions highlight the suitability of case study methodology to understand the complex factors influencing computer-mediated collaborative learning in educational contexts (Schrire, 2006; Stahl, Koschmann, & Suthers, 2006).

Participants

Eighteen university students participated in the research. They used the CSCL-based environment KnowCat during two terms in the context of three regular university courses of the Psychopaedagogy degree. Each course had a duration of 12 weeks (4.5 hours per week).

Intervention: Main pedagogical characteristics of the CSCL educational context

In order to assist the students in constructing knowledge collaboratively with KnowCat, specifically KnowCat notes as improved scaffolds that could help their classmates to improve their documents, we designed a specific educational process with the following three pedagogical prerequisites (Arvaja, Häkkinen, Eteläpelto, & Rasku-Puttone, 2000; Dillenbourg, 2002):

- Firstly, we used a student-centred approach (as opposed to a master class approach). Students actively participated in all the activities. We combined face-to-face meetings with asynchronous and virtual work.
- Secondly, 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 instructors and students.
- Thirdly, the main procedure of the students' work with the CSCL system was as follows: a) individually, students had to read some information about a specific topic course; b) next, they 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) then, the students had to read a peer's report and annotate it –i.e. by giving assistance– in order to help a fellow classmate improve on it. For each individual topic, students had to annotate a minimum of one classmate's report and write at least three notes (these three notes could be done to one or more documents). During the study, students were strongly encouraged to annotate the reports of different classmates. Despite this recommendation, the students' documents received an irregular number of annotations, but none of the students' documents received less than three notes and, finally, d) the document's author had to read the notes concerning his/her own report, taking into account the classmates' scaffolds, then re-wrote his/her own document and submitted it back into the system.

Data Analysis

The study used a structured interview in order to analyse the students' metacognitive knowledge after participating in the KnowCat educational environment. At the end of the year, a structured interview protocol was designed to find out what knowledge students' had attained by using the KnowCat system as a collaborative learning tool. The students were interviewed individually by one researcher of our group according to the protocol, and each interview lasted about thirty minutes. The questions of the interview aimed to facilitate the students' description of their learning processes and contextual interpretations during the learning tasks and were related to their interactions to the KnowCat knowledge elements, as follows:

Documents

We aimed to study which learning processes the students were conscious of when they read a fellow's report meant to help them improve their document. Some examples of the questions asked are: KnowCat allows you to read your classmates' documents, what do you think about it? Have you learnt something in reading your classmates' documents? What have you learnt in reading your classmates' documents?

Notes

As regards *sent* (writing) and *received* (reading) notes, we were interested in finding out whether students were conscious of the learning processes carried out during the process of writing and reading notes with the grounded objective of helping a fellow improve on his/her report and the procedures to write it. Questions asked included: KnowCat allows you to annotate your classmates' documents, what note types did you write? Have you learnt anything by annotating your classmates' documents?

In each question, the students were asked to provide reasons for their opinions and to describe possible specific events that illustrated their answers.

To enable coding and analysing, the interviews were transcribed word by word. The analysis of these interviews followed the principles of qualitative content analysis (Chi, 1997; Creswell, 1998). A unit of analysis was defined as a meaningful statement or chunk of text whose content focuses on the evaluation of the student's own knowledge or others' knowledge as regards both their interactions to the knowledge elements supported by KnowCat and their learning processes developed during the learning tasks.

Meaningful statements were categorised and analysed as metacognitive knowledge. Our coding scheme was based on the classical classification of metacognitive knowledge considered as a static and stable component of metacognition, that is: a) knowledge of cognitive strategies broken down into three categories: declarative, procedural and conditional knowledge, b) knowledge of task and context and c) knowledge of one's own self-knowledge broken down into two categories: intra-individual and inter-individual differences (Flavell, 1992). Below there is a definition of each individual category.

a) Knowledge of cognitive strategies was broken down into the next three subcategories:

- *Declarative knowledge of cognitive strategies* were identified as the kind of strategies an individual used in order to solve the task of writing a report about a topic taking into account others' opinions. Also, in this category we aimed to know what strategies students learned after their interaction with KnowCat knowledge elements –documents and notes.

- *Procedural knowledge of cognitive strategies* was identified as the knowledge of which strategy to use and how to use it.
- *Conditional knowledge of cognitive strategies* referred to knowing why and when to use different strategies effectively. In this category, we aimed to find out how students adjust their strategies in order to solve the task efficiently and how this adjustment was caused by their interaction with KnowCat knowledge elements.

Furthermore, this category also included explicit statements on monitoring of learning processes, for example: statements referring to why something is wrong and why it must be improved as well as how it can be improved considering the specific characteristics of the task and the context.

b) Knowledge of task and context category included students' knowledge of the task and how it can influence their cognition.

This category includes those students' statements referring to how specific elements and actions are done in the KnowCat system and how the specific characteristics of task resolution have an influence on their cognition.

c) Knowledge of self was broken down into two subcategories:

- *Intra-individual knowledge*: This category includes judgments related to: the students' strengths and weaknesses to solve the task; the students' capability to perform the task (self-efficacy), their goals for completing the task successfully (learning or just getting a good grade), and the interest and value attributed to each task (high/low interest and high/low value)
- *Inter-individual knowledge difference*: This category includes statements regarding knowledge of other students' strengths and weaknesses and other aspects of knowledge such as self-efficacy and motivation.

Validity and reliability aspects were considered in the study. Two evaluators of our research group experienced in this type of coding scheme participated in the segmentation and categorization process. Both evaluators categorised 22% of the total interviews separately. The Cohen's Kappa coefficient between them was as high as .82 (Lombard, Snyder-Duch, & Campanella, 2005). The rest of the interviews were coded by the two evaluators separately.

Results and Discussion

The interviewer asked students to describe their learning processes and contextual interpretations of their interactions to the content of the two main KnowCat knowledge elements: interactions with the documents (access to others' documents and document versions) and interactions with the notes (*sent* and *received* notes). Table 1 presents the number (and percentage) of metacognitive knowledge results related to these two main KnowCat knowledge elements and the total metacognitive knowledge statements.

Table 1. Detailed number (and percentage) of students statements related to metacognitive knowledge when interacting with Documents and Notes (the two main knowledge elements) of KnowCat

	Metacognitive Knowledge Categories	**Documents**	**Notes**	**Total**
Knowledge Cognitive Strategies	Declarative knowledge of cognitive strategies	5 (4.5%)	18 (23.4%)	23 (12.2%)
	Procedural knowledge of cognitive strategies	33 (29.5%)	9 (11.7%)	42 (22.2%)
	Conditional knowledge of cognitive strategies	24 (21.4%)	35 (45.5%)	59 (31.2%)
Knowledge Task-Context	Knowledge of task and context	29 (25.9%)	0	29 (15.3%)
Knowledge Self	Knowledge of self: Intra-Individual	5 (4.5%)	5 (6.5%)	10 (5.3%)
	Knowledge of self: Inter-Individual	16 (14.3%)	10 (13%)	26 (13.8%)

Metacognitive knowledge about users' interactions with documents

The objective of this section of the interview was to know what learning processes students were aware of when they interacted with different documents related to the same topic in the KnowCat system (see Figure 1).

When analysing the number of metacognitive knowledge statements of each category, we found that statements related to knowledge of cognitive strategies were the most frequent ones. Students were aware that their interaction with classmates' documents increased and helped them improve their cognitive strategies to solve the task. Most of the students' statements were related to learning new strategies to manage and organise information –procedural knowledge of cognitive strategies subcategory– and knowing why and when to use these strategies effectively –conditional knowledge of cognitive strategies subcategory.

The interview data show that interactions of students with their classmates' documents encourage them to compare their own cognitive strategies to solve the task with the others'. From our point of view, the interaction with KnowCat documents, with the common learning objective to improve one's own and the others' learning processes, provided feedback to solve specific problems. Classmates' documents acted as a mirroring tool (Jermann & Dillenbourg, 2008) which provided students with different versions to solve the task. In our opinion, this problem-solving feedback has had a positive incidence in raising awareness of students' learning new cognitive strategies to solve the task and in deliberately using these strategies. This result is similar to that obtained in a previous study carried out with students enrolled in an Artificial Intelligence course at UAM (Díez & Cobos, 2007). Those students used KnowCat for one year and created collaborative documents about theoretical parts of Artificial Intelligence. During the course, students interacted with documents, notes and votes. At the end of the course, students admitted in a survey that reading and interacting with the documents of their classmates was of assistance to them.

There is agreement among educational researchers that the deliberate use of learning strategies (strategic use) can empower learning (Bransford, Brown & Cocking, 1999). Strategic learners are aware of different types of strategies and of how and when to use them to solve specific learning tasks (Pintrich & De Groot, 1990). This awareness can 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).

Our results also show that students are aware of how the characteristics of the KnowCat educational process had a strong incidence in their cognition –metacognitive knowledge of task and context category. As many as 25.9% of the students' metacognitive statements reported that the interaction with the KnowCat system involved high cognitive effort and resulted in the development of high cognitive strategies. Among these strategies, students highlighted monitoring and self-regulation processes. These results also revealed that our study designed a computer-supported collaborative learning environment capable of activating the students' self-regulation processes, and that the KnowCat "document" knowledge element assisted students in developing cognitive self-regulation and strategic activities (Pifarré & Cobos, 2008).

Particularly interesting is the students' awareness of inter-individual differences in solving the task. 14.3 % of the students' metacognitive statements reported that the interaction with KnowCat made them more aware of how different people can solve the same task. In the interview students reported awareness that fellow students used different strategies, understood different ideas about the same topic and showed different ways of interacting with KnowCat. Likewise, students reported how this diversity in solving the task helped them improve their own strategies and learn new ones. A number of educational researchers have concluded that the emergence of a social space is a positive indicator for the establishment of a learning community, which affects the degree of social interaction in CSCL environments (Gunawardena, 1995; Tu & Isaacs, 2002). Kreijns, Kirschner and Jochems (2003) have confirmed that this social dimension of learning interaction is necessary to achieve the cognitive goals of collaborative learning. In order to accomplish collaborative learning, students should develop individuating impressions of their fellows, i.e. “getting to know the other” enhances the construction of community building, which, in turn, reinforces social interaction and collaborative learning.

Metacognitive knowledge about user’s interactions to the content of notes

One of the main operations available to users of the KnowCat system to build up knowledge collaboratively was note contribution. In our work, students received their fellows’ opinion about how they solved the different learning activities through notes. Our educational approach emphasized the use of KnowCat note knowledge element as explicit external scaffolding among equals. Thus, we were especially interested in the students’ awareness of the metacognitive learning processes gained from note contribution.

Our results revealed a high level of awareness that students received through note contribution as it proved to be a unique opportunity to monitor and regulate their cognitive strategies to solve the task. As many as 45.5% (see Table 1) of the students’ metacognitive statements referring to note contributions were categorised as *conditional knowledge of cognitive strategies* category. On the one hand, this category included statements referring to how note contributions from others helped students diagnose errors and become aware of essential information that was missing. On the other hand, this category reported statements referring to how note contribution helped students improve the document as regards quantity and quality of ideas about the topic. Besides, many students emphasized that note contribution promoted the use of deeper-processing strategies that improved the organisation of ideas and the relationship between concepts.

These results show evidence that the KnowCat note knowledge element was helpful in assisting students develop constituent components of metacognition: i.e. planning, monitoring, evaluating and revising their learning activities to solve the tasks efficiently (Brown, 1981).

Students highlighted that note contribution encouraged them to develop critical processes about task solving and evaluate which efficient strategies could be used to reach learning objectives. The interview data show that the annotation knowledge elements of KnowCat acted as an interactive feedback strongly related to the task. Zummback, Hillers and Reimann (2004) conclude that both interactive feedback and problem-solving feedback can lead to a higher degree of reflection on the best strategies to solve a task and how to use them.

Finally, we want to highlight the students' awareness of their fellow's thoughts and emotions when they wrote a note (13% of metacognitive knowledge of self: Inter-individual –see Table 1). The students´ statements revealed that when they wrote a review, they took into account what the other might need to improve his/her document and what emotional reaction those notes could involve. Many studies have related how affective learning activities are of importance to the extent to which, and how, students develop learning activities (Vermunt, 1998; Kreijns, Kirschner, & Jochems, 2004).

Conclusions

In this paper, we have analysed the development of metacognitive knowledge in a computer supported collaborative learning environment. In order to do so, our study applied the CSCL-based KnowCat system to regular university courses during a single academic year with a view to developing regular and authentic higher education activities: writing documents about specific topics and solving practical cases. One of the main educational objectives of the courses was to make explicit use of the document annotation option of KnowCat as improved assistance among peers.

The results of the research study showed that the educational application of KnowCat can favour and improve the students' metacognitive knowledge. The content analysis of the students' interviews revealed the existence of metacognitive knowledge regarding the learning processes that students develop while interacting with KnowCat knowledge elements. Students showed high levels of consciousness about learning new strategies and about the conditional use of these strategies to solve specific tasks efficiently.

The findings of our work suggest that self-regulated strategic activity is shaped when students interact with CSCL-Knowcat and that specific metacognitive learning processes are developed by them. These metacognitive learning activities help promote deeper learning, i.e. they improve the students' intention to comprehend their learning material, interact critically with the learning context, logical thinking, create new ideas, debate and argue subjects, share knowledge and elaborate on each others' ideas and results.

However, although it is true that students developed higher-order cognitive processes that could, in turn, lead to better learning, educational research also highlights that these beneficial effects on learning are not straightforward and do not happen every time. Further research on this direction should be done. Therefore, the importance of metacognitive skills in CSCL learning environments demands closer attention with respect to defining the instructional characteristics of the stimulating features of the CSCL environment to develop metacognitive skills.

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