Collaborative Concept Mapping Activities in a Classroom Scenario

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Abstract

The aim of this study is to test collaborative concept mapping activities using computers in a classroom scenario and to evaluate the possibilities that Elkar-CM offers for collaboratively learning non-technical topics. Elkar-CM is a multilingual and multimedia software program designed for drawing concept maps collaboratively. Concept mapping is a widely accepted technique that promotes meaningful learning. Graphically representing concepts of the learning domain and relationships between them helps students integrate new knowledge into their current cognitive structure. This study was carried out with Social Education degree students at the University of the Basque Country (UPV/EHU). The experiment included two learning activities. First, all students collaboratively constructed in the classroom a CM on the subject of *Moral Development*. Second, students were organised into groups to complete the CM generated in the first part.

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1.- Introduction

Since human beings are born they are engaged, consciously or unconsciously, in a constant learning process. Some kinds of learning happen naturally in everyday human life without the direct intervention of external agents. Others are more effective if they have the support of external agents such as teachers or automatic educational programs. It is necessary to involve the learners in a set of mental activities or cognitive processes that can help them to manipulate and transform new information into knowledge using the knowledge they already have.

Concept mapping is the process of constructing concept maps. Although originally concept mapping was defined as a method to graphically represent knowledge and information, it has become a useful teaching and learning tool. A *Concept Map* is a graphical way of representing and organising knowledge (Novak, 1977). It is comprised of nodes and links, arranged in a certain order to reflect the domain information being represented. Nodes symbolize concepts, and links represent relationships between concepts. Both nodes and links are labelled and may be categorised. Constructing Concept Maps (CMs) gives learners improved confidence of the content – it is easier to incorporate information into their knowledge frame (Jonassen, 1997). The concepts and their relationships can be seen as "visual languages" (Hermann *et al.,* 2003) used to define palettes adapted to the learning domain. The use of CMs allows the learner to abstract important information, relate ideas, and represent them in a structured manner.

The fundamentals of concept mapping are in Ausubel's learning theory (Ausubel, 1968): meaningful learning refers to the learning of ideas, concepts, and principles by relating new information to knowledge in memory (Ausubel, 1977). Novak and Cañas (2008) pointed out that one of the reasons concept mapping is so powerful for promoting meaningful learning is that it serves as a kind of template or scaffold that helps organize and structure knowledge

The main goal of this study is to test collaborative concept mapping activities using computers in a classroom scenario, and to evaluate the possibilities that Elkar-CM, a collaborative Concept Map editor, offers for collaboratively learning. More precisely, the study is aimed at checking the effects of computer mediated collaborative concept mapping activities on the learning of a subject and on the concept mapping ability itself. In this paper two experiences carried out with Elkar-CM are presented. The first one deals with the collaborative construction of a CM about Moral Development in a classroom environment (the map was produced by the class as a whole). In the second one, students were organized into groups and each group completed or adapted the CM generated in the first experiment.

The paper is structured as follows: First, some attempts or experiences carried out to construct CMs collaboratively are presented. Next, the main characteristics of Elkar-CM are reviewed, followed by the design issues and procedure of the experiences carried out. Then, the results of the study are analyzed and discussed. Finally, conclusions and suggestions for future research are presented.

2.- Collaborative Concept Mapping

Although most of the literature about the use of concept maps in the educational area refer to the use of concept maps by individual students, some attempts to construct concept maps collaboratively have already been carried out. In fact, Khamesan & Hammond (2004) argue that one of the most promising uses of concept maps is its integration into collaborative learning activities (Koschmann, 1996). Gao *et al.* (2007) includes a review of studies published after 1990s in which collaborative concept mapping was used mainly as an instructional strategy. Later, Lupion & de Cássia (2010) presents a survey on the use of concept mapping tools to facilitate collaborative learning in several contexts: e-learning, face-to-face learning, and pre-school, primary and secondary schools.

In individual concept mapping, when making the implicit ideas explicit learners are communicating constantly with themselves and are engaged in a transformative process. This transformative process is more intensive when concept mapping is employed in collaborative learning situations, and multiple instances of presenting and interpreting ideas must occur before ideas are communicated and understood within the group (Gao *et al.,* 2007). Conceptual representations could more effectively support collaborative knowledge construction than threaded discussions (Suthers et al., 2007), specially in online learning situations. CMs are informal and informality allows organizational variations (Marshall *et al.,* 2006). Interaction and communication between group members not only helps to develop the reconstruction of individual's understanding but it also provides some practice in important interpersonal reasoning skills (Barros & Verdejo, 1998).

Kwon and Cifuentes (2009) investigated the comparative effects of individually and collaboratively constructed computer-based CMs on middle school science concept learning. One hundred and sixty one students organised in three groups participated in the study: 40 students were not trained in concept mapping, 59 students were trained to individually construct concept maps using computers, and 62 students (31 pairs) were trained to collaboratively construct concept maps using computers. Two results are relevant: (1) collaboratively and individually constructing concept maps had equally positive effects on concept learning and (2) students who collaboratively constructed concept maps created significantly higher quality concept maps than those who did the work individually.

Concept mapping and collaborative learning techniques complement one another (Simone et al., 2001). While concept mapping aids in the external representation of ideas, collaborative learning, with its emphasis on dialogue and discussion, furthers the elaborations of these externalizations so ideas can be shared. Learning environments are most effective when learners are actively involved in constructing their own meanings and doing so within authentic learning situations (Brown et al., 1989). Even more, motivation is likely to be highest when students work collaboratively (Westwood, 2004).

Another noteworthy aspect of concept maps is that they allow the reusing and sharing of models between groups, as part of the collaborative process (Hoppe, 2002), thus being as a mechanism for social knowledge building (Stahl, 2000). For this purpose, multilingual facilities are useful because the students can interchange their results independently of the language used to write the content of the concept map.

Gao et al. (2007) and Suthers & Jones (1997) pointed out the necessity of developing collaborative tools that would provide something more than a primitive support. For example, Martínez *et al.* (2010) presents Cmate, a new way to support collaborative learning using a tabletop. Users create a multi-layer CM, with a separate layer for each individual and one for the collaborative map that represents the propositions that all the users agreed on. Cañas *et al.* (2010) presents LiveMappers.net, a learning environment that supports collaborative concept map-based projects among schools. Although some CM software provides the environment and tools for collaborative construction of CMs they usually does not include the complete environment necessary for collaborative projects, particularly when the projects include thousands of teachers and students participating in collaborative projects.

In general, collaborative learning approaches focus more on the process of how activities are carried out than on the result (Koper, 2004). So, it seems that the tendency is changing. In this field, several efforts have been made to represent and study the collaborative learning process, both quantitatively and qualitatively. Some modelling and concept mapping tools save a log of the steps to the solution – CoolModes (Pinkwart, 2003), Belbedere (Suthers & Jones, 1997) – that allows the representation, relay and analysis of the collaborative process with different criteria or Modelling Space (Avouris et al., 2004). In this way, Martinez *et al.* (2011) proposes a set of visualisations mechanisms which aim to give teachers insights into longitudinal participation of each group member in a collaborative process.

Kim et al. (2005) find in the research literature three ways of creating collaboratively a concept map: F2F computer-mediated, synchronous networked and asynchronous networked. While most F2F research was conducted in real-life classrooms situations, almost all studies of networked were conducted in laboratory settings were students were divided into small groups, and required to construct a concept map collaboratively only by communicating through networked computers within a set time. For example, the results obtained by Layne *et al.* (2010) indicate that CMs are a practical and effective strategy to help distance learners communicate and collaborate in order to solve problems in online courses.

Together with the efforts in the educational area, one of the most promising research field of collaborative CMs is to investigate the collaborative development of ontologies and their use in processes of collaborative learning and knowledge generation (Allert et al., 2006; Gangemi *et al.,* 2007; Soares and Sousa, 2008; Chitra and Aghila, 2011).

3.- Elkar-CM

Elkar-CM (Arellano *et al.,* 2006) is a multilingual collaborative CM editor that allows synchronous collaboration based on token-passing. Figure 1 shows the edition window of Elkar-CM where users can draw the CMs. The window shown in figure 2 groups the collaboration management functions: at the top of this window the user can ask/release the token; in the middle the connected users are displayed and at the bottom (communication messages) the chat service is shown.

As most of the CM editors, the tool used in this study allows the user to draw multilayered CMs – CMs whose nodes and links can have attached other CMs – and multimedia CMs. The nodes and relationships in a CM can have hyperlinks attached to other CMs or to external files, for example images, videos, text files, etc. The interface of the tool offers the possibility of working with different views of the same CM. All the views share the same structure, i.e. the same nodes and relationships.

However, each view can have its own way of representing nodes and relationships. In addition, Elkar-CM, like CMapTools and SMART Ideas™, is able to record the stages during the development of a CM. This feature allows the users to replay the evolution of the CM development using video-like buttons. Elkar-CM has been designed following the internationalization-localization guidelines. The tool can be localized not only at interface level but also regarding the final CMs it generates. With this feature multilingual CMs can be drawn using the view mechanism. This treatment of multilingualism represents an innovation in CM editors and it is a step ahead in the path set by Stahl (2000). A detailed comparison between CM editors can be found in (Rueda, 2009).

Elkar-CM follows the client/server architecture (figure 3). In the architecture there are two kinds of clients: the application for building CMs collaboratively and the application for managing the Server. It uses synchronous collaboration based on token-passing. Several users can be working at the same time looking at the current state of the CM but only one at a time can perform operations in the CM. When the user wants to work on the CM s/he must require the token and, if it is taken, the request is queued. Once the user gets the token s/he has a limited time (a configurable parameter) to work on the CM. The system notifies the user before passing the token to the next user. Nevertheless, the user can leave the token before the time expires.

Elkar-CM is aimed at two types of users: the system administrator and the author of CMs. Authors can have two roles depending on their responsibility with the CM. Each CM has a supervisor and a group of authors that collaborate on its development. The supervisor of the concept map manages the group of people that collaborate in the development of the CM. Each author is the supervisor of the CM s/he creates.

When talking about collaboration and knowledge sharing, a key issue is the communication process among the community of authors. Elkar-CM provides two ways of facilitating this communication. The users can interchange ideas through the chat utility and they can also use the flags and notes area to annotate the nodes and relationships of the CM. The chat is synchronised with the actions performed by the users and it is also included in the log (see figure 4), so the user can replay the development of the CM together with the communication maintained between the authors. The log stores the information about the actions performed, including the user, length of time and type of action, and also the interventions on the chat performed by the users. Using the logs the collaborative process of constructing the CM can be reproduced in the tool including the conversation that took place.

4.- Study

In this section the design, participants, instructional material, learning resources and procedure of the study are described.

4.1 Design

This study took place during the second term of 2008/2009 course in the compulsory *Educational Psychology* subject of the Social Education degree at the University of the Basque Country UPV/EHU. Within the subject, *Moral Development* (Etxeberria, 2000) was the topic chosen to work with Elkar-CM. The aim of the study was to test collaborative concept mapping activities in a classroom scenario and to evaluate the possibilities that Elkar-CM offers for learning non-technical topics in collaborative activities. The experiment was composed of two parts. First, all students collaboratively constructed in the classroom a CM on the subject of *Moral Development*. Second, students were organised into groups to complete the CM generated in the first part.

4.2 Participants

The whole group of students enrolled in the subject (95 students) was invited to participate in the study. In the end a group of 42 students took part in the first part of the experiment and 49 students in the second part. Regarding gender, there was a majority of women in all cases: total number of students enrolled (79.2%), students who participated in the study (76%), and students who did not (82.6%).

Some of the students had participated the previous year in another experiment drawing CMs (Rueda *et al.*, 2009) where they used a different version of the software CM-ED to draw CMs individually.

4.3 Instructors

The teacher of the subject and ELKAR-CM developers participated in the study. The teacher had taught this course for 13 years and was well trained in creating and assessing CMs created with paper and pencil (P&P) and with computer software. The developers of Elkar-CM were members of the Ga-Lan research group (http://galan.ehu.es/Galan) of the Computer Languages and Systems department at the University of the Basque Country UPV/EHU.

4.4 Instructional materials

Since a theoretical model that integrates the fundamental components of morality – emotional, cognitive and behavioural – and their development has not yet been designed, the available teaching materials on moral development (Etxebarria, 2000) offer a comprehensive but not an integrated vision of the subject.

Regarding Elkar-CM, instructors provided students the software, the on-line user guide and instructions for downloading, installing the software and constructing CMs collaboratively.

4.5 Procedure

The study was carried out in two two-hour long lab sessions. The study consisted of nine phases: (1) content teaching sessions, (2) Elkar-CM presentation, (3) first collaborative activity with the complete group, (4) first test, (5) student team formation for the second activity, (6) second collaborative activity in smaller groups, (7) second test, (8) final concept map collection and evaluation, and finally, (9) the exam.

(1) Content teaching sessions

Students took six introductory 60 minutes lectures on the topic of moral development. In the first part the teacher reviewed the most important contributions made from each of the three perspectives: emotional, cognitive, and behavioural. The psychoanalytic approach focuses on moral emotions, the cognitive-developmental on moral reasoning, and the theories of learning on moral behaviour. Then, the types of educational practices that may be more beneficial to children's moral development were analysed, and finally the possible differences between men and women in the field of moral development were studied.

(2) Elkar-CM presentation (warm up)

During the first half of a two-hour laboratory session students were briefly introduced to the main characteristics of Elkar-CM. Then they worked collaboratively in groups (2 to 4 students) using the same computer and independently from the rest of the groups. This gave them time to practice with Elkar-CM.

(3) First collaborative activity with the complete group

The second part of the first session involved the complete group in the collaborative construction of a CM from scratch using Elkar-CM. Under the supervision of the teacher a map was produced by the class as a whole. The constructed CM was projected on a screen along the whole process, and communication took place verbally, with the students and the teacher discussing contributions made to the CM. Due to the big number of students, and to avoid some coordination problems that arose at the beginning of the activity, instructors had to manage the collaboration by having the students taking turns.

(4) First test

The students completed an anonymous survey at the end of the first session. The test allowed participants to give both their first impressions of Elkar-CM and to comment on their previous experience using concept maps, related software programs and constructing concept maps collaboratively. The survey consisted of 15 closed questions and 2 open items. It included two main groups of questions. The first group was intended to find out the experience of the students in concept mapping and their familiarity with computers. The other group dealt with general aspects of the activity such as collaboration and interaction issues, as well as with questions about the suitability of ELKAR-CM to carry out such activities. Closed questions had four possible answers (1, 2, 3 and 4).

(5) Student team formation for the second activity

The instructors designed the working groups configuration before the second part of the experiment began. Students were divided in 6 groups of 8 to 9 members. Each group had three computers running Elkar-CM client and worked on the same CM. 1 to 4 students worked in each computer (61% 3 students and 28% 2 students). Students decided in with group they wanted to work. All groups worked independently from each other.

(6) Concept map development in the second activity

The second lab session was carried out one week after the firs session. Taking the CM generated in the first session of the experiment as the starting point each group of students had to work collaboratively but independently from the rest of groups to complete and simplify the concept map. They were asked also to add cross-links between concepts. Interaction types were: talking, chatting and map annotation. Students worked for an hour and 15 minutes. When there was just half an hour left to end the session, the instructors realized that there was no text in the links. Therefore, they prompted the students to establish semantic relationships between concepts.

(7) Second test

At the end of the second lab session 48 students filled in an anonymous survey to evaluate the second part of the experience. The questionnaire was composed of 16 closed questions and 2 open items. The survey was similar to the previous one. It included a group of questions to find out the previous experience of the students in concept mapping and computer software; questions about collaboration and interaction aspects of the activity, and questions about the suitability of ELKAR-CM to carry out such activities. In addition, both activities were compared. Again, closed questions had four possible answers (1, 2, 3 and 4).

(8) Final concept map collection and evaluation

The instructors responsible for ElkarCM software collected the information saved in the server in both parts of the experiment. The final results and the collaborative knowledge construction process together with the interaction logs were gathered for evaluation.

For the first part, the final CM, the sequence of the performed operations to build the CM and the whole chat log between students during the CM development were collected and sent to the subject teacher for assessment. The final CM was put in Moodle platform so that students could access it and analyze it.

For the second part, the information gathered was: six CMs (one for each group) and the whole chat log of each group together with the sequence of CM edition operations performed. Also, chats and CM operations were filtered to analyse each group's contribution. All the information was again sent to the subject teacher in order to assess the activity results.

(9) Final exam

Of the 30 final exam questions, eleven were taken from the moral development topic.

4.6 Results and Discussion

The results of the study are based on the following data: Students' opinion expressed in the anonymous tests, teacher's opinion, teacher's evaluation of the CMs, the student's marks in the 11 items of the exam related to the experience and the interaction history.

Students were asked about the experience to know the level of acceptance of this kind of collaborative activities and the use of computers for doing them. It was expected that differences could be found between students with different familiarity level concerning use of computers and concept mapping. Marks obtained by the students in the CMs and the final exam were inspected to detect differences in the outcome of the students who took part on the activities or not. These results are contrasted with the teacher's perception. In addition, the collaboration process is analysed to know which kind of operations students perform in each part of the collaboration process. Regarding the communication between participants it was also observed to know whether meaningful communication took place or not and also how the message type changed during the session. Meaningfulness of the communication would confirm the involvement of the students in the task and its usefulness.

After an in depth analysis of the collected concept maps, the students' data and the teacher's opinion it must be pointed out that the results were positive.

4.6.1.- Student's opinion

In consonance with results gathered in other similar experiences (Simone De *et al.,* 2001; Jang, 2010), students have a really positive opinion about the experience. Figure 5 shows the percentage of positive evaluations expressed by the students regarding the study. It is remarkable that all of them were strongly positive, and that the evaluations given by students to the common questions of the second survey were even higher. The majority of the students were interested in doing these activities (88.1% in the first one and 89.6% in the second one). Regarding the overall perception of the quality of the experience, the first activity was evaluated positively (69%) and the second one very positively (91.7%). Concerning the collaborative issues, the first activity got the worst results – around 60% – however these results increase significantly in the second one – around 80% –. It can be inferred that the second setting was found more appropriate for collaborative work than the first one. Regarding the perception of the students about their learning, it must be pointed out that after the second activity 93.8% of students thought that the experience helped them in acquiring the topic concepts. However, the percentage of students – even though it is above 68.8% - that thought the experience helped them relate the topic concepts to the already acquired ones is lower. Regarding Elkar-CM, students expressed a positive opinion. 83.3% of the students who did the second activity found the tool suitable to carry out this kind of activities. As it could be expected, when only taking into account the students who were interested in the experience, more positive opinions are found.

The answers to the contextualising questions of the survey show that prior to these activities 59.5% of the student had problems using computers, 30.9% of the students were familiar with concept mapping and 30.9% had some experience using a concept map editor. The answers have been analysed statistically using t-test to know whether there were differences among students depending on their answers to contextualising questions. Statistically significant differences were found in the cases included in Table 1. Therefore, interested students judged the experience's quality better and thought that the quality of the developed CMs was higher.

In the questions specific to the first activity, most of the students (76.2%) agreed that the role of the teacher in the first activity was important and only 30.9% thought that this kind of activity does not require the guidance of a teacher. Students were also asked whether they thought the activity could be done remotely and 58.3% answered affirmatively. Finally, most of the students, 70%, found the second activity a more valuable learning experience than the first one. This result can be explained because of the more realistic collaborative experience of the second activity. Although the first activity was also collaborative it was quit similar to other practical activities that were carried out in the classroom. The second one faced students with real collaboration with other students based on computers and they understood the applicability of it to other learning contexts.

4.6.2.- Teacher's opinion

The quality of the CMs varied depending on the student's profile. Most CMs were constructed in a clear and very comprehensible way.

Considering the whole experiment the students collaborated properly and they interacted by means of the chat. The distribution of the task in two sessions was successful. However, there were important differences between both activities. In the first one students were more playful and the number of students was too big to create a proper working environment. In the second activity, once the students were familiar with the system students' attitude changed considerably and they were more focussed on the task

Regarding collaboration, some groups showed a great capacity to make proposals, adjust and assimilate own and others' proposals, and integrate them into more complex CMs. Other groups, however, created simpler CMs because the participants' failure to reach agreement forced them to retrace their steps and to simplify the CM's .representation.

The behaviour and grades obtained by the students can be classified in two different groups according to attitude, everyday habits, knowledge of the subject matter, and computer skills.

In general, teacher found Elkar-CM a very valuable didactic resource. As it allows students to participate actively in the learning process.

Besides, Elkar-CM brings the Information and Communication Technologies closer to the students. However, most of them only used the graphic resources of the editor (nodes, links, labels, propositions, forms and colours). This was probably the case because they were taught the basic features of Elkar-CM, but with more instruction, they should be able to take advantage of all the functionality of the tool.

4.6.3.- Assessment of the CMs

Regarding the teacher's assessment of the developed CMs, students got high marks on them (see Table 2). The criteria followed to evaluate the CM were the creativity, imagination and critical development of the student, and the thoroughness of the final CM. The levels of performance were: excellent (3), good (2), satisfactory (1) and unsatisfactory (0). The majority of the students (53.1%) got the highest mark and only 12.2% failed. There is no statistically significant difference for gender.

Probably, similar results could be obtained with a different collaborative CM editor. However, performing these tasks with P&P would increase the problems of organising the CM (Chang *et al*., 2001). Looking exclusively at the marks, it can be concluded that it is a useful and effective teaching tool for 87.8% of the participants.

4.6.4.- Student's outcome in the exam

In the final exam 11 items out of 30 were related to the topic of the experience. The mean of the marks of the students that did the activities was 5.7 points (10-point scale), one point higher than the marks' mean (4.6 points) of the students who did not. A t-test analysis confirms that results are statistically significant ($p<0.012$). It could be argued that students groups had different motivation because of the voluntary participation in the experiments and, therefore, they could get different overall results. The analysis of the results obtained in the rest of the items (19) shows that the group that participated in the experiment got 6.3 (10-point scale) and the other group (5.7). Thus, there is a difference between both groups but half of the improvement detected in the 11 items. In addition, this difference is not statistically significant ($p<0,159$). There is also no statistically significant difference for gender.

Considering the evident improvement in the exam results, it is plausible to say that the collaborative development of the concept map provides a significantly better knowledge of the topic. The proactive peer development using the CM editor allows a deeper understanding of the subject matter due to mutual cooperation, critical contribution and explanations among the team members.

In addition, the attitude of the learners during the learning sessions, confirmed in the test they did, showed the interest of the students in the learning tasks. The use of

Information and Communication Technologies in the classroom increased the motivation of the students and their involvement with the tasks.

4.6.5.- Interaction history

In general, collaborative learning approaches focus more on the process of how activities are carried out than on the result, so it is crucial to analyze the interaction history. Chat interaction analysis has been carried out only in the second activity. As it has been pointed above, the first activity was carried out in the classroom and the majority of the interaction was talking aloud.

The analysis of the interaction between the students through the chat is based on the Collaborative Learning Conversation Skills Taxonomy developed by Soller (2001). It includes three learning conversation skill types – Conversation, Active Learning and Creative Conflict – and breaks them down into sub-skills. Three are the sub-skills related to Active Learning: Inform, Request, and Motivate. The sub-skills related to Creative Conflict are Argue and Mediate. Finally, Task, Maintenance and Acknowledge are the sub-skills related to Conversation skill.

After classifying the interactions gathered from the logs of the chat into the main skills identified by Soller et al. (1999), it was found that 66.5% were related to Conversation, 22.5% to Active Learning, 22.5% to Creative Conflict, and, finally, 10% were found irrelevant or even inadequate. Figure 6 shows the percentages of chat interactions for the different sub-skills. Task sub-skill is the main sub-skill involved in the interactions. In the analysis of these interactions it was found a big number of coordination phrases. It seems that the reason behind this is that students were neither familiarised with this kind of learning activities nor with the software used in it. In addition, there are some coordination interactions that were caused by the fact that usernames given to the students were generic (e.g. clientAA) and did not identify individuals, so participants asked often for the identity of the student performing actions or chatting. These interactions would not have taken place if proper identifiers (students' names) had been used. Finally, there is no Mediate interaction because the teacher did not participate in the second part of the experience.

The chat history was studied dividing the experience in four phases (figure 8 and figure 9). This analysis shows that *Task*-related interactions were performed mainly in the first quarter and in the last one. In the first quarter participants were planning the task and introducing themselves and in the final quarter they were negotiating the final task. Most of the *Inform*-related chatting was made in the second quarter and the discussion was carried out mainly in the third part. The last quarter was devoted to *Motivation* – congratulations on the work done – and to finishing of the task.

This kind of analysis is very informative to study the way students perform the tasks and the problems they encounter. It is also useful to improve the setting of the task in future experiments, with better planning and an appropriate learning context. For example, in the present study learners exchanges messages asking for clarifications about the tasks that could be avoided by providing more information from start.

Furthermore, a tool for analysing the conversation on-line and off-line would be very useful.

4.6.6.- Drawing history

Due to the different tasks performed in the two activities the distribution of the drawing operation performed by the students on the CM was very different. In the first activity, in which student had to draw the CM from scratch, different types of operations were performed. Figure 9 shows the distribution of those actions by type. Figure 10 shows the evolution of the operation types in the above defined four phases. It can be inferred that the students mainly focus on the basic drawing operations such as topic identification and relationship identification (Node Insert, Relation Insert and Label Edit). They were not concerned with graphic issues, but only with the spatial distribution of the topics (Node Move). Therefore they concentrated in the essential features of the task. Since in the four phases the students were still performing important operations involving node, relationships and label editing once time was up, it is clear that more time to finish the task will be needed. However, it must be pointed out that the aim of the second activity was to finish the CM.

In the second activity the distribution of the drawing operations was different. Figure 11 shows the distribution of those actions by type. Figure 12 shows the evolution of the operation types in the above defined four phases. In the second activity the students performed mainly operations to redistribute nodes in the CM, modify the CM appearance and also agree on the labelling of nodes and relationships.

5.- Conclusions

In this paper, a study carried out with Elkar-CM, a collaborative concept map editor, had been presented. Social Education students at the University of the Basque Country UPV/EHU used Elkar-CM to collaboratively construct concept maps within the subject of Moral Development. In this experiment students were involved in two collaborative learning activities. First, all students constructed a CM collaboratively in the classroom about the selected topic. Second, students were organised into groups to complete the CM generated in the first part.

Regarding the results of the study, students evaluated positively the collaborative concept mapping activities. Results gathered in the surveys show that both activities were seen as satisfactory, being the second one slightly better evaluated. Both the students and the teacher were satisfied with the quality of the created Concept Maps as the marks students got demonstrate. The students that were involved in the experiment performed better in the topic related questions of the final exam.

However, the first activity, the collaborative construction of the Concept Map carried out by the complete group, was not properly organized for a big group. It seems to be the case that students need to have more training on the tool before performing the task, and that more time must be allocated to perform the activities.

Finally Elkar-CM was evaluated as a suitable tool for collaborative concept mapping. However students did not use many of the functionalities it offers. They concentrated in basic Concept Mapping but did not take advantage of its graphic resources.

Elkar-CM provides mechanisms that allow the analysis of not only the final result of collaboratively constructed concept maps but also the concept map creation process. Current work is focused on the development of a tool to ease the analysis of the process of creating the Concept Map automating some basic analysis and showing graphically the gathered data. It will be aimed at helping teachers to better assess collaborative concept mapping activities.

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Students grouped by degree of interest in the experience	**Issue**	**Valuation (1-4)**	**Significance**
Interested Students	Overall quality of the experience	2.81	p<0007
Not-interested Students		2.20	
Interested Students	Quality of the developed CM	3.00	p<0344
Not-interested Students		2.4	

Table 1. Statistically significant differences detected between opinions of interested and not-interested students in the experience.

CM’s Score (0-3)	Percentage of students
3	53.1%
2	34.7%
1	12.2%
0	0

Table 2. Distribution of the scores that students got in their CMs.

FIGURE CAPTIONS

Figure 1. Edition window of Elkar-CM.
Figure 2. Collaboration management window of ElkarCM.
Figure 3. Client-Server Architecture.
Figure 4. Sample of group collaboration log.
Figure 5. Percentages of students' positive evaluations in both tests.
Figure 6. Overall distribution of the Interactions.
Figure 7. Temporal distribution of the Interactions.
Figure 8. Temporal detailed distribution of the Interactions.
Figure 9. Distribution of the drawing operations (Activity 1).
Figure 10. Temporal distribution of the drawing operations (Activity 1).
Figure 11. Distribution of the drawing operations (Activity 2).
Figure 12. Temporal distribution of the drawing operations (Activity 2).

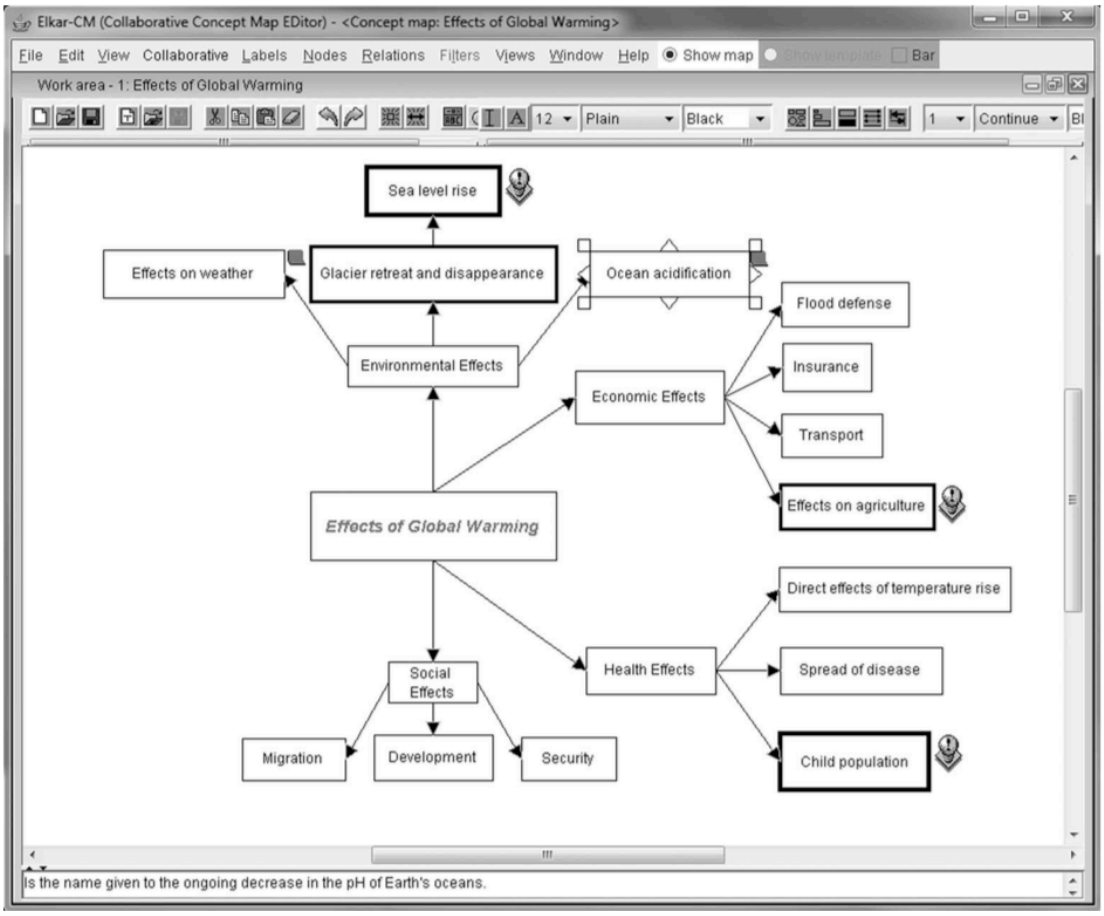

Figure 1. Edition window of Elkar-CM

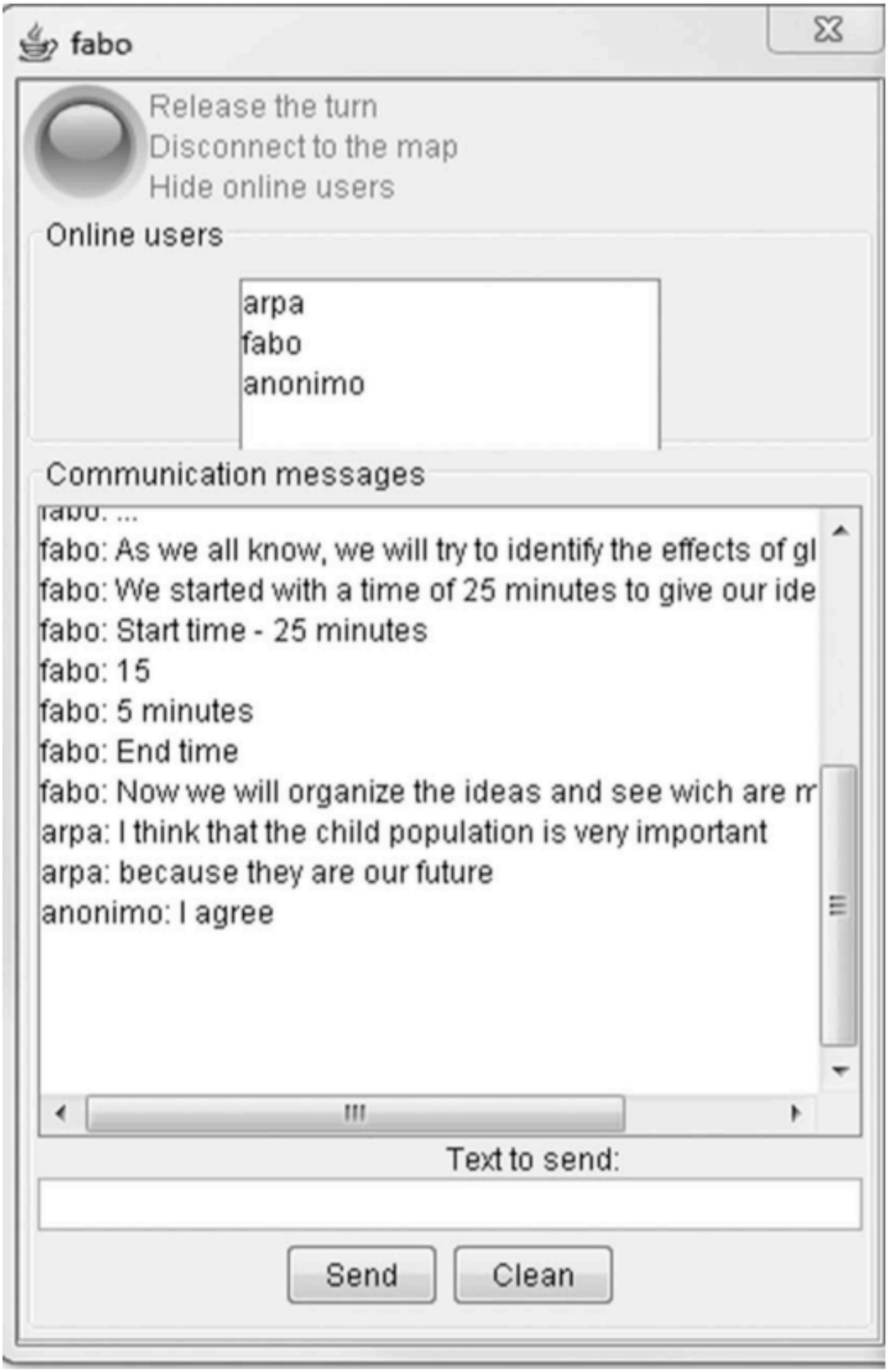

Figure 2. Collaboration management window of ElkarCM

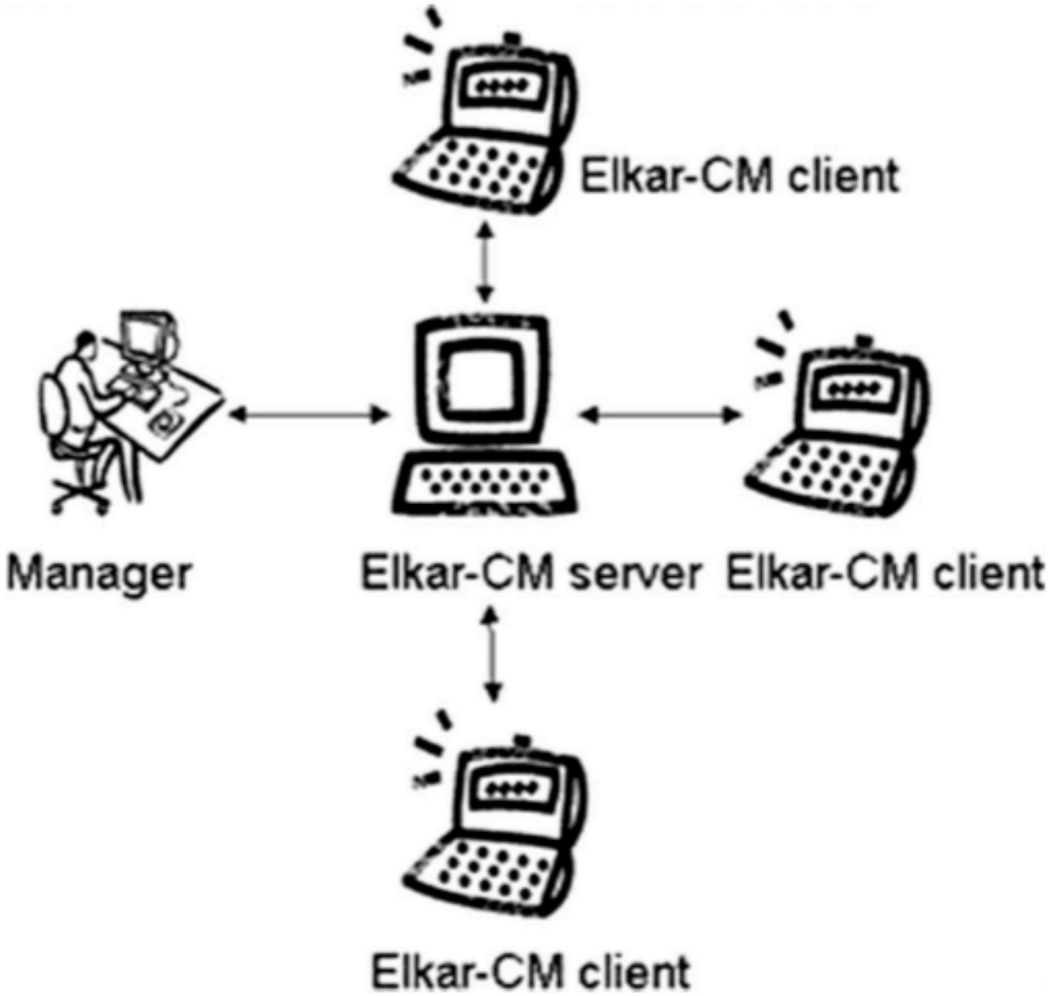

Figure 3. Client-server architecture.

```
(Operation made by) clienteAA (Time) 2009-05-14T09:32:33.889 (Operation made) NodeMoved-KEY
(Chat from user) clienteAA (Chat text) mailakatu! besteekin! petatxo bat ematen du

(Operation made by) clienteAB (Time) 2009-05-14T09:33:11.088 (Operation made) LabelEdited-KEY
(Chat from user) clienteAA (Chat text) beheraka ezarri hau da secu desberdintasun garrantzitsuetatik behera

(Operation made by) clienteAB (Time) 2009-05-14T09:33:38.960 (Operation made) DefaultNodeInserted-KEY
(Chat from user) clienteAC (Chat text) zuek mugitu lasai eh... sk tenemos un kakao

(Operation made by) clienteAB (Time) 2009-05-14T09:34:23.956 (Operation made) LabelEdited-KEY
(Chat from user) clienteAA (Chat text) bai guk ere baiño iruitze zaigu mailakatu in beharko zela... besterk ez!

(Operation made by) clienteAA (Time) 2009-05-14T09:34:58.827 (Operation made) DefaultNodeInserted-KEY
(Chat from user) clienteAC (Chat text) q ya...

(Operation made by) clienteAA (Time) 2009-05-14T09:35:03.624 (Operation made) LabelEdited-KEY
(Chat from user) clienteAC (Chat text) arrazoia daukazue..

(Operation made by) clienteAA (Time) 2009-05-14T09:35:25.699 (Operation made) NodeMoved-KEY
(Chat from user) clienteAC (Chat text) saiatzen gea dena txukuntzen eta GERO JARRAITZEN DGU TEORIAREKIN?

(Operation made by) clienteAA (Time) 2009-05-14T09:35:31.324 (Operation made) DefaultNodeInserted-KEY
(Chat from user) clienteAB (Chat text) ze ai zeate Gilligani buruz?
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Figure 4. Sample of group collaboration log

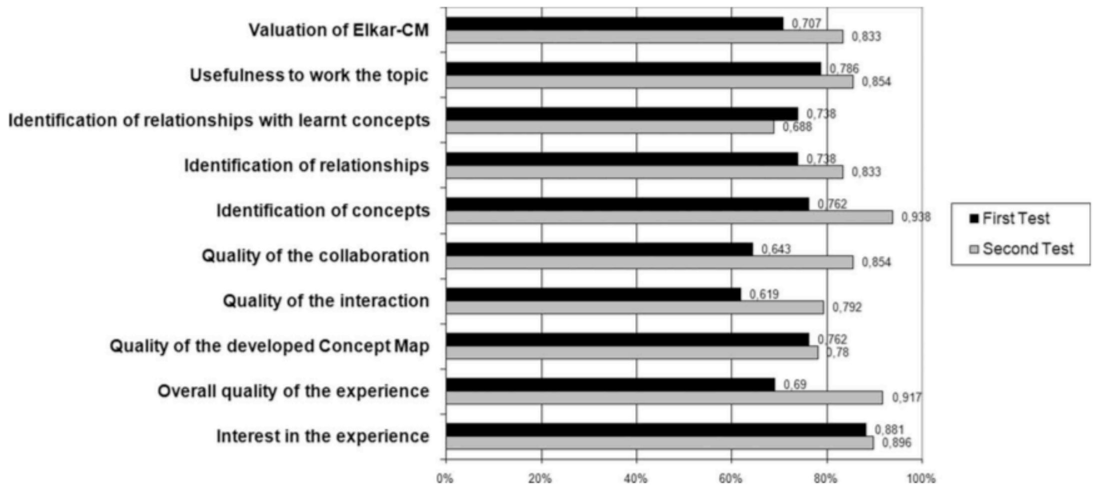

Figure 5. Percentages of students' positive evaluations in both tests

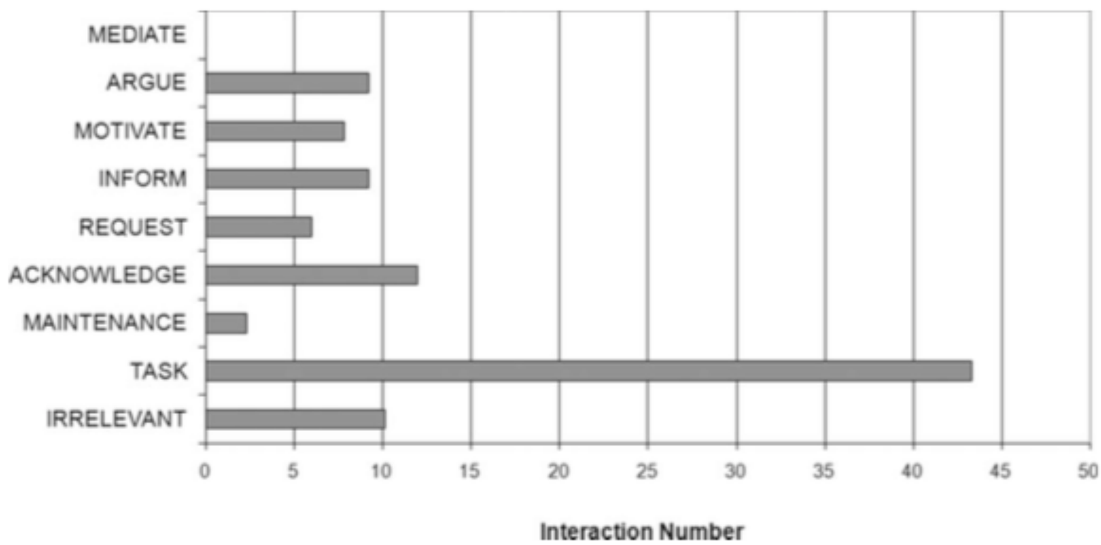

Figure 6. Overall distribution of the Interactions

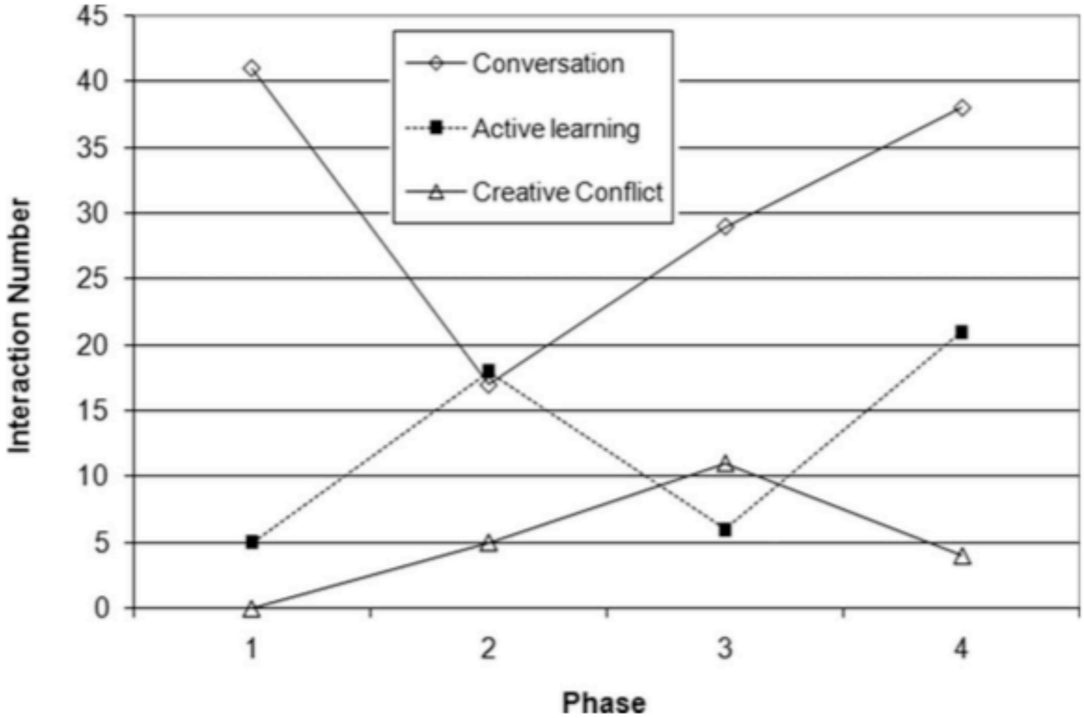

Figure 7. Temporal distribution of the Interactions

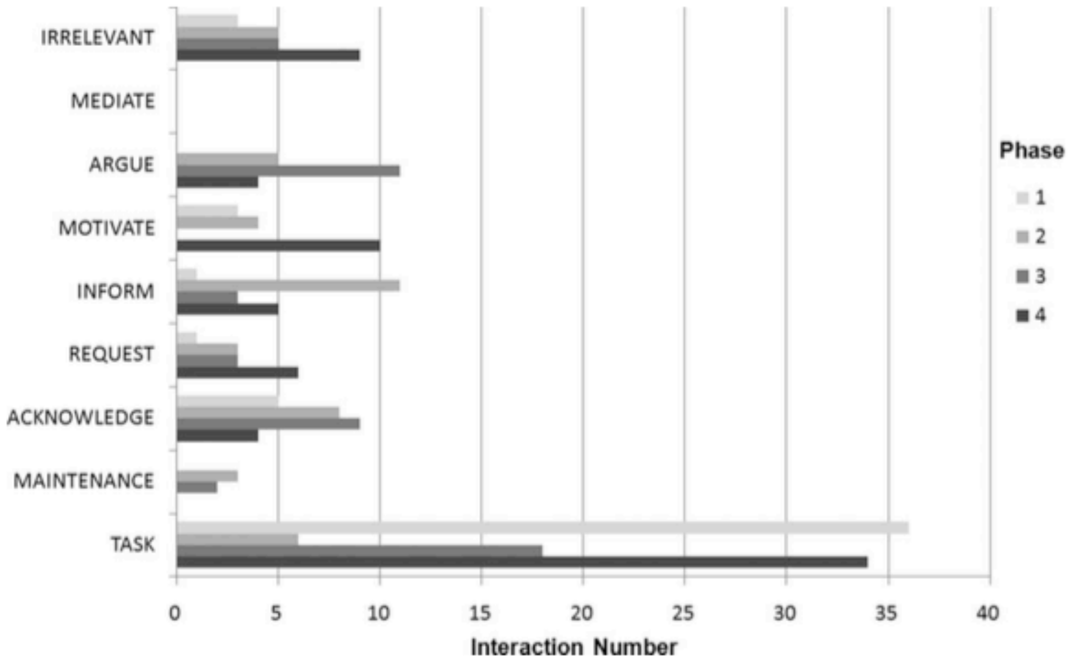

Figure 8. Temporal detailed distribution of the Interactions

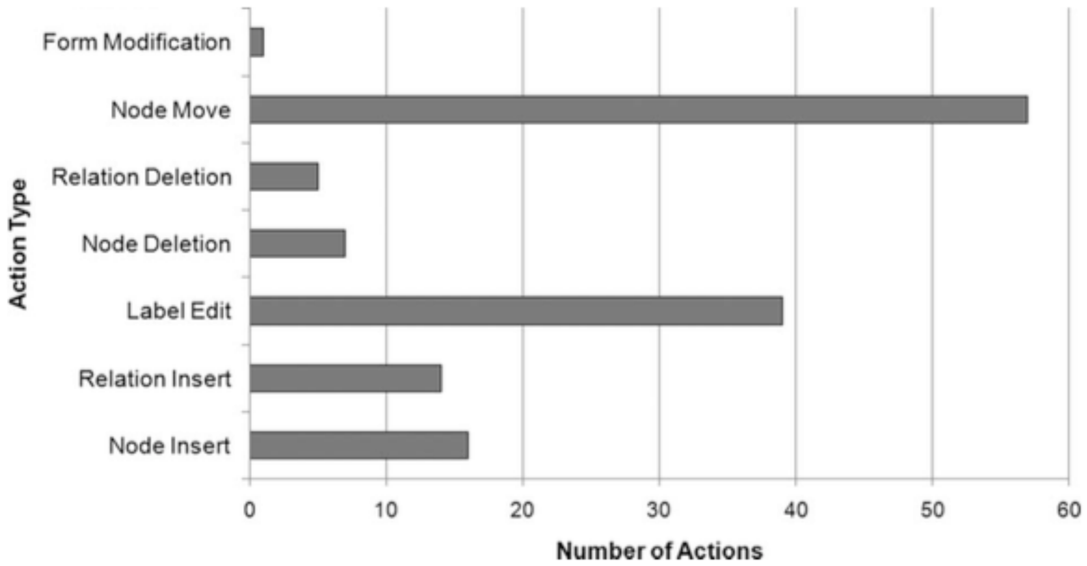

Figure 9. Distribution of the drawing operations (activity 1)

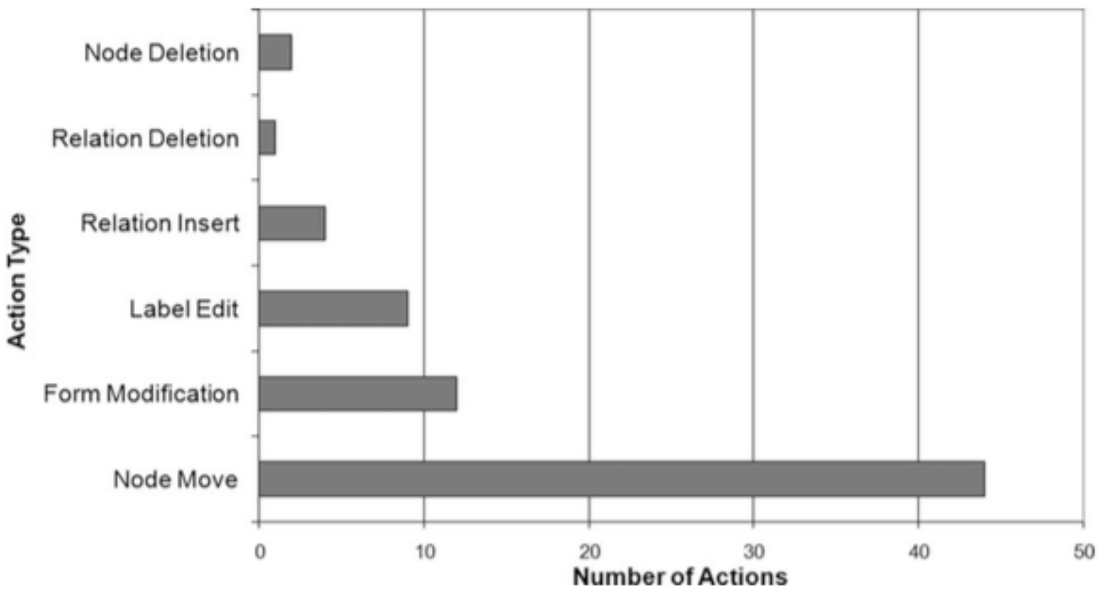

Figure 10. Temporal distribution of the drawing operations (activity 1)

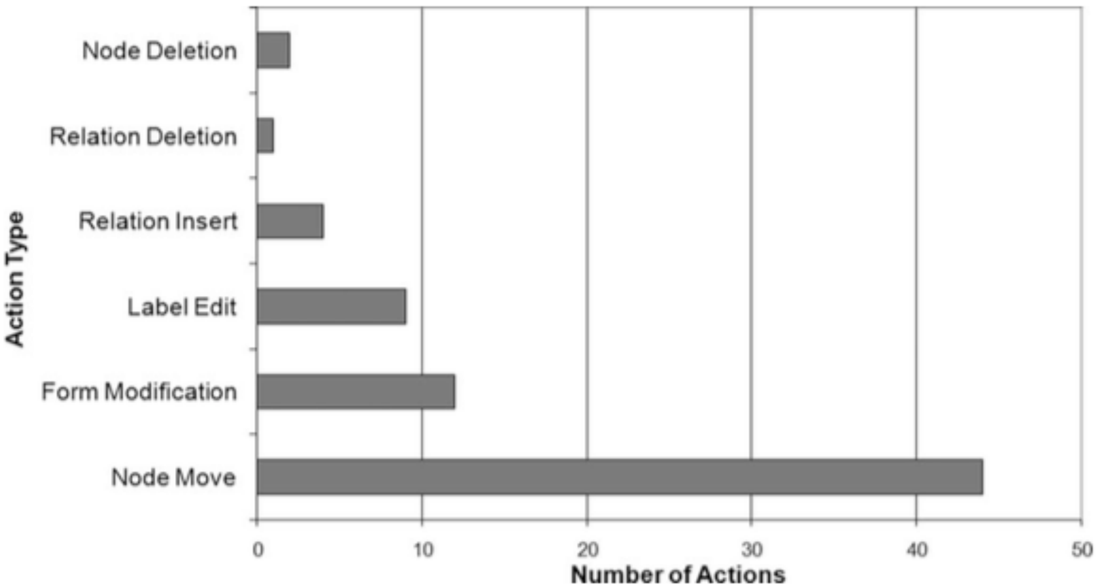

Figure 11. Distribution of the drawing operations (activity 2)

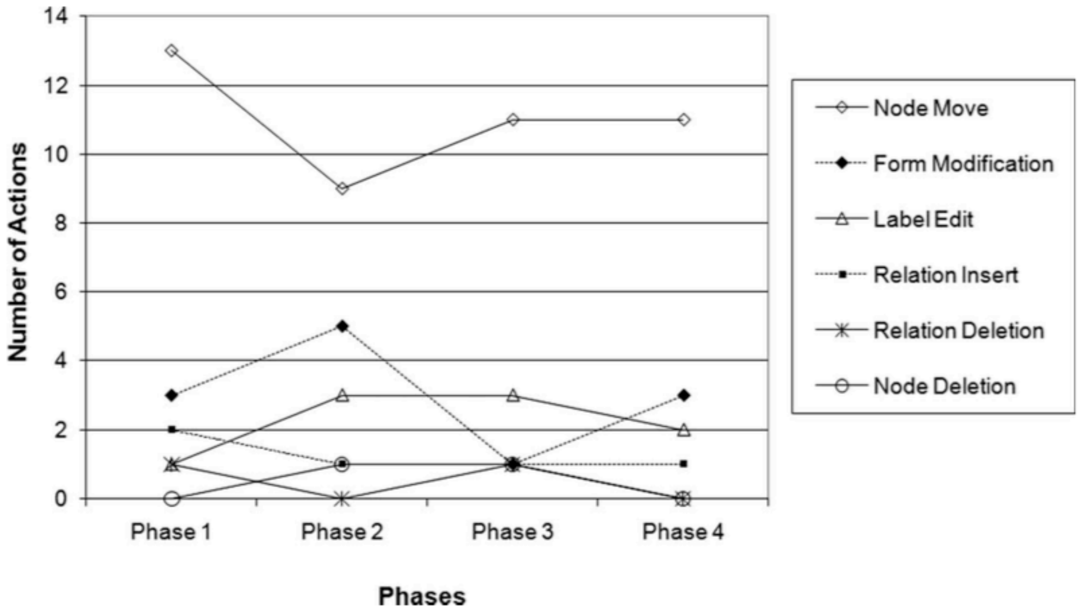

Figure 12. Temporal distribution of the drawing operations (activity 2)