COLLABORATIVE DISCOVERING OF KEY IDEAS IN KNOWLEDGE BUILDING

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ABSTRACT

In this paper, we describe our work-in-progress for developing Collaborative Discovering Tool (CoDi tool) that is meant for enhancing knowledge building environment in the Fle2 system. Knowledge-building discourse in Fle2 type of systems usually leads to gradual accumulation of notes so that the users find it very difficult to get an overall picture of knowledge produced and synthesize knowledge advancement. By providing means for the participants to mark key ideas that they find particularly useful, the CoDi tool is designed to facilitate collective management of knowledge and inquiry. The data produced by marking key ideas can be used to create various visual representations of the database that help the participants to navigate through the database and build on the recognized ideas. We report results of a pilot experiment of the CoDi prototype. The prototype appears to be a promising tool but there are certain open questions concerning what are the social and pedagogical effects of marking ideas in different educational setting, how marking should be organized so that it would provide strongest facilitation of knowledge advancement, and whether the results should always be shared not only by tutors but also by students. Regardless of the challenges, the development of the CoDi tool appears to open up an interesting line of inquiry that we would like to share with the CSCL community.

Keywords: Knowledge building environments, shared understanding, social awareness, agent technology

INTRODUCTION

The main aim of computer supported collaborative learning (CSCL) environments is to provide students advanced computer tools for knowledge production taking place in an interaction between the users (Scardamalia & Bereiter, 1993; 1994). In most of the CSCL applications (e.g. CSILE, CoNotes, Belvedere, Knowledge Forum) the knowledge production happens in a shared working space where students may carry out discussion by writing their notes. The idea of CSCL systems is to provide students a shared working space where students may post their knowledge products and carry out progressive discourse interaction (Scardamalia & Bereiter 1994).

This study is about the Future Learning Environment 2 (Fle2), which has been designed to support collaborative knowledge building and progressive inquiry (http://fle2.uiah.fi, see Leinonen, Raami, Mielonen, Hakkarainen, Muukkonen, 1999). The idea of progressive inquiry is to support a research-like study process, where the students themselves generate research problems, make hypothesis and search explanatory scientific information as a group (Hakkarainen, 1998; Hakkarainen & Sintonen, in press; Muukkonen, Hakkarainen, & Lakkala, 1999; Muukkonen, Lakkala, & Hakkarainen, 2001).

The Fle2 system and its Knowledge Building (KB) module have been tested in several university courses in Finland and other Nordic countries. From the daily use of the system, exact testing periods and number of experiments we have noticed several shortage of functionalities. We have observed that in some stages of use the Fle2's KB does not fully support the pedagogical ideas on which it has been based on. We call these barriers of using pedagogical usability problems.

In this paper we are presenting some of the pedagogical usability problems noticed and propose some solutions based on our research leaning on action research and rapid prototyping activities. The new pattern introduced is named Collaborative Discovering –prototype (CoDI tool) helping participants to discover key ideas in collaboration from the Fle2's KB database. The CoDI tool is enabling several new views to the KB database offering students more possibilities to visualize, analyze, and synthesize their common understanding. The CoDI-prototype is also increasing participants' awareness of each other and the process of learning. All of the above the system is also helping students to see the process of progressive inquiry more as a deepening circle than a linear process.

KNOWLEDGE BUILDING WITH THE FLE2

The current version of the Fle2's Knowledge Building (KB) module functions as a shared space for asynchronies dialogue and conferencing. The discussion is constructed around *Course Contexts* set by the tutor and all notes posted to the database are labeled with a *Category of Inquiry* reflecting a step in process. Categories of Inquiry used in the course in question where: *Problem*, *Working Theory*, *Deepening Knowledge*, *Comment*, *Meta-comment*, *Summary* and *Help.* The knowledge building discussion of the group can be viewed as a thread or as a list of notes sorted "by writer" or "by category of inquiry". The user may also view only those notes written by herself. (Leinonen 2000). In the current version of the Fle2 KB we have noticed the following pedagogical usability problems (see Muukkonen, Hakkarainen, & Lakkala):

1. When the amount of the KB notes increases rapidly they are difficult to find and locate (knowledge-management challenge).
2. Other participants' activities are difficult to match (awareness challenge).
3. The process of progressive inquiry appears for the students more as a linear process than a deepening circle (deepening-inquiry challenge)

An essential aspect of Fle2's KB is that all knowledge artifacts are saved to the database. This way the Fle2 KB becomes an organizational memory of the group of learners. Effective organizational memory should be able to answer such important questions as "Why did we do this?" and "How did such and such come to be the case?" (Conklin 1993). In the Fle2's KB a crucial problem is that when the amount of notes grows high investigating back to the history of the knowledge building and making overall impression of the database becomes very difficult. Students have reported that many of the notes containing key-ideas get easily "lost". For this reason a transition to new level of knowledge – to rise above - in the process of inquiry has been difficult to put into practice. For instance in the Knowledge Forum environment (http://www.learn.motion.com) there is a "rise-above" -functionality, which helps participants to point out new understanding by writing summaries of their earlier thinking. These "rise above –notes" acts at the same time as a summary of the earlier notes and as a new starting point for further knowledge building.

The process of progressive inquiry is a deepening spiral of iterations of questions and theories (Hakkarainen, 1998). Mostly because of the limitations of the web user interface the current views of the Fle2's KB are showing the process of progressive inquiry as a linear process. The users may browse the notes of the database only as a tread view or as a list sorted in some re-defined manner. To visualize the spiral and fuzzy form of the process several alternative views to the Fle2 KB has been considered. In general the users should have more possibilities to display the Fle2's KB database in several visual manners. In several CSCL systems using locally ran separate client software the shared workspace is shown as a two-dimensional open space where students are free to locate their notes.

In online environments participants' awareness of each other's activities is critical feature when trying to built communities of practices (Jermann, Soller, & Muehlenbrock, 2001; Schlichter, Koch, & Chengmao, X. 1998). The social navigation of information space where other users are giving hints to each other on interesting information is seen one of the key model of action in online communities (see Munro, Höök, & Benyon, 1999). In testing of the Fle2 KB we have noticed that in many cases teams of participants have hardly been aware of who else in the learning community share the same kind of ideas and interest in the knowledge building as they do. To reach join activities and commitment to the community has been difficult in the Fle2's KB.

RESEARCH SETTING

This study is focused on developing a new tool to solve the problems stated above related to the handling of information flows in a knowledge-building environment, making students more aware of the nature of the progressive inquiry process and aiming to increase participants awareness of their co-students thinking and the groups collective ideas.

The study has followed the procedure of action research which can be described as an interacting spiral and loop of looking, thinking and acting (Stringer 1996). In our study the loop has contain looking for the Fle2 Knowledge Building by using it ourselves, thinking about it by presenting several pedagogical usability problems related in it and designing possible solutions, and acting by creating and building prototypes of the design and testing them with real users.

Looking and thinking of the Fle2 is something we, as the main developers of the Fle2, are doing all the time. The Fle2's Knowledge Building is used by us in several study course as well as in the study and design process described in this article. For this reason we have been able to focus more on rapid prototyping activities where several new features are quickly implemented to be part of the software and tested with real users in a real situation. The rapid prototyping is a process used in design process for problem solving, exploration and sharing of thoughts (Horton 1995). In our study the ultimate objective was that based on the experiment and testing of the functional software prototype some of the features of the software could be implemented in to the next version of the software. This way the experiment was also rapid proof-of-concept prototyping.

The purpose of the study was to develop and test new pedagogical tools helping students to gain on more efficient meta-cognitive thinking by helping students to raise important key ideas from the knowledge building, being more aware of the groups common activities and stage in the progressive inquiry process. The idea was to give students some real-time software tools helping them to make their own interpretations of the process they are involved in. In a way we were trying to empower students with new software tools to make interpretations of their own discourse in a similar way as researchers are carrying out quantitative analyses and qualitative content analyses. The purpose was not to make automated interpretations of their activity in the knowledge building, but rather offer students the data in easy to understand visualized form for their own interpretation and further discourse.

CoDI Prototype

The first concept design of the Collaborative Discovering of Ideas tool (CoDI tool) was meant for marking relevant material in the knowledge building notes, so that important notes could be accessed easily later. The original concept idea of the CoDi tool was a marking tool supporting the students in making sense of the KB process, identifying, what is important in the notes produced, helping to compile a synthesis of the KB discussion, and, thereby, help them to manage their knowledge advancement. In the first phase of design it was also assumed that the possibility of sorting out relevant material from the KB database, might help people coming late to the course, passive users, and visitors to get on overview of the progress of community's knowledge-building discourse and catch up faster with current challenges of the community's inquiry. It was also thought that the tool could work a an automatic reminder that produces a summary of the week's KB discussion and sent it e.g. via e-mail or sms to participants' mobile phones. Already with the first concept design it was noticed that it is important to be careful not to make superficial participation too easy for the participants and the effects of these kinds of summaries should be carefully empirically tested.

Based on these first assumptions we made a functional software prototype for highlighting interesting points from the knowledge building notes. The CoDi tool can be used for both individual and collaborative highlighting, where all the personal highlights of the notes could be summed up to produce a collection of those, which the whole group has highlighted. The student would be able to review her individual highlights as well as group's highlights.

In the Fle2 Knowledge Building we have noticed that most of the notes contain more than one idea and only finding key notes is not giving the right picture of the variety of good ideas in the database. In the software prototype developed users may mark from the notes those paragraphs she or he finds important. We decided that a paragraph was considered to be the smallest unit to be marked. Naturally free selection of text by highlighting part of the text with a mouse would have been more intuitive user interface but not possible to implement with the current restrictions of the web browsers. Also the marking of a line is not possible since the lines can vary from user to user based on the window size of the web browser.

Marking a paragraph as interesting the user had the option to mark it as a 'summary point' or a 'main point'. In the prototype 'Main point' was defined as a paragraph of a note, which a student considers important or valuable. It could be compared with underlining a paragraph of a note. 'Summary point' was defined as a paragraph of a note which the student considers important to be in the summary of the whole knowledge-building process. The Summary point is more important than the main point which was also stressed when the tests where run. In the prototype we used this two-level division. After some empirical testing and brainstorming about these issues, we decided to have only one level of highlighting and named in to be 'key idea'. In the current specification of the Codi tool participants are collecting 'key-ideas' in a 'virtual notebook', which can be viewed in personal or in collective mode containing all participants markings.

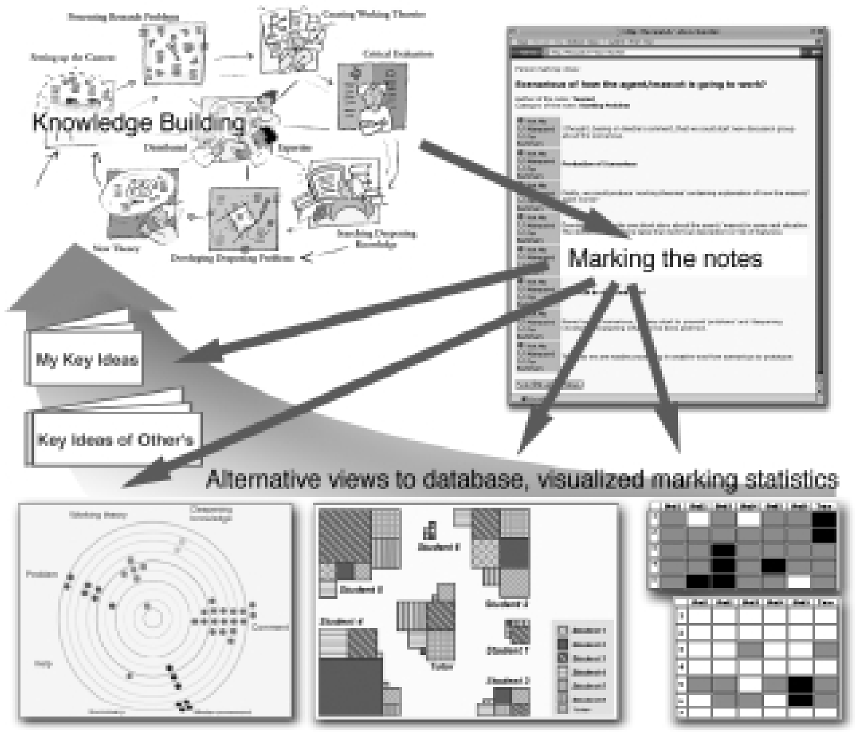

Figure 1: Knowledge Building, marking the notes and data provided for the users.

Figure 1 describes a user scenario of the CoDi tool. At first the students are working with the KB database according to the model of progressive inquiry by adding their own study problems, theories, and deepening knowledge in to the KB database. In some stage the tutor is introducing the CoDi tool for the students and asking them to highlight the most important ideas from the notes in the KB database. After this the data related to the highlighting and the notes (writer, data, category of inquiry, link) are offered as an alternative views of the database. These visualizations can then be used as a starting point for further discourse. In the CoDi tool all computing and quantitative operations carried out are invisible for the user. The users are only highlighting or underlining notes and getting back several easy to understand visualizations of they own and the groups 'key ideas' and those proportion to each other. In any stage of use the users are not operating with numbers of statistics.

Testing the Prototype

The experiment with the CoDI tool was carried out with students taking part in the study project on Design for CSCW/L (computer supported collaborative work/learning) carried out as part of the Future Learning Environment study project organized by the UIAH Media Lab at the University of Art and Design in autumn 2000. The study project lasted four months.

Six participants of the study project where all MA level students. In addition, there were two research fellows of the Media Lab tutoring students' working. An interesting feature of the group was that most participants (students and tutors) were from different nationalities including Finland (3), Denmark, Colombia, Ghana, Lithuania and Switzerland. The group was also representing many different areas of expertise, such as new media design, industrial design, computer science, communication and journalism, and educational science. The participants where working both in weekly face-to-face meetings and in the Fle2. In three months of active working students posted more that 250 notes to the Fle2's KB. More detailed description of the course and class can be found from the http://www.euro-cscl.org database.

To test the CoDI tool we took from the study project's KB database one starting problem and all the following notes of the first note. The testing of the software prototype was carried out by the study project. This way the group taking part in the testing were the same persons that contributed the notes to the discussion thread chosen. The testing of the software was carried out several weeks after the discussion had been ended by the participants.

Data Analysis

The testing of the software prototype was carried out by seven participants of the study course. The number of the notes used in the test were 41 containing 171 paragraphs. The average number of paragraphs in all the notes was 4.17. From the paragraphs of the notes participants highlighted 105 summary points and 275 main point.

The average of highlighting per note by student varied from 0.8 to 2. The number of notes with participants' highlighting contribution varied from 2 to 12. On average, there were 6.7 main points and 2.6 summary points per note. The frequency distribution of markings made using the CoDI tool in our experiment are shown in Table 1

Table 1: Basic Statistics of the Marking by the Participants.

	Summary points marked	Mainpoints marked	Points marked total	Avg. marks per note	Number of notes contributed
Student 1	1	33	34	0.8	5
Student 2	11	55	66	1.6	4
Student 3	29	55	84	2.0	5
Student 4	7	34	41	1	12
Student 5	14	35	49	1.2	9
Student 6	18	37	55	1.3	2
Tutor	25	26	51	1.2	4

One of the principal ideas of the CoDI concept was to match those notes from the KB database which could have some special value for the group. To find those notes we made a formula counting scaled value (from 1 to 10) for each note. The reader should notice that the calculations serve only visualization purposes, they are not intended to be used by the participants in anyway, and we are not especially interested in ranking students productions (beyond identifying key ideas by highlighting). The formula used for counting the value is as follows:

$$\text{Value for a note} = \frac{10}{pu}\left(\alpha s + m\right) \qquad (1)$$

The p stands for the notes paragraphs and u stands for the number of users. This is then multiplied with the sum of the marks where s is Summary Points and m is Main Points. The alfa (a) in the formula is in our case defined to be 1 although there should be more weight on it e.g 1.2 (this would of course affect the scaling). This weighting is necessary since in our case we emphasized the value of the summary point over the main point, which should be considered when counting the values. The overall idea of counting the value for a KB-note using the formula is because longer KB-notes can have more markings compared to shorter ones and in using the formula we are eliminating the effect of the KB-notes length.

The scaled value of notes counted with the formula one varied from 0 to 9. The distribution of values was rather even. The most common scaled value got with the formula was 4 and only one note got a value 9. The notes values from 0 to 10 divided as in Figure 2.

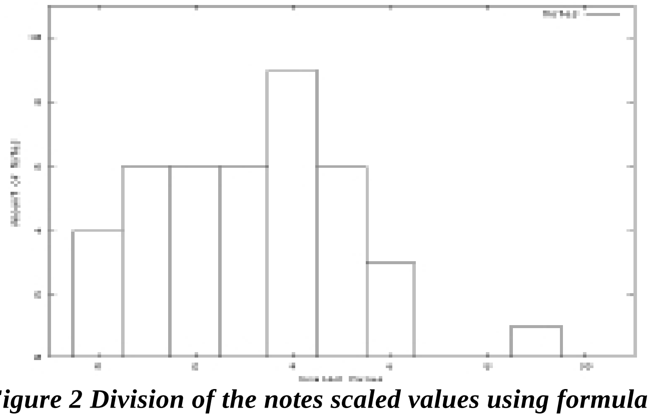

Figure 2 Division of the notes scaled values using formula 1.

To get a better picture of the social structure and shared understanding in the group we decided to analyze who was marking whose notes. For this reason we made a matrix showing the division of the markings people made to other people's notes. The divisions of marking between the students are shown in the Table 3.

Table 2: Percentages and Frequencies of Participants' Markings to Other Participants' Notes.

	Author of the Note							
	Student 1	**Student 2**	**Student 3**	**Student 4**	**Student 5**	**Student 6**	**Tutor**	**Total**
Student 1	**14.7%(5)**	17.6%(6)	11.8%(4)	14.7%(5)	26.5%(9)	2.9%(1)	11.8%(4)	100%(34)
Student 2	3.0%(2)	**18.2%(12)**	9.1%(6)	42.4%(28)	16.7%(11)	4.5%(3)	6.1%(4)	100%(66)
Student 3	8.3%(7)	14.3%(12)	**10.7%(9)**	17.9%(15)	27.4%(23)	3.6%(3)	17.9%(15)	100%(84)
Student 4	2.4%(1)	17.1%(7)	14.6%(6)	**26.8%(11)**	17.1%(7)	0%(0)	22.0%(9)	100%(41)
Student 5	6.1%(3)	22.4%(11)	12.2%(6)	18.4%(9)	**22.4%(11)**	6.1%(3)	12.2%(6)	100%(49)
Student 6	5.5%(3)	18.2%(10)	7.3%(4)	12.7(7)	21.8%(12)	**7.3%(4)**	27.3%(15)	100%(55)
Tutor	9.8%(5)	25.5%(13)	15.7%(8)	3.9%(2)	23.5%(12)	0% (0)	**21.6%(11)**	100%(51)
Total	100%(26)	100%(71)	100%(43)	100%(77)	100%(85)	100%(14)	100%(64)	
Markings of All the Notes	6.8%(26)	18.7%(71)	11.3%(43)	20.3%(77)	22.4%(85)	3.7%(14)	16.8%(64)	**100%(380)**

It is good to remember that the division of marking does not show whose ideas and notes where considered important. For instance participants 2, 4, 5 and tutor got many markings in their notes because they also contributed heavily to the Knowledge Building, indicating that they were having more notes in the database to be marked. However, the matrix is 'raising up' some students' notes to be considered to contain relative many markings. The tutor's notes got a lot of marking from students 2 and student 3 which were not very active during the Knowledge Building. We may assume the students 2 and student 3 where more willing to trust on and value high the tutors ideas than their peer students' ideas as they were not that inside in the knowledge building. Interesting result is also that students 1 and 6 where giving most of all markings for their own notes in the Knowledge Building.

To understand deeper the social relations we were trying to analyze who found same notes valuable according to scaled value. For this reason we counted the correlations between the participants base on the values of the KB-notes participants gave for the notes when counted with the formula 1. The correlations are shown in the Table 4.

Table 3: Correlations Between the Participants Based on the Scaled Values of the KB-notes

	Student 1	**Student 2**	**Student 3**	**Student 4**	**Student 5**	**Student 6**	**Tutor**
Student 1	1	0.09	0.21	0.11	0.33	0.11	0.41
Student 2	0.09	1	0.18	0.08	0.41	0.42	**0.02**
Student 3	0.21	0.18	1	0.31	0.11	0.18	0.21
Student 4	0.11	0.08	0.31	1	0.55	0.39	0.49
Student 5	0.33	0.41	0.11	0.55	1	0.72	0.26
Student 6	0.11	0.42	0.18	0.39	**0.72**	1	0.12
Tutor	0.41	0.02	0.21	0.49	0.26	0.12	1

From the correlations we may point out the extremes: student 5 and student 6 markings correlation was 0.72 and student 2 and tutor whose correlation was only 0.02. During the knowledge building student 2 was very active and highly challenging tutors point of views by presented a lot of individual thinking.

OUTCOMES AND IMPLEMENTATIONS

Most of the problems of the Fle2 KB pointed out in this article could be solved by developing better tools for searching and filtering information in the KB database and by offering more data of other peoples activities in the Fle2 system. However, we argue that highlighting of key ideas from the notes in the KB can be meaningful step in the process of progressive inquiry. It appears to us that when highlighting key ideas for the KB students had to think and analyze what had been important and valuable in their process of learning and knowledge building. In this way the collaborative discovering of key ideas with the CoDi tool can be seen to serve both critical collaborative self-evaluation and collaborative self-coordination of students working. In our experiment, for instance, the highlighting appeared to generate a lot of meta-level discussion of the knowledge building process. When presenting the results of experiment to the participating students were asking such questions as 'why so many of us thought this idea to be important?', 'how come nobody else did not highlight this idea?', 'why everybody found student's X's thought valuable to be highlighted?', 'why do we share only so few markings?' etc. There are of course a lot of open questions and a need for carrying out further rigorous studies in different educational settings in order to fully understands the cognitive and social implications of highlighting the key ideas generating new discussions between the students.

Based on the experiment we designed some new views and user interfaces to the database taking advantage of the data collected when users are using the CoDi tool. The ideas is that the design could offer the user the opportunity to select an interface that he or she is most comfortable with from several possible interfaces (thread, list, map, etc. views). The new interface offers an interesting possibility to combine and display many different levels of data at one glance. Users might take different views to the same notes of the Knowledge-Building database, or they may choose to use different views in various phases of the learning process. The alternative views designed which can be used also for browsing the database are: (1) *The KB Dartboard view* (Figure 3) basing on the notes scaled value calculated with the formula 1 (2) *The KB Social Blocks view* (figure 4) which is one kind of social network analyses using the data presented earlier in the Table 3 and (3) *The Key Idea Cluster views* of each note showing what paragraphs each participant has marked as the main point and the summary point. The purpose of these views is to help participants to collectively assess progress of their knowledge building inquiry and navigate across the database with the help of the key ideas.

The KB Dartboard view (Figure 3) was design to help students to find and locate important KB notes and to offer them a picture of their stage in the learning process. The data is used to organize the notes into a view where the notes containing a lot of important ideas (based on the scaled value) would be located in certain areas. This way the valuable note could be used as background to write 'raise above' –note or new Course Context. The most important notes according the scaled value are located in the center and less important ones are more remote. The notes are also divided and arranged according to the 7 progressive inquiry categories: problem, working theory, deepening knowledge, comment, meta-comment, summary and help (see Muukkonen et. al., 1999). The time of production of the note is represented by intensity of the color of the dot, so that most recent notes are sharper and more visible.

The Dartboard view can be used also as a user interface for browser the notes of the KB database. Clicking a dot opens the note and display it. Each of the dots in the view would be linked also to the Knowledge building thread view. This way the student would have the possibility to find notes relevant to the discussion and stay aware of the context and relations of each note with the rest in the thread. In the Dartboard view there could be also zooming functionality making more 'distant' view available being helpful as the amount of notes increases.The view would give the student an overview about the group activity, learning process at one glance and would help her to orient in KB discussion easier. For many people it is easier to learn and recall things (in our case notes) if they are visually represented as objects and locations, rather than purely logical system of textual links. Therefore we are systematically developing tools that enable us to visually represent, organize, and access knowledge.

The Dartboard view can be seen also as a map of the Knowledge Building database. Different kinds of other Knowledge Building maps could be created using different variables or combining more levels of data, like the author of the note, amount of markings, the length of the note etc. The different map views could give possibility for the student or tutor to compare individual effort with the rest of the group, for example by indicating personal important point markings on top of the note dots and giving the possibility to view other groups members' individual markings at the same time.

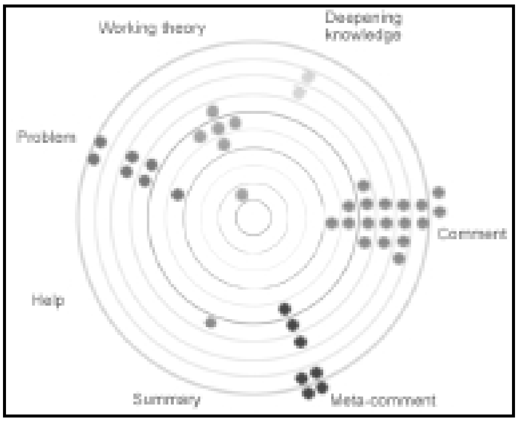

Figure 3: KB The Dart Board View

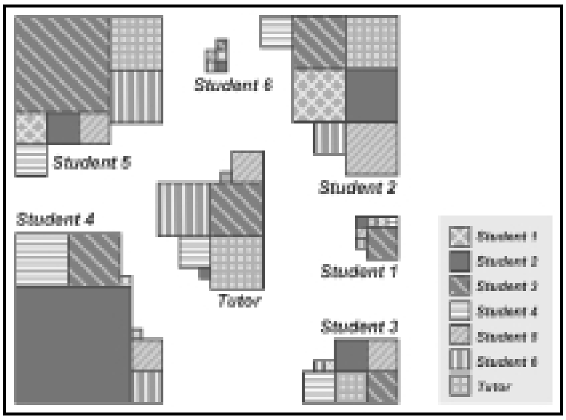

Figure 4 The markings of the participants

The KB Social Blocks view (Figure 4) is another possible usage of data collected by using CoDi tool. The view is one kind of social navigation map generated in a real time based on the amount of markings people made for each other. The data presented earlier in the Table 3 is visualized in Figure 4. The amount of markings made for each student by others is represented by the size of squares. This kind of social network map makes comparison of a single student's activity in the context of the whole group easier. It is based not only on the amount of notes produced, but also on whether peer students find them interesting and important. By making each other's opinions visible for students in real time this kind of map would call for action, if, for example, a specific person does not produce enough of notes or, her opinions differ a lot from the rest of the group. For instance the figure 4 is showing in simple way that the students 6 and 1 did not get many markings compared with others, which may indicate, that they were not working enough and their contributions to the Knowledge Building were considered not relevant by the group. If this kind of map would have been presented during the process of learning, it would have made the students more aware of the situation in the group. It may also have raised discussions about learning itself and helped the passive students to become more integrated into the group. An important thing in this view is, that it is not based on the amount of notes produced, but on the amount of key ideas that other people highlighted. In this way it presents a quite precise view of the actual learning situation in the group.

It is, however, possible that this kind of social evaluation may be experienced as threatening by a participant in cases when the social community does not appreciate his or her ideas. It is possible that students -- who pursue original lines of inquiry that are difficult for the other participants to understand -- feel socially excluded if their ideas are not recognized by the community. Therefore, we think that it is important to carefully consider to what extent and in what form the participants will get this kind of social-network data. Especially while working with younger students it is important to carefully consider how this data would affect communal efforts of building knowledge. In any case, this data appears to be very important for the teacher or tutor who would be able to re-distribute his or her effort so that students working at the periphery of the community would get more support.

The Key idea Cluster view (Figure 5 and 6) is showing each note markings by participants and paragraphs. The numbers in the Figure 5 and 6 represent the paragraphs of the note, the darker squares are summary points and the lighter squares are the mainpoints which the participants gave for each paragraph of the note. This view is giving simple aid for participants to browser in fast manner notes with many key ideas. It is also making visible in a note level the participants differences and similarities of making interpretation what is important in the note and what is not.

Figure 5

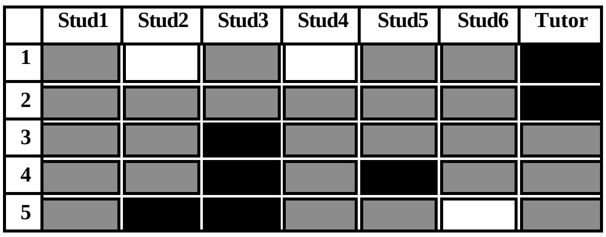

Figure 6

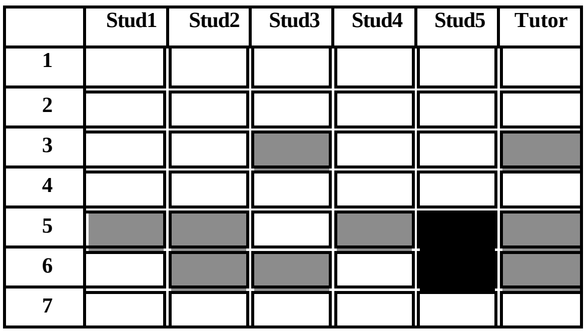

Figure 5 & 6. The Key Idea Cluster Views

The Key idea Cluster view also reveals the weakness of the formula 1 used for giving scaled value for the notes. By browsing *Key idea Cluster* view we notices that some of the notes containing some paragraphs with a lot of markings did not get very high scaled value. For instance the note presented in the Figure 5 gets a value of 9.14 (also the highest value among the notes) when using the formula 1 whereas Figure 6 illustrates a note which gets a value of 2.24. The counted value for the note is low although the note has interesting paragraphs inside the note as indicated with the participants' markings. The formula therefore lacks the ability to detect the notes which only have parts that are considered to be interesting. This problem should be taken into consideration in formula 1 by adding values for notes based on the "clusters" of markings the notes have.

CONCLUSIONS

The prototype described in this paper offers interesting possibilities for students and teachers to define group's key questions and compare them with individual interests. It may also function as a learning process negotiation tool helping to orient and coordinate individual activity in the group context, raising discussions about other people's opinions, encouraging collaboration and possibly supporting reflection of learning and knowledge-building processes. The tool also helps to solve the problem concerning the representation of the KB-discussion, which should be more spiral in nature as indicated by the progressive inquiry model (see Hakkarainen, 1998; Muukkonen et. al., 1999). The solution proposed in this paper appears to be promising in terms of solving the problem of growing number of the knowledge-building notes.

Assuming that the CoDi tool will be taken to active use, it is an open question in what stage of a project the marking should be conducted. We are not yet sure whether it should be done in the end of the learning process when summaries are produced, or whether it should take place simultaneously with the knowledge-building process Initially the tool was designed to mark the notes that the student was reading for the first time in order to find them easily afterwards. But a marking task could be problematical if the student does not know the context of a particular note. It follows from these considerations that the marking tool should be activated (possibly by a tutor) at some point in the learning process, when the students have a perspective to the overall process, for example, when starting a new Knowledge Building thread or entering the stage of critical evaluation. In several courses it has been observed, that the first round of Knowledge Building tends to be a brainstorming session rather than a well-structured discussion: people are not yet familiar with each others perspectives or viewpoints and with the field of their interest in general. At that stage the most important thing is to post some of ideas to a shared workspace and get in tune in with other group members. As the students advance and come to the stage of critical evaluation, they may find it useful to go through all the previous notes and by marking interesting ones to help the system to generate different new views of the database. These new views visualizing the knowledge building process in a new way may raise new meta-learning discussions within the group.

Most of the data analyzes of the use of the CoDi tool was carried out with automated formulas. However, in the version of the CoDi prototype used in the experiment the data and results of the use were presented for participants only after the process was carried out. From a technical point of view there is no reason not to present the data already during the learning process. We assume that this kind of real-time automated analyzes could significantly engage students to think more their knowledge building and also benefit students to direct the inquiry process to right course. This area will be one of the topics of our future research. The automated data collection, data offering and formulas offers also some interesting aspects for developing agent technology to be used with the Fle2 Knowledge Building. The agent could send reminders of work-in-process though email or sms to mobile phones with short summary of the current ideas under consideration in the course or suggest some participants to collaborate as they do (or do not) have common highlighting in the KB database.

The challenge of developing the CoDi tool is to integrate syntax and semantics. Currently, the participants are highlighting key ideas generated by the users of the Fle2 in order to generate visual representations of knowledge building process. In certain contexts the highlighting procedure may, however, direct the participants' interest from the content of ideas to assess the participants' social importance or popularity. We are currently struggling for developing tools that would allow the users engage in further elaboration and building on of the collectively recognized key ideas. We are considering trying to facilitate knowledge building by asking the participants to justify why they find an idea valuable or from what perspective they are assessing it. Ideas can be evaluated from multiple perspectives and an idea that does not appear to have general interest may be valuable on condition that it answers to your research question or is challenging or corresponding your personal perspective (Stahl, 1999).

Although the idea of the CoDi tools appears very promising to us, we have some uncertainty concerning pedagogical and social implications of selecting the key ideas. The point of the CoDi tool is to help participants engage in productive collaboration for building knowledge together. The tool provides means for the participants to assess on-line how each participant is contributing to knowledge building and what key ideas emerge from the joint process of inquiry. Our explorations with university students indicate that the developed tool serves this function. If the tools is applied in different context, for instance at elementary and secondary level education, it is possible that selection of key ideas could have negative consequences. It is possible that ideas of a popular student may be highly valued also in a case when it would not be justified from the knowledge-building perspective. The fact that other participants do not appreciate a student's ideas may make him or her to feel small in a very concrete way. Therefore, it is important to carefully examine good practices of using the CoDi tool in different educational contexts.

In some contexts it might be advisable to give information of relative social acceptance of one's ideas only to the teacher so that he or she could focus on coaching and guiding a student who is not participating intensively enough or who is in danger of getting left out of the social community in question. It is also important to develop pedagogical practices that help to use the CoDi tools to support advancement of knowledge rather than just assess relative contribution of participating students. There are always substantial differences between students socio-cognitive resources and rather than comparing their knowledge-building resources in relation to others, we would like to guide students to focus on advancing their ideas. From the viewpoint of creative activity is very important to achieve "collective flow" (compare Csikszentmihalyi, 1996; Sanna Järvelä, personal discussion in spring 2000); i.e., get so completely immersed with the collective process of building knowledge that an agent forgets all his or her worries concerning whether s/he is as good as the other students and not to think whether s/he is able to solve the problems being addressed. We would like students to learn to respect all ideas posted to the database notwithstanding who created them idea, and create new knowledge on the basis of the ideas. The CoDi tool will be considered successful as far as it is able to provide significant support for attaining these goals by helping the participants to identify their key ideas.

There are still many open questions concerning pedagogical effects and technical implementation of the CoDi tool. We believe, however, that this kind of a tool or framework for tools would offer good possibilities to further developed Knowledge Building environments in other systems beside Fle2 as well.

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