

Computer-Supported Collaborative Learning with Mind-Maps^{*}

Dmitrij Koznov¹ and Michel Pliskin²

¹ Saint-Petersburg State University, Software Engineering Department,
Universitetskij pr. 28, 198504, St. Petersburg, Russia
dkoznov@yandex.ru

² Comapping, Blaagaardstraede 8FDK-4000, Roskilde, Denmark
pl@tepkom.ru

Abstract. Collaborative learning is a set of various approaches in education that involve joint intellectual effort by students or students and teachers. It opposed to the traditional 'direct transmission' model, in which learners are assumed to be passive, receptive, isolated receivers of knowledge and skills delivered by an external source. Today Computer-Supported Collaborative Learning (CSCL) is actively developed to support collaborative learning process with the help of modern information and communication technologies. Mindmaps is one of the wide-known learning technique which can be used in CSCL. In this paper we present new mindmaps Web-based tool Comapping, which provides a wide variety of ways to organize collaborative processes in education. We also describe our experiments with applying the CSCL-paradigm using Comapping while teaching Software Engineering in Saint Petersburg State University.

Keywords: Computer-Supported Collaborative Learning, Collaborative Learning, Mind maps, SADT, Author/Commenter Cycle Review Process.

1 Introduction

Mind maps [1] are a popular technique having been widely used in the education area for several decades by now. It is used both on its own and as a part of other methodologies like active learning [2] and others. Mind maps are extremely efficient when working individually on learning material as they emphasize human creative skills, improve memory and are generally proved useful in all kinds of intellectual activities. There are a number of software mindmapping solutions on the market now (please refer to [3] for a complete listing). However, use of a mindmapping in collaborative learning is not too widely recognized at the moment. At the same time, mind maps are proved to be a great tool for different kinds of collaborative work between both the teacher and the student and inside a group of students.

Computer-supported mind maps are efficient in organizing all kinds of collaborative processes in various areas: business, education, science and more. A mind map

^{*} Educational experiments with Comapping tools described in this paper were partially funded by Hewlett-Packard and RFFI (grant 08-01-08342).

can easily be sent by email to friends and colleagues and revise it later according to their comments. Some of mindmapping tools: MindMeister, mind42 and others have lots of extra advanced collaboration features. However, all of them lack the ability to handle large diagrams efficiently and visually clearly, which is an essential thing for most educational uses.

This article is focused on how to apply mind maps in Computer-Supported Collaborative Learning (CSCL) [4]. We are going to introduce a software application named Comapping¹, being a pure online mindmapping application. Comapping has numerous advanced collaboration features like real-time collaborative editing, live indication of other users' position, and efficient support for large maps. We are also presenting the results of our experiments to use Comapping-based mind maps to set up efficient collaborative learning processes in Software Engineering Department of Mathematics and Mechanics Faculty of Saint-Petersburg State University.

2 Background

2.1 Computer-Supported Collaborative Learning

Briefly, CSCL is focused on how collaborative learning supported by technology can enhance peer interaction and work in groups, and how collaboration and technology facilitate sharing and distributing of knowledge and expertise among community members [4]. Collaborative learning is in an education process when two or more people learn or attempt to learn something together [5]. There are many interpretation of this concept and it now mostly seen as a general framework unifying lots of different educational methods, approaches and techniques.

It is not easy to decide when and where to start CSCL history. Collaborative learning is the subject of study in a wide variety of disciplines such as developmental psychology (e.g., sociocognitive conflict), social psychology (person perception, motivation, group processes), sociology (status, power and authority), cognitive psychology (how learning occurs, learning outcomes) and sociocultural perspectives (cultural influence on interaction, mediation of learning) [6].

2.2 Mind Maps

The approach was suggested by Tony Buzan in 1970 as an efficient way to work with arbitrary information. The idea is to use a very simple diagramming notation: the central (primary) object is drawn in the middle, and secondary and further objects clarifying the meaning of the central one are put around it and connected together. This makes a radial structure suitable to analyze and understand large amounts of data. The approach is widely used in education, business, psychology and other areas. There are also a number of software tools implementing the approach. More information can be found in [1, 3].

2.3 Mindmapping Tools

In this section we are going to give a brief overview of current online mindmapping solutions and will try analyze them a bit from collaboration learning perspective. This

¹ www.comapping.com

overview is not supposed to be 100% comprehensive as there are more and more applications appearing nearly every day, and it does not seem feasible to cover all of them, but we are going to cover the basic trends and most often used examples.

First, let us list the features we consider most important for collaboration.

Pure online application in a modern highly-heterogeneous cross-platform world, the only reasonable way to communicate is to use online applications. Desktop applications are just not the way to go anymore because the complexity they bring makes the real learning and communication complicated up to useless.

Live collaboration is the key feature for collaboration. It allows people to edit a single map simultaneously in real time, to share maps, and therefore to communicate efficiently.

Export & import to/from other formats allows convert move the data quickly between applications (both online and desktop), providing easy ways to back up, store and integrate data.

Automatic intelligent layout of different kinds as shared maps tends to become large, users need an efficient way to work with these large maps efficiently. As screen space is always limited, applications need efficient ways to handle the problem, leading to different kinds of automatic map layout engines.

Smart printing paper copies are still very important in academic world, and intelligent printing seems to be one of key features.

Based on these criteria we can summarize the popular online mindmapping solutions in the Table 1. We consider the following online applications: MindMeister, Mindomo, Mind42², comparing them with Comapping³.

Table 1. Online mindmapping solutions

Feature/Tools	MindMeister	Mindomo	Mind42	Comapping
Pure online application	YES	YES	YES	YES
Live collaboration	YES	NO	YES	YES
Export/Import	YES	YES	YES	YES
Intelligent auto-layout	Partial	Partial	Partial	YES
Smart printing	NO	NO	NO	YES

As we can see, most tools are quite similar in terms of basic functionality. We can only mention Mindomo not having online collaboration and Comapping’s unique auto-layout and smart printing features.

2.4 Author/Commenter Cycle Review Process SADT/IDEF

In this section we describe wide-known collaborative technique to elaborate visual models which we use for collaborative mindmapping development. This is author/Commenter cycle review process SADT/IDEF [7] in 70s, which was introduced in SADT and after that formalized in EDEF-standards [8] in 90s.

² MindMeister – www.mindmeister.com, Mindomo – www.mindomo.com, Mind42 – www.mind42.com
³ For more information concerning mindmapping tools we would recommend [3].

SADT (Structural Analysis and Design Technique) method is to perform structural analysis of a software system allowing to reduce the number of expensive errors by structuring the knowledge about the system as well as improving the communication between developers and users or customers. SADT was used in ICAM (Integrated Computer-Aided Manufacturing) of US AirForce leading to adopting some part of it as IDEF0 standard and wide adoption of this standard in the US military industry. SADT is not used in software development now, but it is still in active use for business process modeling.

Author/Commenter cycle review process is one of SADT/EDEF. In order to build a usable description of a system in question, we need to evaluate the models quickly by experts and future users. The two primary roles here are author and commenter - the second one being the domain expert. Author is interviewing the commenter to get the necessary information. He is then fixing commenter's comments in the model. The models are thus created in an iterative way until considered ready by the experts.

3 Comapping

3.1 Overview

Comapping (www.comapping.com) is a next-generation collaborative online mind-mapping application. Its basic purpose is to allow users to create, edit and share mind maps. Comapping introduces features like easy drag'n'drop, smooth animation, support for large maps with smart auto-focusing feature, and more. Tree-like notation (left-to-right mindmapping) is proved better for computer-based mindmapping when

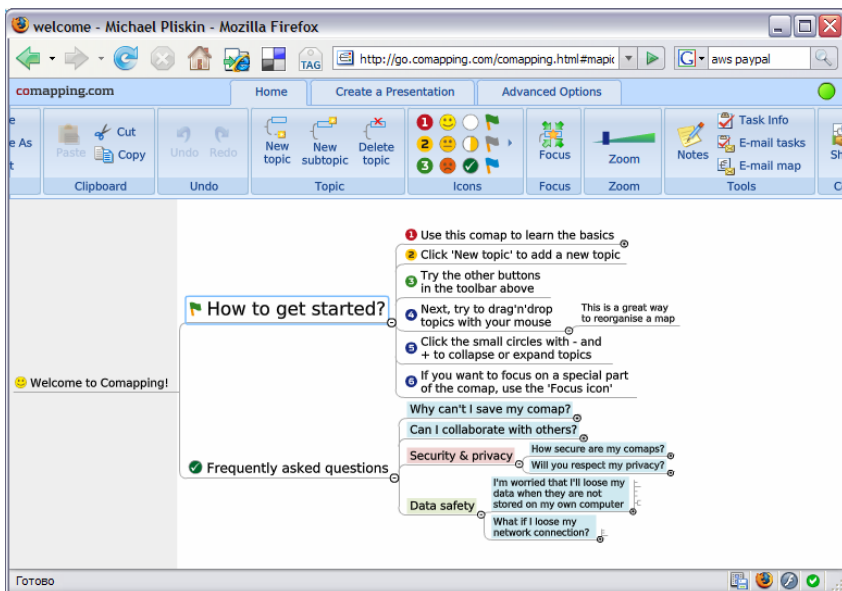


Fig. 1. Example mind map diagram

combined with auto-layout algorithm as it is easier to read and understand than the center-based one, and the intuitive power of the center-based approach goes away when map is no longer static as it is on paper. An example mind map in Comapping is presented in Fig. 1.

Comapping has the following extra features to ease collaboration and active learning:

1. **Pure online application.** This allows users to avoid the hassle of installing the application locally and taking care of mind maps stored as local files as they are kept on the server instead. The application also has built-in communication tools eliminating the need to use external e-mail and/or chat software like Microsoft Outlook or Skype. Users can also work offline for a while if the connection goes down as all their data will be automatically copied to server once it is up again.
2. **Real-time collaborative map editing.** The system allows sharing maps to any number of users, as well as notifying users about map changes. These changes are then highlighted on a map with the detailed information about who and when made each individual change. Other users can then review the changes and leave comments making Comapping a great tool for professors to review their students' work.
3. **Smart, convenient and flexible printing.** Allows a professor to print a number of maps quickly and then review them offline. Multiple printing options (such as fit to page, fit to multiple pages, print parts of map) makes it possible to review even large maps and models with just a sheet of paper.
4. **User-friendliness and ease of use.** People (especially students) do not normally need a user manual or any other documentation everything is intuitive and self-explanatory.
5. **Export/import features.** Ability to insert mind maps into PowerPoint presentations and interoperability with other popular software is a key thing for collaboration as well⁴.

3.2 Implementation Details

Technically, Comapping is implemented as an Adobe Flash application on the client and as a Apache/Neko⁵ application on the server. The client is built using the Model-View-Controller design pattern and is coded using haXe⁶ programming language. Due to the nature of Flash virtual machine, the client is using functional programming concepts like high-order functions and pattern-matching pretty extensively, allowing for simple code performing the complicated tasks. The server is a relatively simple stateless HTTP request processor (providing therefore an excellent scalability), coupled with a database engine.

3.3 Usage Examples

In this section we present several projects done by students using the Comapping tool. These projects include:

⁴ Reader can try Comapping for free to evaluate it herself. The service has an one month free trial.

⁵ <http://www.nekovm.org>

⁶ <http://www.haxe.org>

- An UML quiz designed by students
- A plan of an article to be written by PhD student and his supervisor.

As you can see from the screenshots below, the tool helps to structure the problem, split it into subproblems, and go on with this process for as long as needed. At the same time, other peers can review/augment/comment the work done, and thus perform the task together efficiently.

In case of UML quiz Comapping was used to present a lot of information in a nice group discussion-friendly way. A high-level overview of the quiz is presented on Fig. 2. You can see the first level completely and three more levels of the main branch. The quiz itself appeared to be large and deeply structured, and therefore we needed a tool to create an outline for it and then navigate, change and review this outline easily.

Fig. 3 shows how Comapping can display large models: you can see one of deep levels “focused” allowing the user to concentrate on it and its details, and the left grey area shows the context preventing the reviewer from getting lost in a large diagram.

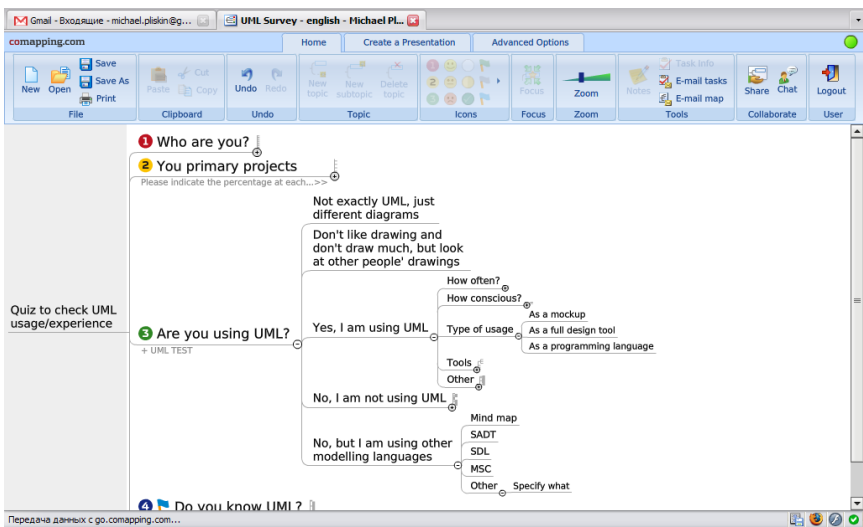


Fig. 2. UML Usage/experience survey

The second example (see Fig. 4) solves a different task. A student has written an article which contained all the necessary information, but the structure was not adequate and sometimes it was not focused properly. The supervisor then restructured the article using a paper-based mind map, and then the student was offered to re-do this mind map in Comapping. The original paper-based mind map was intentionally not very accurate, and some parts were even made unreadable. The supervisor wanted to make the student understand the plan better while converting, actually to make her own new plan using the original one only as inspiration. The obvious reason is that student will need to write a new article according to the plan, and working on your own plan is a lot more efficient compared to working on someone else's plan. The result has been reviewed several times and was finally successfully converted to a

ultimately published good article. The definite conclusion is that the traditional paper-based review loop would take a lot more time and effort for the both parties, and especially for the supervisor, as explaining your position about a heavily detailed and complicated problem to someone else without the right tool is a very difficult task.

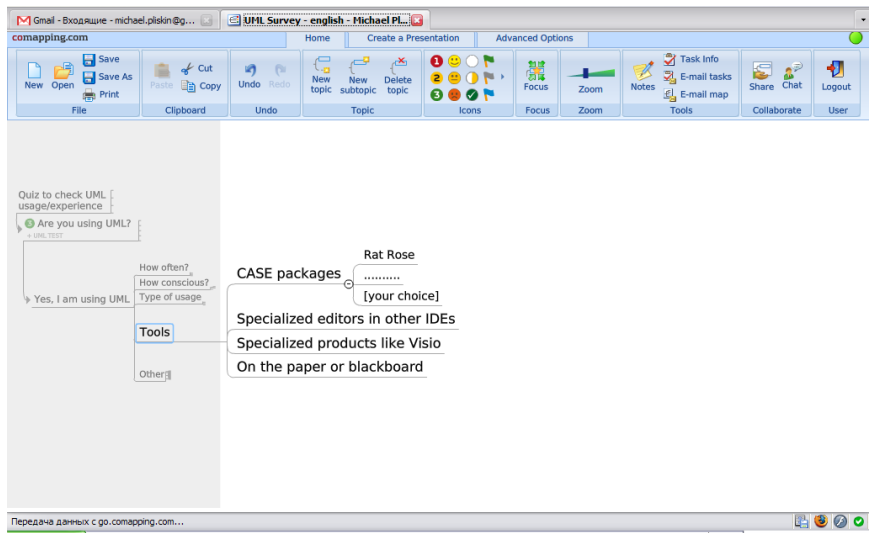


Fig. 3. Details of UML quiz

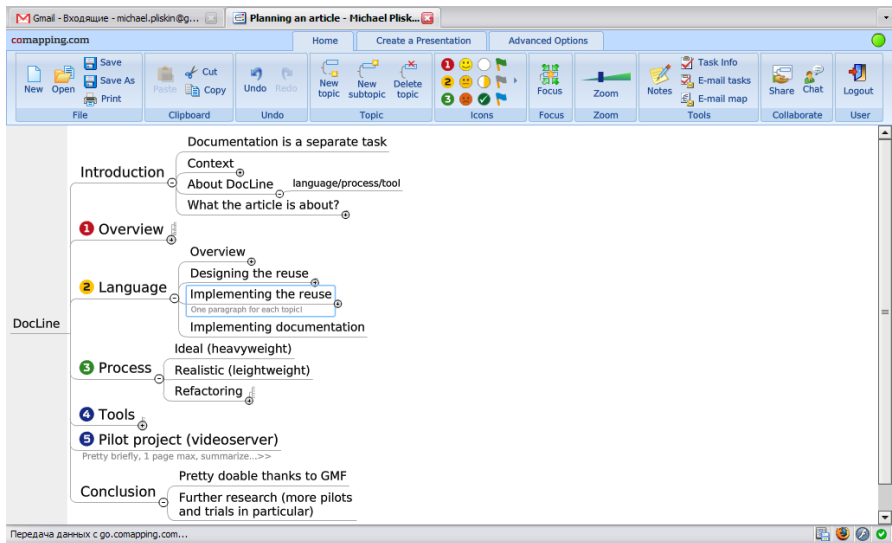


Fig. 4. Planning an article

Fig. 5 shows the real-time collaboration on the mind map of article along with the share dialog used to invite more people to collaborate. You can see also how the tool indicates what other users are doing on a map currently, allowing for even more efficient collaboration and group work (mark «Dmitrij Koznov» near the node «Implementation documentation»).

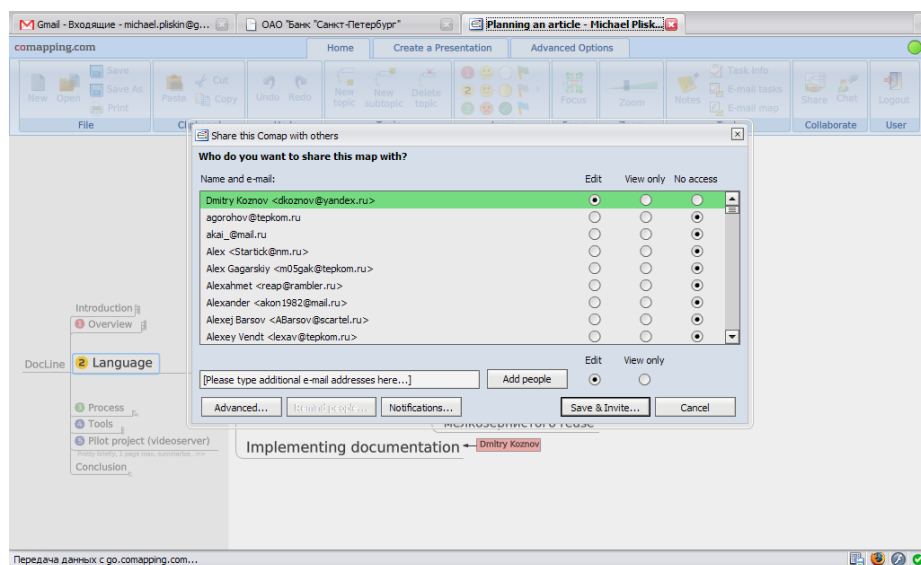


Fig. 5. Collaboration on the article plan

4 Education Experiments with Comapping

4.1 Starting Points

The basic purpose of our experiments was to make collaborative learning processes in Software Engineering Department of Saint-Petersburg State University more efficient and make students more active, involved and committed. This basically applies to seminars, lectures and writing papers of all kinds (term papers, Bachelor, Master and PhD thesis). We realized that the current learning processes are mainly focused on teachers, while students are mostly playing a passive role.

Having looked deeper on the problem, it is easy to realize that most teaching courses consist of two levels. The first level is focused on basic concepts, notions and facts, and requires student mostly to remember some amount of information. The second level is a next step and is focused on understanding, analyzing and (later) practical usage of the knowledge given. This essentially means that while the first level is pretty similar for all students and is perfectly measurable using traditional tools like tests, exams, and simple assignments. The second level, if passed for a student, leads to very student-specific results which are far more difficult to measure using traditional tools. After passing the second level, student comes with her own

understanding and point of view on the area, which might differ significantly from what was given on the lectures and how the teacher thinks about it. This is an essential thing for practical application of knowledge given, and thus is especially important in highly practical areas like for instance Software Engineering.

The problem we are facing then is how to induce and then evaluate student achievements on the second level. We found the mind maps in general and Comapping tool in particular are of a great help here.

4.2 Issues and Solutions

Comapping allowed us to organize learning process more efficiently. The following is a quick summary of the most important things we tried.

1. **Get a measurable result quickly.** This applies to both understanding the lectures and talking to the supervisor. It occurred that a mind map created after a lecture or a talk is a very good measure of what does student actually understand about the subject. Oral communication which is normally used often merely creates an illusion of understanding, and the real picture might reveal only much later. As opposed to that, mind maps created on the spot allow teachers to measure the understanding fast and easily and to explain in detail what exactly is wrong and where to improve. Carefully designed mind map-based assignments not only need students to remember and reproduce the information, but they are much more focused on demonstrating how they understand the material. It is a good practice to focus on relations between different topics or concepts, preferably the ones that are implied from the course material but were not explicitly mentioned. Mind maps then allow to check students on a number of topics much quicker than an oral examination could take (of course sacrificing the quality compared to oral exam). We use this approach for regular tests at the beginning of a lecture to check how the last lecture is understood and in exams. The exam itself worked more like an intensive seminar in this case and could last for several hours, and the best thing was to run a group process, when everybody were working on the same task, but with completely different results.
2. **Organize the iterative collaboration between teacher and students.** There are a lot of situations (on seminars, exams, etc.) when teacher and student intensively communicate with each other. And very often this communication occurs in iterative manner: student gets some information from supervisor and should think over it. In this case mind maps are a good mean for student to reflect her current level of understanding of a subject and for supervisor to check this level and make corrections or comments. Comapping collaborative features allowed us to organize this work into iterations with intermediate reviews by teacher. We used Author/Commenter cycle review process SADT/IDEF by adopting the iterative author-commenter collaboration improving the same mind map. Student is normally acting as author, and teacher is normally a commenter. And thanks to online nature of Comapping we were able to perform this communication over the Internet easily.

3. **Improve paper writing efficiency.** Many students experience considerable difficulties creating their term papers and all kinds of thesis. On the other hand, it is often a time-consuming work for a supervisor to review the papers multiple times during their preparation. Comapping allowed to go from iterative reviews to iterative planning: instead of rewriting the real text many times, a student together with his supervisor is working on a detailed plan of paper. Tree-like expandable structure of Comapping Mind maps with text nodes allows focusing and discussing individual aspects or abstraction layers of a paper while still keeping the overall concept in mind. Online collaborative features allow to use the Internet to share results and notes. As a practical note, mind map-based plans of articles and other writings work best if kept small to fit in just 1 page. This allows for viewing them as a whole and at once without checking the details on different pages. It is similar to One Page Method [9] which is used in business meetings (in project management, research areas etc.) to focus on a given topic. Ability to see the problem as a whole is a must when dealing with complicated information⁷.

The best way to apply mind maps and Comapping is not from the very beginning but when some part of real work is already done and the author now has to understand its meaning and write the text. At this point, the information is usually abundant, not scarce, and thus the author needs to realize what she is focusing on and what has to be left aside. Mind maps are of great help here, but the most important things are not the maps themselves but the thoughts and understanding they in fact induce.

4. **Organize a student groupwork.** Someone just creates a map and shares with everybody including the teacher. Other people are then making changes (all at once or one-by-one as agreed beforehand). The teacher can easily see how actively each individual student is working by looking at her changes, and she can also make her own changes into the shared map. We also use Author/Commenter cycle review process SADT/IDEF. Students are rotating as authors, and teacher and other students are commenters. Each next author has to improve the work of the previous ones, not to start everything from scratch. In order to achieve that the group aligned itself and developed a shared vision before making the initial mind map.
5. **Make the results of students' work publicly available.** Assignments and results made in Comapping appear to be a great material for further teaching. We have the whole libraries of mind maps on different subjects.

4.3 Problems

However, we've also met some problems while using mind maps and Comapping.

1. We have found out that we have to teach our students how to make good maps (not how to use Comapping).

⁷ Reducing a complicated phenomenon to a compact rule is the basic principle of western science. It is also applied in using drawings in construction and engineering, visual modeling, (SADT [7], UML [10], etc.), in software engineering.

2. Sometimes it is more efficient to make maps on paper instead of Comapping. Moreover, we have also used other diagrams (for instance, UML [10]). These changes are often necessary to adapt to specific requirements of some students or courses. For instance, as we are teaching Software Engineering, it was often making sense to use the classical diagramming notations of this domain.
3. Another problem we observed sometimes is that students and teachers often tend to focus on designing and improving the maps themselves (in multiple review-comment-fix cycles). The problem here is to keep focusing on the content, not the form. Sometimes we found ourselves spent a great deal of time making a great map which does not make any sense at all.

5 Conclusions

Our experiments involved about 200 students totally during one academic year. We taught two courses and several seminars using mind maps with Comapping. There are about 30 students that used Comapping to create their term papers and Bachelors/Masters/PhD thesis. We've noticed booming efficiency of collaborative learning processes and student activity, and the entire education process seems to have become more creative and interesting. We are going to continue this experiment, and we do believe that the key thing here is not only to create and facilitate the common approach to use mind maps in Computer-Supported Collaborative Learning, but to stimulate the creative work of both students and teachers. Each course, each lecture, each student can be taught in a highly customized way based on these basic ideas and principles.

We're also going to improve and develop Comapping further to make it better for educators. This includes a bunch of new features (like better notes, support for equations and maths, and many more) as well as co-operating with major educational institutions and industry leaders to promote Comapping usage actively in education area.

References

1. Buzan, T.: The mind map book, 2nd edn. BBC Books, London (1995)
2. Willis, C.L., Miertschin, S.L.: Mind maps as active learning tools. *Journal of Computing Sciences in Colleges* 21(4), 266–272 (2006)
3. <http://mindmapping.typepad.com/>
4. Lehtinen, E., Hakkarainen, K., Lipponen, L., Rahikainen, M., Muukkonen, H.: Computer-supported collaborative learning: A review of research and development (The J.H.G.I Giesbers Reports on Education, 10). University of Nijmegen, Department of Educational Sciences, Netherlands (1999)
5. Dillenbourg, P.: Introduction: What do you mean by collaborative learning? In: Dillenbourg, P. (ed.) *Collaborative Learning: Cognitive and computational approaches*, pp. 1–19. Elsevier Science, Amsterdam (1999)
6. O'Donnell, A.M., Hmelo-Silver, C.E., Erkens, G. (eds.): *Collaborative learning, reasoning, and technology*. Erlbaum, Mahwah (2006)
7. Marca, D.A., McGowan, C.L.: *SADT Structured Analysis and Design Technique*. McGraw-Hill, New York (1988)

8. Integration Definition For Function Modeling (IDEF0). Draft Federal Information Processing Standards Publication 183, 79 p. (1993)
9. Koznov, D.V.: Visual Modeling and Software Project Management. In: Krivulin, N. (ed.) Proceedings of 2nd International Workshop New Models of Business: Managerial Aspects and Enabling Technology, Saint-Petersburg, pp. 161–169 (2002)
10. UML 2.0 Infrastructure Specification (September, 2004), <http://www.omg.org/>