THE USE OF PROJECT MANAGEMENT TOOLS TO SUPPORT THE COORDINATION OF COLLABORATIVE LEARNING

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Abstract: Coordination plays a fundamental role in collaborative learning. When collaboration is supported by computers, automatic coordination mechanisms must be deployed. This paper aims to study the possibility of transfering project management tools commonly used in work contexts to learning contexts. We propose a coordination model that makes the change of area feasible, and that favours learner's autonomy. Two case studies were carried out and a new tool was built in order to test the hypothesis. The results of the current research suggest that project management tools are viable alternatives to automatic coordination support, as long as they are used under a proper paradigm.

1 INTRODUCTION

There is a general agreement that collaboration among students and teachers is an essential instrument in the learning process. According to Johnson, D. W., Johnson, R. T. and Smith K., (2007), cooperative learning is an accepted instructional procedure and it is used worldwide in all levels of education. The same authors sustain that "cooperation, compared with the competitive and individualistic efforts, often results in higher achievements, long term retention of what is learned, critical thinking, creativity in solving problems and more willingness to persist". Although there is still some controversy about the words "collaboration" and "cooperation" (Resta and Lafarriere, 2007), in the present paper, the expression "collaborative learning" is used to describe learning which happens with intensive participation of students who interact with each other and with the teacher for construction of knowledge. According to Dillenbourg, Baker, Blaye and O'Malley (1995), in collaboration the focus is on the mutual engagement of participants and in cooperation the focus is on the division of labor. To the authors, cooperation is achieved by splitting the task into independent sub-tasks, while in collaboration there is a division into intertwined layers. Therefore, collaboration is a term that better defines the active participation of students. But it should be noted that, sometimes (Johnson, Johnson and Smith, 2007), authors use the term cooperation to refer to the same type of process.

The theoretical foundation for advocating the benefits of collaboration in learning can be found in the traditional studies of Vygotsky (Vygotsky, 1998). According to the Russian researcher, collaboration among peers is an essential action for learning, as it expresses the heterogeneity that exists in groups and helps the development of strategies and skills to solve problems due to the cognitive process implicit in interaction and communication. Social interaction is a way to access a wide source of data used as a basis for anyone to develop and learn. Based on Vygotsky, it is possible to state that an individual performs better when he works with more prepared ones. His definition of the Zone of Proximal Development (ZPD) highlights the value of collaboration. He defines ZPD as the distance between the actual level of development, which is identified as the capacity of independently solving problems, and the level of potential development, identified as the capacity of solving problems with aid. Social interaction is, therefore, a way to learn

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and develop. Learning is favored by a collaborative environment. Teacher's mediation, as well as interactions with other colleagues through the learning environment, has positive impact for a better use of the student ZPD. What was only a potential level of development can more easily be achieved. Morishima et al. (2004) summarize the benefits of using a collaborative learning environment through the expressions "learning by teaching" and "learning by observation".

Considering that collaborative learning brings benefits to the cognitive process, it is natural to use information technologies in order to support collaborative activities. The study field that researches the use of computer systems to support collaborative learning is commonly known as Computer Supported Collaborative Learning (CSCL). Over the years, several researchers have been devoted to this subject and a variety of disciplines are related to the issue: psychology, sociology, education. In addition to these disciplines, one central point of research in CSCL is technology. For Järvelä, Häkkinen, Arvaja and Leinonen (2003), the purpose of CSCL is to support students so that they can learn efficiently. According to Suthers (2006), CSCL has an obligation to design technology that effectively supports collaborative learning. According to Soller, Martinez, Jermann and Muehlenbrock (2005), the current focus of research is the identification of computational strategies that positively influence group learning.

There are three main activities in collaborative learning: cooperation, communication and coordination (Singh, 1989; Fuks, Gerosa, Raposo and Lucena, 2004). Without coordination there is no guarantee that tasks will be done in the proper way, at the right time and with necessary resources (Fuks et al., 2004). Coordination is an essential part of collaboration and students need to devote some effort to it (Janssen, Erkens, Kirschner and Kanselaar, 2010; Moguel, Tchounikine and Tricot, 2010; Anaya and Boticario, 2009; Wang and Woo, 2010). Stahl (2004) argues that CSCL systems should be designed, among other things, to support the collaboration and to structure its coordination. Kim and Kim (2008) state that learners need adequate support for the coordination of collaboration. To Hesse (2007) the need for a coordinating structure appears to be even more urgent in computer-mediated settings than in face-to-face ones.

Because coordination plays an essential role in collaboration and collaborative learning environments must provide solutions to that subject (Hesse, 2007; Wang. and Woo, 2010), the usage of project management tools was studied. Those tools have been used for many years in the Computer Supported Cooperative Work (CSCW) context, which has a different focus than CSCL Stahl (2006, page 287). Nevertheless, we believe that CSCL research can take advantage of that technology.

The main question of this study is: "Can a project management tool, initially created to benefit cooperative work, contribute to the coordination of collaborative learning?" In order to test the hypothesis, a coordination model was defined and two case studies were carried out.

2 COORDINATION MODEL

It is possible to coordinate the learning process through collaboration scripts, which are educational models that can structure collaborative learning, outlining the sequence of activities of a group. Roles, phases and activities may be defined (Dillenbourg and Hong, 2008). However, the use of scripts brings with it the risk of restricting collaboration (Dillenbourg, 2002) and the effectiveness of scripting is a highly contested matter (Stahl and Hesse, 2010). Heinze and Procter (2006) conclude that either unguided or very structured collaboration are not satisfactory in a community of practice. It is clear that some balance has to be established. The same idea is corroborated by Schneider (2009).

Although a certain degree of freedom is important for learning communities to develop, activities with highly interdependent tasks are not well coordinated only by social protocol (Fuks et al., 2004). Explicit coordination mechanisms are necessary. Avouris, Margarita and Komi (2003) also support that idea in a study about the use of conceptual maps as collaborative learning environment. They conclude that the use of explicit coordination mechanisms make students argue at the meta-cognitive level of the activity and externalize their strategies, a fact that helps them deepen their collaboration, and lead to improved learning.

When students collectively construct knowledge, it is fundamental to organize what will be realized. Besides the teacher, pupils themselves coordinate their activities. Carell, Herrman, Kienle and Menold (2005) sustain that while teachers are responsible for defining the task, a collaboration plan has to be developed by the students themselves. When students collaborate in a project, even when the ultimate goal is defined by or negotiated with the teacher, steps to achieve such goal are, usually, elaborated by members of the group. Sub-tasks and deadlines are established. The process is reviewed and new directions are taken at some moments. Without planning, collaboration does not happen and the final objective is not achieved.

The definition of sub-tasks allows students to picture more abstract steps and to refine them in a top-down way of thinking. Collaboration is a cyclical process (Fuks, Raposo and Gerosa, 2003) and this kind of top-down definition of tasks reveals this constant renegotiation that leads to the establishment of new tasks. Those mechanisms should not be viewed as a limitation of the collaboration process since the scheme of collaborative work done by those who are collaborating facilitates the attainment of the desired goal. De Graaf, De Laat and Scheltinga (2004) go further in the idea when they argue that there is no need for students to work collaboratively during all the stages of a collaborative task. Tasks can be subdivided and integrated later.

A non-script approach does not imply the absence of structuring. The basic premise is that students, along with the teacher, define a collaboration schema appropriate to the specific context and they organize their activities based on it. In order to use a project management tool to support coordination of collaborative learning it is necessary to define a coordination model that produces collaboration and that is compatible with such tool.

Concerning activity planning and control, project management tools have four main elements: the project, the tasks associated with it, the team members and the team leader (figure1).

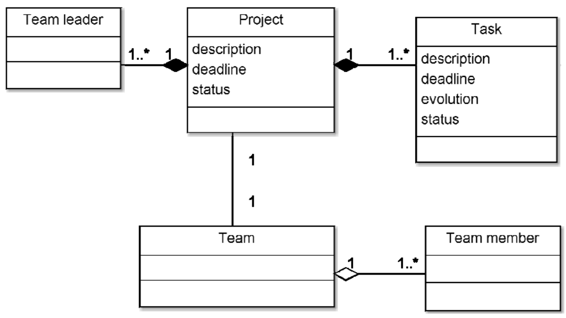

Figure 1: Class diagram of project management tool in CSCW context.

Activity organization consists in defining the project, with goals and deadlines; defining tasks necessary to execute the project, which also have associated goals and deadlines; and controlling execution. The ultimate purpose of teamwork is to build a product and the team leader has a preponderant coordination role (figure 2). The project is not a group construction. It is a corporation choice or a boss decision. Not even task definition is a collaborative activity; it is done by the leader who may consider some suggestions.

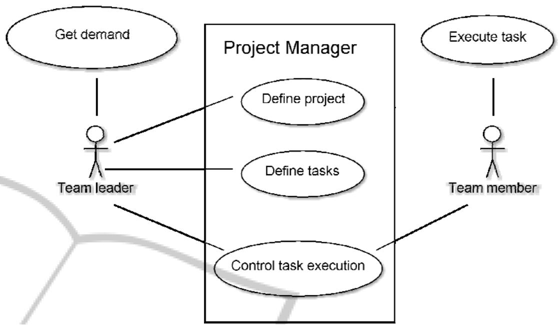

Figure 2: Use case diagram of project management tool in CSCW context.

Clearly, this model may fit into a cooperative, but not into a collaborative work. It corresponds simply to a division of labor regulated by the boss. The team does not elaborate a plan of collaboration and the leader is much more than a facilitator. Considering that students should regulate the coordination of collaborative learning – defining tasks, deadlines, objectives and control points – working like this is inadequate. However, this coordination model, which leads to a cooperative work, is not enforced by the tool. It is the common way to use project management applications.

To be coherent with criteria like interaction, participation and autonomy levels, such coordination model must not be reproduced in collaborative learning. Project management tools need to be used under a new paradigm. A new coordination model is proposed. The proposed model has four main elements: the project, the tasks, the team members and the team leader. Team leader is replaced by teachers and team members by the students. A project is coordinated by one or more teachers, it belongs to a group of students and it has one or more tasks associated (figure 3).

The leading role played by the boss is replaced by the guiding role played by the teacher, and tasks are not communicated to the students, but built by them (figure 4). Students suggest different paths that will conduct to knowledge building and the teacher regulates such paths. The autonomy level of learners will be dynamically determined. As there is no universal balance, the coordination model must allow a flexible role adjustment. There is a predefined coordination schema that allows users to create different collaboration schemas.

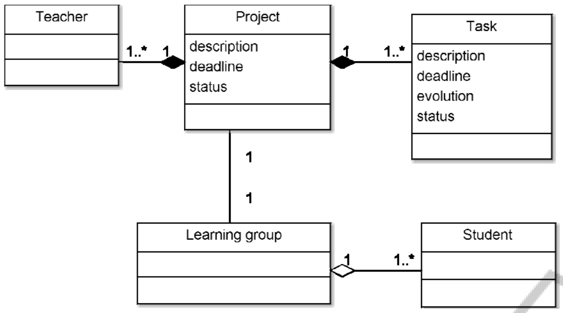

Figure 3: Class diagram of project management tool in CSCL context.

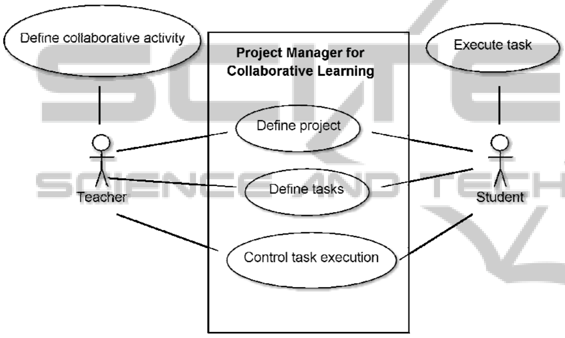

Figure 4: Proposed use case diagram of project management tool for CSCL context.

By claiming that students should have active participation in project definition, we are not affirming that they will define the content to be learned or the skills to be acquired. The teacher has the responsibility to define learning objectives and most suitable activities to accomplish the final goal. Students may propose different activities and the teacher has to decide if they will lead to the intended goals. Figure 5 corresponds to a state diagram of that interaction. The teacher's role is to stimulate discussion and to evaluate whether the proposed project will allow students to actually reach the overall objective. From the definition of an activity by the teacher, students are encouraged to create a project. The teacher assesses whether the project fulfills the goals. If students are not capable of proposing meaningful project the teacher may intervene in the process. Some groups make better use of autonomy than others.

After defining the project, tasks must be detailed. Figure 6 presents the state diagram of the task class. Students create a collaboration model specific to their learning context. It is the teacher's role to verify if the created model is really a collaborative model.

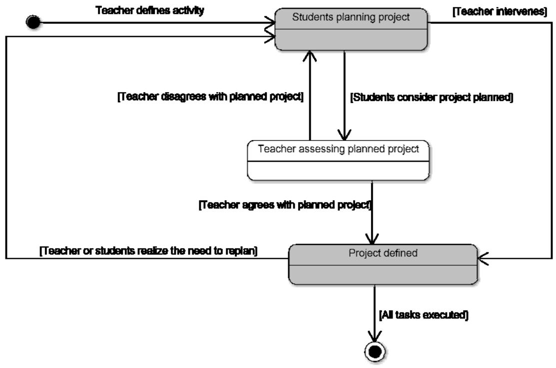

Figure 5: Proposed project state diagram for CSCL context.

Sometimes, it is necessary to redefine tasks.

It is also important to control task execution. Again, students and teachers perform that activity together.

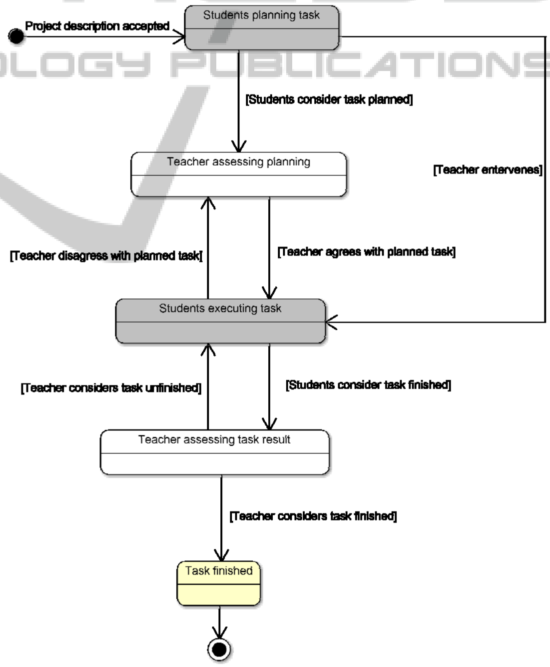

Figure 6: Proposed task state diagram for CSCL context.

3 CASE STUDIES

Two case studies were carried out in order to analyze the use of a project management tool according to the proposed model to support collaborative learning. Both studies were conducted in a post-secondary course that prepares apprentices to work as computer programmers.

In both experiments, students had to use a project management tool in order to coordinate their activities in a distant PHP Programming Language discipline. At the end of the discipline, students should be able to develop computer programs using PHP. The students already had the necessary background to easily learn a new programming language because that discipline was offered in the last semester of the course.

To study the use of a computational tool in collaborative learning it is essential that students and teacher work under this paradigm. Discipline assessment was based on projects that should be realized by groups of two to five students. Group members were chosen by the students with no intervention of the teacher. They should interact among themselves and with the teacher while implementing a system using PHP. The definition of the system was a group responsibility. The teacher controlled if the project would create collaboration and would permit the achievement of the discipline.

3.1 Case Study I

3.1.1 Method

In the first experiment, students were supposed to coordinate their activities using the eGroupware (http://www.egroupware.org) project management tool. Fifty students of a remotely taught programming language (PHP) discipline participated of the study. The majority (82%) had no experience with PHP.

Moodle (http://www.moodle.com) was used as a Learning Management System (LMS). That was not a challenge for the students because they were used to the learning environment. Most of the course disciplines make use of Moodle as a manner of supplying learning objects, defining tasks and communicating with students either synchronously or asynchronously. All fifty students were accustomed to that environment.

Students should use eGroupware to establish objectives, phases, deadlines and responsibilities, as well as to control project progress. The teacher should use it to track activities and intervene when necessary.

At the end of the discipline, all groups presented their finished projects to all colleagues and to the teacher. Afterwards, they answered a questionnaire about the experience. The first four questions were intended to investigate if the project management tool contributed to the occurrence of collaboration and to identify its positive and negative aspects. The last question was meant to identify whether students had any kind of restriction against collaborative learning that could lead to bad results not related to the project management tool.

3.1.2 Results

Only 16% of students would have preferred to do the project individually. And the reasons appointed by those students were:

- Difficulty of organization;
- Lack of participation of colleagues;
- Loss of autonomy.

The case study was thus performed with a group of students prepared to learn the discipline content, used to computer tools and without significant objections to collaborative learning. It is important to notice that the first two items are related to coordination issues.

Although students were stimulated to continuously use the project management tool, its use did not correspond to the expectations. Only five out of twelve groups used the software to plan and refine their projects. Even those groups used eGroupware more as a tool to present the development of the project to the teacher than as a method to coordinate group work. No more than 36% of the students reported frequent use of the tool, but 90% considered it useful. The main aspects that were considered positive were the possibility of structuring and organizing all activities and monitoring the project. These are coordination activities.

The reason for low usage was not, therefore, the lack of usefulness of the project management tool. The most important reasons for not having a continuous use of the tool were the difficulty, the interface and the use of other tools (72%). The fact that these were computer science students, combined with a set of suggestions given by them to improve the system (table 1), lead to the conclusion that the project management tool should be integrated with other communication tools and, preferably, should be part of an environment already known by the student.

Table 1: Students' suggestions to improve eGroupware in CSCL context.

Suggestion	Occurrences	Percentage
Interface	20	57%
Training	5	14%
forum tool	3	9%
version control tool	2	6%
e-mail alerts	2	6%
communication tools	1	3%
link with other tools	1	3%
chat tool	1	3%

Coordination, communication and cooperation must all be integrated to produce collaboration. The use of a single tool to manage one aspect of collaboration was not reasonable for the students. They did not fail to coordinate their activities. They found solutions in other tools that they knew before and that incorporate email, instant messaging and forums.

This case study also revealed the difficulty of performing a deeper analysis of the collaborative process without proper logs. A corporate project management tool stores definitions, phases, deadlines, responsibilities. However, to analyze collaborative learning process one needs to observe the students' proposals, discussions, changes of ideas and even the teacher's interventions. This kind of monitoring is essential for CSCL research and is also important for the assessment of activity progress. A project management tool for educational purposes must have mechanisms to make the whole process more visible. If in the world of work the most important thing is the final product, in collaborative learning the most important thing is the process of knowledge construction, and that process has to be logged.

3.2 Case Study II

3.2.1 Method

Aiming to avoid the limitations faced in the first experiment, a project management tool integrated with Moodle LMS was developed. In this paper, that tool is referred to as CLPMtool (Collaborative Learning Project Management Tool). CLPMtool is a project management plug-in for Moodle that explicitly implements the coordination model proposed in section 2. It also aggregates a Gantt Map, a forum and a chat for the group in the same interface (figure 7).

The second experiment was carried out with eight students divided into three groups. Like in the first experiment, students were supposed to learn

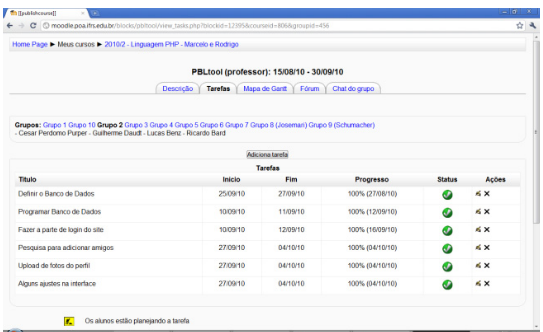

Figure 7: Screen of CLPMtool.

the PHP programming language, and most of them (six) had no experience with the language. The same procedures used in the first experiment, regarding project and task definitions, were used in the second one. Besides the questionnaire answered by students, data were collected from CLPMtool logs. The following actions were registered by the system:

- Project Description View;
- Project Description Edition;
- Project Status Update;
- Task Creation;
- Task List View;
- Task Status Update;
- Task Deletion;
- Gantt Map View.

All these logs are related to coordination activities. The user may be organizing (edition, update, creation and deletion) or controlling (view) the development of collaborative work. Therefore, the observation of those events allows identifying how the tool contributes to the coordination of collaborative learning.

3.2.2 Results

All four groups used CLPMtool and all students found the tool useful. They considered it beneficial to organization, control and communication. Table 2 presents a summary of logs generated by CLPMtool during the experiment.

Table 2: Access made by students and teacher to the CLPMtool in case study II (S =Student, T=Teacher).

Access type	Hit number					
	Group 1		Group 2		Group 3	
	S[1]	T[2]	S	T	S	T
Project Description View	35	11	100	46	64	37
Project Description Edition	1	0	2	0	0	1
Project Status Update	0	1	0	3	0	1
Task Creation	5	0	3	4	0	3
Task Edition	14	2	26	14	14	4
Task List View	44	20	102	74	27	56
Task Status Update	6	6	13	8	3	3
Task Deletion	0	0	1	0	0	0
Gantt Map View	6	0	24	3	4	0
Total	111	40	271	152	112	105

Group 2 had more hits because it had four members. Analyzing planning activities (project description edition, task creation, task edition and task deletion), it is possible to notice a difference of autonomy among the three groups. Group 1 defined its project and all its tasks, group 2 established the project and three out of four tasks, and group 3 had all the activities defined by the teacher. In order to control the evolution of collaborative work, students and teachers often accessed the task list.

Integrating a project manager tool with the virtual learning environment made possible to overcome the problems identified in the preliminary study. CLPMtool logs demonstrate that students effectively used the tool. Values related to task list view, and even Gantt Map view, indicate that students' actions did not limit to produce the requested planning like in the first experiment. Students used CLPMtool to get situated and to control the execution of collaborative process.

Logs also reveal the multiple collaboration schemas produced by the coordination model. While in the most autonomous group (group 1), the number of teacher hits were less than half of students', in the less autonomous group (group 2), the number of teacher hits overcame students'. The same coordination model organized collaborative activities with different equilibrium points between students' freedom and teacher's guidance.

4 CONCLUSIONS

Coordination mechanisms must be deployed to support collaborative learning. Software solutions can help coordination especially with remote students. Project managers found in corporate environments, commonly used to organize cooperative work, seems to be an important alternative, but its use does not guarantee collaborative activities. The coordination model usually associated with such tools does not promote collaboration. Therefore, the pure transposition of project manager tools to an educational context is not sufficient to ensure its utility: it must be applied under a different paradigm.

We consider that the responsibility for coordination is collective; students must be actively involved in structuring their activities, under the supervision of the teacher. Students should suggest collaboration models according to each learning context, avoiding the use of pre-formatted scripts. Therefore, a coordination model that makes use of the existing project manager taxonomy, but favours collaborative work was proposed. That model does not create a rigid collaboration scheme because it does not establish how team members collaborate. Instead, it defines the way students organize their actions. A group of learners can structure their work, with teacher's guidance, in accordance with its objectives, without limiting it to a particular paradigm of collaboration. The coordination model hereby presented permitted that groups with different characteristics could create their own collaboration schema.

The two case studies support the hypothesis that a project manager can help collaborative learning coordination through mechanisms that clarify activity planning and monitoring. The two experiments demonstrated that project management software can be useful in coordinating collaborative learning, as long as they are used under a paradigm that promotes collaboration and that they do not create an interface burden to the students.

Although CLPMtool is just an implementation of the proposed coordination model, it proved to be a valid alternative to promote collaborative learning through Moodle VLE. Future works will try to implement automatic mechanisms that will favor and control the participation of all group members in coordination activities.

REFERENCES

Anaya, A. R. and Boticario, F. G. (2009). Reveal the Collaboration in a Open Learning Environment. *Methods And Models In Artificial And Natural Computation (LNCS 2009 - part 1)*, 5601, 464-475.

Avouris, N.; Margaritis, M and Komis, V. (2003). Real-Time Collaborative Problem Solving: A Study on Alternative Coordination Mechanisms. *Proceedings of the The 3rd IEEE International Conference on Advanced Learning Technologies*. 86-90.

Carell, A.; Herrman, T.; Kienle, A. and Menold, N. (2005). Improving the coordination of collaborative learning with process models. In Koschmann, T.; Suthers, D. and Chan, T. W. (Eds.), *Proceedings of the CSCL 2005* (pp 18–27). Mahwah, NJ: Lawrence Erlbaum Associates.

De Graaf, R.; De Laat, M. and Scheltinga, H. (2004). CSCL-ware in practice: goals, tasks and constraints. In Dillenbourg, P. (Series Ed.); Strijbos J. W.; Kirschner, P. A. and Martens, R. L. (Vol. Eds.), *Computer-supported collaborative learning: Vol 3. What we know about CSCL: And implementing it in higher education* (pp 201-219). Boston, MA: Kluwer Academic/Spinger Verlag.

Dillenbourg, P.; Baker, M.; Blaye, A. and O'Malley, C. (1995). The evolution of research on collaborative learning. In Spada, E. and Reimann, P. (Eds), *Learning in Humans and Machine: Towards an interdisciplinary learning science* (pp 189-211). Oxford: Elsevier.

Dillenbourg, P. (2002). Over-Scripting CSCL: The risks of blending collaborative learning with instructional design. In KirschnerR, P. A. (Ed.), *Inaugural Addres, Three Worlds of CSCL. Can We Support CSCL?* (pp 61-91). Heerlen: Open Universiteit Nederland.

Dillenbourg, P and Hong, F. (2008). The mechanics of CSCL macro scripts. *International Journal of Computer-Supported Collaborative Learning*, 3(1), 5-23.

Fuks, H.; Gerosa, M. A.; Raposo, A. B. and Lucena, C. J. P. (2004). O modelo de colaboração 3C no ambiente aulanet. *Infomática na Educação: Teoria e Prática*, 7(1), 25-48.

Fuks, H.; Raposo, A. B. and Gerosa, M. A. (2003). Do Modelo de Colaboração 3C à Engenharia de Groupware. *WEBMIDIA 2003 - Simpósio Brasileiro de Sistemas Multimídia e Web, Trilha especial de Trabalho Cooperativo Assistido por Computador*, Salvador, nov 2003, 445-452.

Heinze, A.; Procter, C. (2006). Online Communication and Information Technology Education. *The journal of information technology education*, 5, 235-249.

Hesse, F.W. (2007). Being told to do something or just being aware of something? An alternative approach to scripting in CSCL. In Fischer, F; Kollar.; I; Mandl, H and Haake, J. (Eds.), *Scripting computer-supported collaborative learning. Cognitive, computational and educational perspectives* (pp. 91-98). New York: Springer.

Janssen, J.; Erkens, G.; Kirschner, P. A. and Kanselaar, G. (2010) Task-related and social regulation during online collaborative learning. *Metacognition and Learning*, doi: 10.1007/s11409-010-9061-5.

Järvelä, S.; Häkkinen, P.; Arvaja, M. and Leinonen, P. (2003). Instructional support in CSCL. In Kirschner, P.; Strijbos, J. and Martens, R. (Eds.), *What we know about CSCL in higher education* (15-29).

Johnson, D. W.; Johnson, R. T. and Smith K., (2007). The State of Cooperative Learning in Postsecondary and Professional Settings. *Educational Psychology Review,* 19(1), 15-29.

Moguel, P.; Tchounikine, P. and Tricot, A. (2010) Supporting learners' self-organization: An exploratory study. *Intelligent Tutoring Systems*, 2, 123-133.

Kim H. and Kim, D. (2008). The effects of the coordination support on shared mental models and coordinated action. *British Journal of Educational Technology*, 39(3), 522-537.

Morishima, Y.; Nakajima, H.; Brave, S.; Yamada, R.; Maldonado, H.; Nass, C. and Kawaji, S. (2004). The Role of Affect and Sociality in the Agent-Based Collaborative Learning System. In Andre E. et al. (Eds) *Affective Dialog Systems: Tutorial and Research Workshop* (ADS 2004). Springer-Verlag New York Inc. New York, NY. 265-275.

Resta, P. and Lafarriere, T. (2007). Technology in support of collaborative learning. *Educational Psychology Review*, 19(1), 65-83.

Schneider, D. K. (2003). Conception and implementation of rich pedagogical scenarios through collaborative portal sites: clear focus and fuzzy edges. In: *International Conference on Open and Online Learning* (ICOOL), University of Mauritius. Retrieved from: <http://tecfa.unige.ch/proj/seed/catalog/docs/icool03-schneider.pdf>.

Singh, B. (1989) Invited talk on coordination systems. In *Organizational Computing Conference*, Austin, TX, 1989.

Stahl, G. (2004). Building collaborative knowing: elements of a social theory of CSCL. In Dillenbourg, P. (Series Ed.); Strijbos J. W.; Kirschner, P. A. and Martens, R. L. (Vol. Eds.), *Computer-supported collaborative learning: Vol 3. What we know about CSCL: And implementing it in higher education* (pp 53-85). Boston, MA: Kluwer Academic/Spinger Verlag.

Stahl, G. (2006). *Group cognition: computer support for building collaborative learning*. Cambridge, London: The MIT Press.

Stahl, G. and Hesse, F. (2010). A prism of CSCL research. *International Journal of Computer-Supported Collaborative Learning*, 5(2), 137-139.

Soller, A; Martinez, A; Jermann, P. and Muehlenbrock, M. (2005). From Mirroring to Guiding: A Review of State of the Art Technology for Supporting Collaborative Learning. *International Journal of Artificial Intelligence in Education*. 15, 261–290.

Suthers, D. D. (2006). Technology affordances for intersubjective meaning making: a research agenda for CSCL. *International Journal of Computer-Supported Collaborative Learning*. 1(3), 315-337.

Vygotsky, L. S. (1998). *Formação Social da Mente*. São Paulo: Martins Fontes.

Wang, Q. and Woo, H. L. (2010). Facilitating coordination in the collaborative learning process. *2nd International Conference on Education Technology and Compute (2010)*, 1, 1181-1185.