RESEARCH PATHS FOR INTERACTION ANALYSIS IN COMPUTER MEDIATED COMMUNICATION: A STEP FORWARD

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Abstract

Computer Mediated Communication (CMC) tools are a significant constituent of Computer Supported Collaborative Learning (CSCL) approaches. Computer-based Interaction Analysis (IA) aims at analyzing the complex interactions that take place in a computer mediated, collaborative learning activity. Up to date it has been used in various CSCL environments for the support of all or some of the involved actors. The current paper studies the existing work on applying IA methods in communication-based CSCL approaches and attempts to identify the step forward for the corresponding research. Issues related to flexibility, adaptability and interoperability are introduced, in an attempt to distinguish the future trends of the IA research field.

Introduction

In all cases of Computer Supported Collaborative Learning (CSCL), following learning theories, such as constructivism and sociocultural theory or even modern approaches such as Learning Communities, participants' interaction and the need to support and enhance it is highlighted. In this vein, Computer Mediated Communication (CMC) tools are widely used in formal or informal educational contexts, applying principles of constructivism, emphasizing in social interaction during learning activities (Gunawardena et al., 1997). Tools such as discussion forae, chats, blogs, wikis, and even social networking services are used within collaborative learning activities. Towards this direction, supporting mechanisms in the form of adaptive tools addressed directly to the users should be researched (Bratitsis & Dimitracopoulou, 2010). Computer-Based Interaction Analysis (IA) is a research field, focusing on automated analysis of interactions among users, in various collaborative situations (Dimitracopoulou, 2009). The core aim is the implementation of supporting tools for all the involved actors (students, teachers, moderators and researchers). On the other hand, the design and implementation of collaborative learning systems able to adapt to the collaborators' profiles and needs is a significant issue for the research community. User modeling, Activity Patterns and Collaboration Scripting are some of the related research topics.

This paper attempts to connect the research findings of the IA field with the research on systems' adaptability in CSCL settings. The paper is structured as follows: first the IA field is briefly presented, followed by an overview of the state of the art, focusing in the analysis of communication based Technology Enhanced Learning (TEL) activities. Then, the topics of collaborative systems' adaptation, flexibility and interoperability are raised. The concluding discussion attempts to distinguish the possible future trends of the IA research field, while further converging with the CSCL field at a common goal.

Computer-based Interaction Analysis (IA)

IA can be defined as the set of automatic or semi-automatic processes that aim at understanding the computer mediated activity, drawing on data obtained from the participants' activities. This understanding can serve in order to support human or artificial actors to partially undertake control of the activity, contributing to awareness, (self-)assessment or even (self-)regulation. The IA field focuses mainly on collaborative activities, within a learning context. The IA process consists in recording, filtering and processing data regarding system usage and user activity, thus producing analysis indicators. The latter may concern: a) the process or the 'quality' of the considered 'cognitive system'; b) the features or the quality of the interaction product; or c) the mode, the process or the quality of the collaboration when acting in the frame of a social context forming via the technology-based learning environment (Dimitracopoulou, 2009).

The IA results are presented to the participants, as well as the observers of the (learning) activities in an appropriate format (graphical, numerical or literal) interpretable by them. The core aim is to offer the means directly to the human actors so they can be aware of and regulate their behaviour, either as individuals or as cognitive groups. In fact, the IA tools support the users in three major levels: awareness, metacognition and evaluation. The objective is the optimization of the learning activity through: a) refined students' participation via reflection, self-assessment and self-regulation, and b) better activity design, regulation, coordination and evaluation by the teachers.

Reviewing the literature, two main directions exist. The first is that of systems which based on the IA output and considering the profiles and the cognitive processes of individuals or collaborating groups, adapt the learning environment to their own needs and preferences or provide guiding messages, thus facilitating participation and collaboration. In this case, the system makes decisions. The second direction is that of providing information directly to human actors, so as to self-regulate their decisions, actions or behaviour, supporting them in a level of awareness and metacognition. In this case the human actors have the locus of control on the collaborative activity. On one hand collaborating students need supporting information describing their own and their collaborators' actions in order to (self-)evaluate in an operational way both the collaborative/learning process and the quality of the overall activity. On the other hand, teachers need supporting information in order to decide upon teaching strategies, perform corrective interventions, or even formative evaluation of their educational actions.

State of the Art

Several collaborative systems integrating IA tools exist in the literature. Jermann (2004) provided tools to dyads of students and observed them in laboratory settings, thus showing that IA tools facilitated students' self-regulation, during synchronous, game-like simple tasks. The students were involved in a problem-solving situation, having the opportunity to discuss upon their solution strategy through a synchronous chat, while attempting to apply the desired solution at the same time. The provided IA tool assisted them in better regulating their discussion and solution strategy, by designating whether they were just trying out solutions (possibly random) or over-discussing their strategy, at the expense of an actual solution application. Detailed study on teachers' self-regulation in matters of applied teaching design and strategies has been conducted by Petrou (2005) in a context of synchronous modeling activities in school classes. By using tools such as a playback of all the activity and additional monitoring and evaluation tools, teachers were able to decide upon the effectiveness of their teaching strategy and the design of the applied learning activities.

Focusing on asynchronous collaboration communication-based activities, one can find systems like the AulaNet (Gerosa et al., 2005), which produces various diagrams, facilitating teachers' tasks. These diagrams provide condensed statistical information, related to the discussions' metrics (thread depth, messages per logical level, thread width, etc), assisting the teacher to evaluate their evolvement. On the other hand, the MailGroup system (Reyes, 2005) uses Social Network Analysis (SNA) tools, addressed to researchers. By examining structural metrics of the conducted discussions through SNA diagrams, the researchers were able to evaluate the effectiveness of their proposed innovative representation of an asynchronous discussion, which took into account both the logical and the chronological constituents of the messages' sequence.

Moreover, the Knowledge Forum system (http://www.knowledgeforum.com/) provides metacognitive tools, assisting students to reflect upon their performance and improve their learning strategies in problem solving situations. The messages are grouped into logical trees, depicting the thinking strategy followed by collaborating actors in order to solve a given problem. By studying these depictions, as well as utilizing other informative diagrams, one can assess his/her thinking strategy or even the one followed by a collaborating group while solving a problem. The Knowledge Forum has been used by many researchers who have implemented add-on analysis tools, some of which can be used during the learning activity, but they are mainly addressed to the teacher or the researcher. For example, Teplovs et al. (2007) provide a set of indicators for the teachers which are directly linked to the Knowledge Forum environment. These indicators reveal information, such as the “evolution of vocabulary” of the students or visualize “the semantic field of the students’ discussion topics.”

The Argunaut system (de Groot et al., 2007) supports teachers in understanding when to intervene, in order to assist students. Other systems provide interesting visualizations, facilitating students’ participation. For example the i-Bee system (Michozuki et al., 2005) provides the students with a representation of their synchronous, chat-based discussion, using a set of flowers and bees. The bees correspond to students and the flowers to keywords, the use of which indicates the proper orientation of the ongoing discussion. By the flowers’ status (blossomed or closed) and the bees’ direction (facing towards the flowers or not), students could better orientate their discussion by using better vocabulary and staying on topic. Also i-Tree system (Nakahara et al., 2005) uses a tree image to represent structural metrics of a discussion forum. The size of the tree, the width of the stem, the number of the branches, leaves and fruit, as well as the color of the sky, depict the discussion evolvement. These images operated as an alerting mechanism, as well as an additional motivation for the students to increase their activity in the discussions. The tool was addressed to the students.

The DIAS system is more focused on both asynchronous discussions and the IA field (Bratitsis & Dimitracopoulou, 2008, 2009, 2010). It provides an extensive set of IA indicators, addressed to all the involved actors of discussion learning activities. Students were able to regulate their actions, better understand the scope of the discourse activity or even coordinate their collaboration more effectively. Teachers were able to detect situations which required regulative interventions, but also evaluated students’ participation and assessed the overall discussions by using the IA tools. Furthermore, researchers were aided in analyzing complex social phenomena within such learning activities. The research was conducted with adult learners (Bratitsis & Dimitracopoulou, 2010), as well as 3rd grade students (Bratitsis & Kandroudi, 2010). Finally, IA tools have been implemented in order to support the collaborating members of a Community of Practice, such as the Kaleidoscope Network of Excellence (Bratitsis et al., 2008), in matters of enhancing social queues and supporting decision making processes.

Most of the existing IA approaches are related to collaborative, communication based activities, usually within a learning context. An additional subcategory is that of systems, providing indicators based on analysis of the discussions’ content, like the CALICO system (Giguet et al., 2009). All the aforementioned examples constitute a representative set of the existing approaches in the IA research field. They are applied to communication based activities, based on an abstract issue, such as a forum topic. Up to now, there are no IA approaches, applied to dynamically alterable communication queues, such as the ones feasible with media annotation systems. In the latter case, a unique communication queue can be initiated in every instance of an annotated video file or every portion of annotated pictorial data. Even in such cases, the communication queues may be split to more than one, separate queues, by distinguishing new initiation points in subsequent annotation targets. For that matter, the set of IA tools integrated into the DIAS system were used to analyze students' participation in blogging systems (Bratitsis, 2010a). The results indicate that the conclusions drawn by several of the produced diagrams can be applied in blog-based activities, facilitating the teacher's evaluation tasks. The latter research is still ongoing.

Adaptation in CSCL

Adaptive educational systems adjust the content's presentation and/or the navigation to a student's model. Personalization (or adaptation) is the process of adapting a computer application to the needs of specific users and takes advantage of the acquired knowledge about them (Gasparini & Lichtnow, 2009). A common adaptation method is that of customizing the User Interface taking into account the student model in consideration, thus adjusting to the perception better fitting the student's needs. This technique copes with what Brusilovsky (1998) refers to as *curriculum sequencing*. According to this notion, either the next concept or topic to be taught is determined or the next task to be carried out. Correlating these approaches, the technique remains the same. The content of a web page or the User Interface is correspondingly adjusted, implementing an *adaptable presentation technology* (Bruisilovsky & Peylo, 2003). Another technique is that of producing guiding or recommendation queues for the students, supporting them in better understanding the learning activity goals. In the case of problem solving situations, these queues can be related to the produced solution (Bruisilovsky, 1998), as well as the solving process. In the former situation comments and advice is provided regarding the correctness of the provided solution, comparing it to the ideal (or the only correct) one. In the latter situation, intelligent help can be provided to the students throughout all the intermediate steps, towards the final solution, utilizing several techniques, such as the use of agents (Bruisilovsky, 1998). *Adaptive collaboration support* aims at supporting collaboration using system's knowledge about different users (stored in user models). In these cases, research focuses in group formation (Hoppe, 1995), peer attribution and peer help (McGalla et al., 1997), and virtual peers and class monitoring (Chan & Baskin, 1990; Oda et al., 1998). In all cases, adaptation is implemented by comparing the actual situation to the ideal situation and then instructing the system to act accordingly.

Flexibility and Interoperability of IA Tools

CSCL approaches are nowadays widely used in education. Furthermore, the Internet has been gradually transformed into a platform of collaboration in which every user actively participates in the construction of meaningful content. Web 2.0 tools, such as blogs, wikis and social networking services, are used also in everyday life, mainly for communicative (direct communication and/or information exchange) purposes. In fact, the term *Education 2.0* has been used in the literature in order the integration of Web 2.0 tools in educational approaches.

In all cases communication, especially in written language form is a fundamental constituent. Communication among collaborating actors is a prerequisite in order to achieve information exchange, argumentation and expression of their thinking processes, rationalization of their actions and finally common knowledge acquisition (Dillenbourg, 2002). On the other hand, such communication is often difficult to achieve, as the collaborating actors, especially younger ones, often lack the necessary dexterities (Soller, 2001). For that matter, several techniques have been proposed in order to facilitate argumentation and the development of constructive dialogues (Jermann et al., 2004). For example, *sentence openers* have been widely used (e.g., Knowledge Forum), as well as types of messages operating as declaratory actions (e.g., DIAS, AulaNet). These approaches assist students to develop argumentation dexterities such as the ability to formulate questions, argumentation, negotiation, and coordination (Andriessen et al., 2003). According to the literature, this type of dialogue structuring contributes to the development of communication dexterities, but also allows the automated dialogue analysis, as well as the evaluation of the actors' interaction and the development of regulative mechanisms (Andriessen et al., 2003; Jermann et al., 2004). Nevertheless, the proposed techniques are not always used properly by the collaborators, thus further designating the need for additional supporting tools. These can be found in the literature in the form of advisory mechanisms (e.g., Baros & Verdejo, 2000) or IA indicators (e.g., Bratitsis & Dimitracopoulou, 2010).

Furthermore, when designing collaborative learning activities, the development of the collaboration platform and the communication tool is not enough. Strategic design and constant effort to sustain collaboration on a desired level are necessary in order to fully exploit the electronic medium (Hiltz, 1997). On the strategic planning level, the use of *collaboration scripts* has been proposed as a solution (Fischer et al., 2007). Furthermore collaborating actors formulate different cognitive systems, usually having different informational and supporting needs, so as to sustain a high collaboration level (Dimitracopoulou, 2008). Also a teacher has increased informational needs for monitoring learning activities and intervene whenever it is necessary or even evaluating the cognitive processes and/or the learning outcome. Finally a researcher has more complex data analysis needs. In all these cases, similar collaboration and communication tools can be used in diversified manners. Thus, *flexibility* is an important issue. A tool should be developed so as to be used by different types of users and cognitive schemas (individually and collaboratively), different types of activities and collaboration settings, as well as to serve different informational and analysis needs.

One concrete conclusion is that supporting tools seem to be necessary for improved collaboration. On the other hand, one may find numerous communication tools, such as asynchronous discussion forae, chat tools, blogs, wikis, and instant messaging tools. Furthermore, a wide variety of software is available in order to implement all these types of communication via electronic means. Some of them are Open Source Software, allowing code modification, Free Software or even ad hoc solutions, usually integrated as parts of wider systems (e.g., Content Management Systems – CMS). Although the operation logic of these tools is always the same (for example in a discussion forum, discussants exchange messages asynchronously, which are published in a common web page), there are significant structural differences, mainly due to the underlying technology. For example, in asynchronous discussion forae, a database system is often used for storing and accessing the posted messages. The structure of the database (tables and relations) is usually different in every available forum platform, especially in the Free–Open Source platforms or even not available, especially in the case of forum tools being integrated as a subsystem in wider collaboration platforms, such as CMS. This is usually due to the fact that most of the available software has not been developed for strictly educational purposes, but have a different target group. Nevertheless, they are used by educators for learning activities. Furthermore, the underlying technology may significantly vary among similar systems (e.g., different programming language, web service or even operating system), increasing the diversity of the available software and thus the difficulty in developing common analysis tools. For such tools to be used for analyzing educational activities, despite the technological tool used to implement the activities, *interoperability* is a key issue. It can be achieved, for example, by developing analysis tools able to collect activity data from diverse systems, using proper parsing filters and techniques.

Discussion

The current paper attempts to discuss upon the possibility of further converging the IA and the CSCL research fields, focusing on communication-based collaborative learning activities. Examining the IA field's literature several approaches can be found, emphasizing in the implementation of supporting analysis tools for the teacher, as well as the students. One of the field's current trends is that of supporting students on a metacognitive level, so as to self-regulate their actions (Dimitracopoulou, 2009). In fact, the research conducted with the DIAS system is consistent with this trend, having a significant differentiation; the research was conducted in real teaching settings (in situ). For example, the findings of the research conducted with the DIAS (Bratitsis & Dimitracopoulou, 2009) and the AulaNet (Gerosa et al., 2005) systems seem to be complementary. Likewise, all the approaches presented in the State of the Art section describe positive outcomes when using IA, visualized tools. In some cases the research was conducted in laboratory settings and in other cases in real teaching settings. Despite the context of research implementation, the research findings point to the same direction in almost all cases: visualized IA tools facilitate collaborative learning activities. Thus one could argue that this conclusion is concrete enough, so as to advance the corresponding research one step forward.

Given the diversity of the available communication software and the educational approaches, *interoperability* and *flexibility* are the important issues to examine. On the former issue, it is a matter of implementing collaborative and/or analysis tools, able to inter-communicate. Technologies such as parsers and XSLT filters could be implemented by collaborating researchers, in order to allow data exchange among diverse systems. An ideal situation would be the design and development of autonomous analysis toolkits which could operate as “black boxes.” These toolkits could receive input data from the most commonly used communication software (e.g., wordpress blogging system, phpBB forum system), thus fulfilling the need of the researchers to develop new, similar tools as ad hoc solutions, for every designed research approach. On the other hand, these toolkits should provide distinct sets of IA indicators for all types of users (students, teachers, researchers) and educational settings (collaboration script(s), group formation, etc.). For that matter, sharing of expertise and educational strategies is necessary, not only through the literature, but through international researchers’ collaboration. The technology is mature enough to allow such collaboration through Web 2.0 tools.

Regarding the later issue, adaptation seems like a logical succession in research. The utilization of IA indicators by the students in order to self-regulate their actions relieved the work load of a moderator, usually the teacher, in many cases (Bratitsis, 2010b). Adapting the communication tool to the student’s needs could further facilitate self regulation, so as to improve the communication outcome by enhancing the prerequisites for a fruitful dialogue. This can be achieved by implementing User Interface adjustments and utilizing IA indicators’ *Interpretative approaches* for designing alerting and/or advisory mechanisms (Bratitsis, 2010b), thus facing some of the issues discussed in the previous section. In a way, this type of adaptation takes advantage of the students’ activity patterns in order to facilitate the teacher’s goals, when acting as a discussion moderator. Furthermore, the existing tools should be tested in real teaching settings, under different educational conditions. For that matter, the exchange of data among researchers could be helpful. The validity of their findings should be generalized, via their verification in different settings. For example, the IA indicators of the DIAS system seem to function adequately for the teacher, when trying to valuate students’ participation, in the case of a blogging system too (Bratitsis, 2010a). More tests in this direction should be attempted.

Of course the design and implementation of several case studies is necessary in order to verify this hypothesis.

References

Andriessen, J., Baker, M., & Suthers, D. (2003). Argumentation, computer support, and the educational context of confronting cognitions. In J.

Andriessen, M. Baker, & D. Suthers (Eds.), *Arguing to learn. Confronting cognitions in computer-supported collaborative learning environments*, (pp 1–25). Kluwer Academic Publishers.

Barros, B., & Verdejo, M. F. (2000). Analysing student interaction processes in order to improve collaboration. The DEGREE approach. *International Journal of Artificial Intelligence in Education*, *11,* 221–241.

Bratitsis, T. (2010a). Using computer-based interaction analysis tools for evaluating blog participation in tertiary education: An exploratory proposal. In K. Fernstrom (Ed.), *Readings in technology and education. Proceedings of ICICTE* (pp. 269–278). Abbotsford, BC: UFV Press.

Bratitsis, T. (2010b, November). Thoughts on utilizing Interaction Analysis for adaptable asynchronous discussion platforms in collaborative learning activities. *International Conference on Intelligent Networking and Collaborative Systems, 2010. INCOS'10*, Thessaloniki, Greece.

Bratitsis, T., & Dimitracopoulou, A. (2008). Interpretation issues in monitoring and analyzing group interactions in asynchronous discussions. *International Journal of e-Collaboration*, *4*(1), 20–40.

Bratitsis, T., & Dimitracopoulou, A. (2009, June). *Studying the effect of interaction analysis indicators on students' selfregulation during asynchronous discussion learning activities.* 8th International Conference on Computer Supported Collaborative Learning, CSCL2009, Rhodes, Greece

Bratitsis, T., & Dimitracopoulou, A. (2010). Interpretation of computer based Interaction Analysis indicators: A significant issue for enhancing collaboration in technology based learning. In N. Kock (Ed.), *Interdisciplinary perspectives on e-collaboration: Emerging trends and applications*, (pp. 31–59). Hershey, PA: IGI-Global.

Bratitsis, T., Dimitracopoulou, A., Martínez-Monés, A., Marcos, J. A., & Dimitriadis, Y. (2008). Supporting members of a learning community using Interaction Analysis tools: The example of the kaleidoscope scientific network. In P. Diaz, Kinshuk, I. Aedo, & E. Mora (Eds.), *The 8th IEEE International Conference on Advanced Learning Technologies (ICALT 2008)* (pp. 809–813). IEEE Computer Society.

Bratitsis, T., & Kandroudi, M. (2010, November). *Improving 3rd grade students' writing ability via asynchronous discussions: A case study.* International Conference on Intelligent Networking and Collaborative Systems, Thessaloniki, Greece.

Brusilovsky, P. (1998). Adaptive educational systems on the WWW: A review of available technologies. In G. Ayala (Ed.), *Proceedings of Workshop Current Trends and Applications of Artificial Intelligence in Education, 4th World Congress on Expert Systems*, (pp. 9–16). Mexico City: ITESM.

Brusilovsky, P., & Peylo, C. (2003). Adaptive and intelligent web-based educational systems. *International Journal of Artificial Intelligence in Education*, *13,* 159–172.

Chan, T. W., & Baskin, A. B. (1990). Learning companion systems. In C. Frasson & G. Gauthier (Eds.), *Intelligent tutoring systems: At the crossroads of artificial intelligence and education* (pp. 6–33). Norwood: Ablex Publishing.

De Groot, R., Drachman, R., Hever, R., Schwarz, B., Hoppe, U., Harrer A., et al. (2007). Computer supported moderation of e-discussions: The ARGUNAUT approach. In C. Chinn, G. Erkens, & S. Puntambekar (Eds.), *Proceedings of the International Conference CSCL* (pp. 165–167). Rutgers, The State University of New Jersey, USA.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed.), *Three worlds of CSCL. Can we support CSC* (pp. 61–91). Heerlen: Open Univiversity Nederlands.

Dimitracopoulou, A. (2009). Computer based interaction analysis supporting self-regulation: Achievements and prospects of an emerging research direction. *Technology, Instruction, Cognition and Learning, 6*(4), 291–314.

Fischer, F., Kollar, I., Mandle, H., & Haake, J. (2007). *Scripting computer supported collaborative learning: Cognitive, computational and educational perspectives*. Springer editions.

Gasparini, I., & Lichtnow, D. (2009). Quality ontology for recommendation in an adaptive educational system. *International Conference on Intelligent Networking and Collaborative Systems, 2009. INCOS'09*, (pp. 329–334), Barcelona, Spain.

Gerosa, M. A., Pimentel, G. P., Fuks, H., & Lucena, C. (2005). No need to read messages right now: Helping mediators to steer educational forums using statistical and visual information. In T. Koschmann, T. Chan, & D. Suthers (Eds.), *Proceedings of Computer Supported Collaborative Learning 2005: The Next Ten Years!* (pp. 160–169). USA: ISLS, LEA editions.

Giguet, E., Lucas, N., Blondel, F.-M., & Bruillard, É. (2009). Share and explore discussion forum objects on the Calico website. In A. Dimitracopoulou, C. O'Malley, D. Suthers, & P. Reimann (Eds.), *Computer Supported Collaborative Learning Practices: CSCL 09 Community Events Proceedings* (pp. 174–176). International Society of the Learning Sciences.

Gunawardena, C., Lowe, C., & Anderson, T. Analysis of global online debate and development of interaction analysis model for examining social construction of knowledge in computer conferencing. *Educational Computer Research*, *17*(4), 397–431.

Hiltz, S. R. (1997). Impacts of college level courses via asynchronous learning networks: Some preliminary results. *Journal of Asynchronous Learning Networks*, *1*(2).

Hoppe, U. (1995). Use of multiple student modelling to parametrize group learning. In J. Greer (Ed.), *Proc of AIED'95, 7th world Conference on Artificial Intelligence in Education* (pp. 234–249).

Jermann, P. (2004). *Computer support for interaction regulation in collaborative problem-solving*. PhD dissertation, University of Geneve, Switzerland.

Jermann, J., Soller, A., & Lesgold, A. (2004). Computer software support for CSCL. In J. W. Strijbos, P. A. Kirschner, & R. L. Martens (Eds.), *What we know about CSCL and implementing it in higher education* (pp. 141–166). Kluwer Academic Publisher.

McCalla, G. I., Greer, J. E., Kumar, V. S., Meagher, P., Collins, J. A., Tkatch, R., & Parkinson, B. (1997). A peer help system for workplace training. In B.D. Boulay & R. Mizoguchi (Eds.), *Artificial intelligence in education: Knowledge and media in learning systems* (pp. 183-190). Amsterdam: IOS.

Mochizuki, T. et al. (2005). Promotion of self-assessment for learners in online discussion using the visualization software. In T. Koschmann, T. Chan, & D. Suthers (Eds.), *Proceedings of CSCL 2005*, (pp. 440–449). USA: LEA editions.

Nakahara, J. et al. (2005). iTree: Does the mobile phone encourage learners to be more involved in collaborative learning? In T. Koschmann, T. Chan, & D. Suthers (Eds.), *Proceedings of CSCL 2005*, (pp. 470–478). USA: LEA editions.

Oda, T., Satoh, H., & Watanabe, S. (1998, August). Searching deadlocked Web learners by measuring similarity of learning activities. *Proceedings of Workshop "WWW-Based Tutoring" at 4th International Conference on Intelligent Tutoring Systems (ITS'98),* San Antonio, TX.

Petrou, A. (2005). *Teachers' roles and strategies during usage of technology based collaborative learning environments, in real school conditions*. PhD dissertation, School of Humanities, University of the Aegean, Rhodes, Greece.

Reyes, P. (2005). *Structural awareness in mediated conversations for collaborative learning environments*. PhD dissertation, Université du Maine

Teplovs, C., Donoahue, Z., Scardamalia, M., & Philip D. (2007). Tools for concurrent, embedded, and transformative assessment of knowledge building processes and progress. In C. Chinn, G. Erkens, & S. Puntambekar (Eds.), *Proceedings of the International Congress CSCL 2007: Computer Supported Collaborative Learning: Mice, Minds and Society* (pp. 720–722). USA: ISLS Inc.