Guest Editorial: Special Issue on Intelligent and Innovative Support Systems for CSCL

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Computer-supported Collaborative Learning (CSCL) is an interdisciplinary research field that gathers researchers from different backgrounds around one common goal: to facilitate the design, deployment, and analysis of collaborative learning activities whose participants (primarily, students and instructors) are supported by information and communication technologies. CSCL researchers attempt to understand how learning emerges in group settings, and how to create effective scenarios that enable learning through interaction, exploration, negotiation, discussion, and collaborative knowledge construction. Thus, CSCL has contributed to the development of the Learning Sciences by bringing into focus the need to understand the nature, theory, and practice of how we learn in collaborative settings supported by advanced technologies.

Research in CSCL consists of four key dimensions that are the basis of the acronym C-S-C-L:

- **Computer.** Technology (i.e., computer hardware and/or software) plays a major role in changing the traditional view of education by creating the next generation of environments and infrastructures that enable new forms of learning and increase collaboration and educational opportunities to meet students’ needs in the 21st century. New tools to facilitate collaboration, better methods of analyzing students’ interactions, and effective ways to group students are some examples of the benefits that technology brings to the field.

- **Supported.** The term “Supported” refers to both pedagogical and technological support. To enhance collaborative learning, the interaction processes among students need to be well thought out and well structured. Furthermore, teachers need to continually assess students and groups in order to provide formative feedback and better guidance (e.g., scaffolding). Pedagogical support to create collaboration scripts and methods for group assessment is fundamental. Similarly, many other tasks that are already in use or are expected to be adopted by education practitioners will have a stronger impact upon learning if they are compliant with educational research findings. However, conducting these tasks in practice is quite difficult and time-consuming. Therefore, large-scale and effective deployment of collaborative learning can be better achieved through computational support as described above.

- **Collaborative.** In CSCL, collaboration plays the central role in the learning process. Students can learn collaboratively in many different ways: by engaging in argumentation and negotiation activities, sharing ideas, proposing different perspectives to solve a problem, discussing and reaching group consensus, and creating artifacts together with other people. To understand collaboration, researchers have studied the collaborative process as either a process that needs to be designed and managed or as an artifact that needs to be analyzed and understood. Many findings have shown that, in some situations, group learning may take longer, but the knowledge and skills acquired are much deeper and last longer if compared with individual learning [2]. However, grouping students together without any support often fails to create a nurturing, productive learning environment. Therefore, structured interactions and adequate group formation based on theoretical foundations are the keys to increase the chances of fruitful collaboration among peers [1].

- **Learning.** The ultimate goal of any educational technology, pedagogical method, or theory of learning/instruction is to help students learn. Learning is not always a straightforward process where it is possible to write a single recipe. Nonetheless, it is possible to influence the conditions that increase the chances of learning to occur. The emergence and widespread adoption of collaboration technologies that enable people to collaborate anytime and anywhere, and the creation of better and more robust pedagogies and theoretical frameworks to support collaborative learning, have opened numerous new
opportunities for students to engage in well-planned group activities and, through meaningful interactions, gradually construct their knowledge.

This special issue adds one more dimension, "Intelligence," to the four dimensions presented above. In the field of artificial intelligence (AI), the term intelligence is broadly used to indicate that a system can change its behavior in order to maximize the chances of attaining specific goals (e.g., helping students to learn) by taking into consideration characteristics of the environment (e.g., learning states of students). This is particularly interesting in the field of education, where each student has the potential to learn better if the content and/or activities are adapted and personalized to meet the student’s learning strategies and individual needs.

Currently, technologies based on AI have reached a level of maturity that enables successful application in supporting learning in innovative and intelligent ways. In individual learning, research on Intelligent Tutoring/Training Systems has been using AI as the foundation to provide better computer-based learning experiences. In CSCL, the use of AI has grown over the past decade and opened novel and interesting opportunities for enhancing each of the four dimensions of CSCL. Examples of AI technology applied to CSCL include better tools for argumentation and interaction analysis, new and smart ways to provide help through peer tutoring, adaptive user interfaces to facilitate group work, frameworks that facilitate the use of pedagogical/theoretical knowledge in computing systems, intelligent authoring tools for CSCL script design, and software agents that help students to interact [3], [4]. Nevertheless, the CSCL community is still searching for the best ways to leverage AI technologies to support group learning. Some of the challenges in embedding AI in CSCL systems include the need to compute the knowledge state of many students concurrently, proposing well-founded group formations that lead students to attain their individual and group goals, and designing and supporting interactions (actions, dialogues, interventions, etc.) as well as predicting their effects on learning in real time. To develop innovative intelligent systems for CSCL, we need to rethink what is considered state-of-the-art in AI technologies and push the research trends in CSCL towards a new generation of technologically and pedagogically sophisticated systems capable of supporting effective collaborative learning.

In this direction, the special issue on Intelligent and Innovative Support for CSCL aims to bring together researchers from both AI and CSCL communities to share their visions of the next generation of pedagogical approaches, intelligent technologies, and the systems and tools that will enable robust learning through collaboration. In the search for innovation, the guest editors’ view was that analysis, theoretical modeling, and promising pieces of technology can all be considered contributions to the field. Although some evaluation is necessary to prove the usefulness and validity of a contribution, the guest editors were flexible on this point in order to gather the best innovations in the field that will inspire future researchers to create powerful intelligent CSCL applications.

We received a total of 33 submissions which covered a wide range of topics related to both AI and CSCL. Eight of them were accepted and their summaries are provided in the next paragraphs.

In the opening paper, “Adaptive and Intelligent Systems for Collaborative Learning Support: A Review of the Field,” Ioannis Magnnisalis, Stavros Demetriadis, and Anastasios Karakostas provide an important critical review of the recent literature on intelligent and adaptive systems for collaborative learning support. The authors evaluated 105 scientific articles, classified them according to five key factors (Pedagogical objective, Target of Intervention, Modeling, Technology, and Design space), and summarized empirical evidence about the benefits of AI and its adaptation in CSCL systems for students’ learning. Finally, the authors also described the current trends in the field, such as the use of Social Semantic Web technologies, the efforts to combine AI and ubiquitous learning to create better collaborative learning spaces, and the creation of advanced system frameworks and architectures that facilitate the orchestration of collaborative learning activities.

The following paper discusses the architecture of a system that supports collaborative learning, and is presented by Rohit Kumar and Carolyn P. Rosé. In “Architecture for Building Conversational Agents that Support Collaborative Learning,” Kumar and Rosé introduce Basilia, a flexible and powerful architecture for creating agents that can communicate with students and provide guidance, personalized feedback, encouragement, and scaffolding, among other types of interactions. Built upon solid empirical work that has demonstrated strong learning effects (resulting from Basilia’s adaptive support), the Basilia has been extended to enable the deployment of conversational agents (CA) in rich group learning situations, to offer flexible representation capability to produce agents’ behaviors, to enable complex interaction dynamics among agents and users, and to offer the systematization of the CA’s development process. To illustrate some of the unique characteristics of the architecture, the authors presented its use in three educational systems, namely CycleTalk Tutor, WrenchTalk Tutor, and PsychChallenge Peer.

In their paper entitled “Enrichment of Peer Assessment with Agent Negotiation,” Chung Hsien Lan, Sabine Graf, K. Robert Lai, and Kinshuk present a framework that combines agent negotiation and fuzzy constraints to facilitate and enhance peer assessment. In the authors’ approach, discrepancies between assessment results are managed by creating fuzzy constraints that take into consideration imprecision and uncertainty during the assessment process, as well as students’ personal characteristics (e.g., social styles, learning styles, preferences, and experiences). These constraints are used as the foundation for a negotiation mechanism that helps software agents coordinate the interactive assessment process. The proposed framework helps students reflect on their own work and produce detailed, informed, and less biased assessments. Through an experiment with 54 college students, the authors show that collaborating students can reconcile their differences, reach agreement more smoothly, and foster their critical thinking skills.
A small number of intelligent CSCL support systems have been extensively designed, developed, and tested for over a decade. In “Lessons Learned from Comprehensive Deployments of Multiagent CSCL Applications I-MINDS and ClassroomWiki,” Nobel Khandaker, Leen-Kiat Soh, Lee Dee Miller, Adam Eck, and Hong Jiang summarize their seven-year experience in developing and deploying three generations of CSCL support systems and compile useful lessons that could serve as a practical guideline for future researchers. Some of the contributions of this work include techniques to form groups using CSCL best practices, a tool to support the execution of CSCL scripts, and accurate tracking and modeling of students’ interactions.

Assessment in CSCL is a complex and sometimes controversial issue. Discussions about what to assess and how to assess have created lively discussions among researchers in the CSCL community. In “Assessment of (Computer-Supported) Collaborative Learning,” Jan-William Strijbos gives a comprehensive overview and identifies research questions and open issues related to assessment of collaborative learning. The author presents four metaphors for learning in a group context, and discusses how they affect views on assessment. Strijbos then identifies some of the challenges that need to be addressed, including a focus on individual level or group level assessment, the difficulty of assessing students fairly when cognitive outcomes are different for each student, and the use of cognitive outcomes together with other measures. Finally, the author discusses some of the key roles that AI technology (e.g., data mining) can play to better support assessment in CSCL.

The Social Semantic Web, a recent trend that combines the formalism and data-centered architecture of the Semantic Web and the user-friendly interfaces and collaborative tools of the Web 2.0 (also known as the Social Web), can contribute to the creation of learning environments with rich social interactions. Vania Dimitrova, Lydia Lau, and Rebecca O’Rourke explore this interesting opportunity in their work “Semantic Social Scaffolding for Capturing and Sharing Dissertation Experience.” The authors present a collaborative tool referred to as the AWESOME Dissertation Environment, designed to help students overcome some of their difficulties in writing a dissertation. Through the use of ontologies that provide pedagogical structure in the learning space, semantic markup that allows users to share and filter content, and Wikis and social computing tools to enhance peer collaboration, the authors have proposed a new approach to support community-based learning called semantic social scaffolding. The paper discusses lessons learned and implications for future adaptations of the Social Semantic Web in learning environments.

In their paper “Collaborative Writing Support Tools on the Cloud,” Rafael A. Calvo, Stephen T. O’Rourke, Janet Jones, Kalina Yacef, and Peter Reimann present iWrite, an advanced architecture for collaborative writing. iWrite integrates existing cloud computing writing tools with intelligent tools for data mining, automatic feedback, question generation, and for analyzing written documents with natural language processing techniques. The authors have demonstrated the great potential of mashups that combine data and tools from different open sources to create new (and smarter) learning environments. Such an approach can be used not only to develop systems that are ready to use in real classrooms, but also to facilitate the collection, processing, and analysis of student data. iWrite has been evaluated by 491 students and more than 102,000 documents/revisions and hundreds of hours of students work have been gathered.

Much of the research on technology-enhanced learning focuses solely on students. However, by creating intelligent tools to help teachers make sound pedagogical decisions, it is possible to improve the quality of instruction and thereby implicitly support students’ learning. In “Observation of Collaborative Activities in a Game-Based Learning Platform,” Jean-Charles Marty and Thibault Carron combined the compelling power of games with reporting and analysis tools that help teachers to observe and track students’ interactions and to perform regulatory activities that aim at guiding students during learning activities. The authors demonstrated their approach by developing a game-based learning management system, Pedagogical Dungeon, and a set of visualizable indicators (e.g. knowledge and behavioural indicators). Based on these indicators and the learning context, the system provides a set of actions that can be performed by teachers in order to structure the environment and help students collaborate and learn.

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REFERENCES

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