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**From computer supported collaborative learning to deep
learning: A systems approach**

**Ricardo-Abad Barros-Castro
Department of Industrial Engineering
Universidad de los Andes, Colombia**

**José-Rodrigo Córdoba-Pachón
School of Management
Royal Holloway, University of London**

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**Ricardo-Abad Barros-Castro, Department of Industrial Engineering,
Universidad de los Andes, Colombia**

and

**José-Rodrigo Córdoba-Pachón, School of Management, Royal Holloway,
University of London**

Email: R-Barros@uniandes.edu.co and J.R.Cordoba-Pachon@rhul.ac.uk

ABSTRACT

This paper presents a framework to help educators and designers improve their design, experiences and management of computer supported collaborative learning (CSCL). With increasing interest in this subject, a number of aspects (dimensions) related to both learning and the use of technology arise. How these aspects can be addressed in an integrated, comprehensive and inclusive way is a key challenge for CSCL. Using the idea of CSCL as a system, we relate a number of aspects in CSCL through a framework that aims to support future development and research. The paper concludes with implications on how to continue improving CSCL with the help of systems-oriented thinking.

Keywords: Computer supported collaborative learning; systems; systems-thinking; technology.

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Ricardo-Abad Barros-Castro, Department of Industrial Engineering, Universidad de los Andes, Colombia

and

José-Rodrigo Córdoba-Pachón, School of Management, Royal Holloway, University of London

1. INTRODUCTION

Worldwide, the use of computers and other information and communication technologies (ICTs) to aid human learning has been on the increase in the last few years. This use has been considered a new paradigm in education and has been called “Computer-supported collaborative learning” or CSCL (Lipponen, 2002; Lehtinen, 2003; Roberts, 2005; Stahl et al, 2006). The main motivation behind of the use of ICT is to facilitate collaboration and hence improve learning processes by means of sharing and distributing knowledge (Lipponen, 2002).

Due to its popularity, CSCL is being approached from different perspectives. Some include “traditional” ones focusing on cognition – the mental processes of thought (Strijbos et al., 2004b). Emerging perspectives on CSCL encourage educators and other stakeholders to explore and manage several other dimensions of the learning processes involved. These dimensions include but are not limited to the following: peer influence and pressure; the role of tutors and teachers; perceptions, values, goals, interests towards learning and learning performance of people involved; the availability of virtual environments on learning, and the influence of cultural and school norms (Lipponen, 2002; Lehtinen, 2003). Despite the emergence of alternative approaches in CSCL, a key challenge identified in the literature is how to address the above dimensions in CSCL practice in ways that are engaging, coherent, pluralistic, reflexive, flexible and coherent with learning outcomes, resources and contexts of development, (Lipponen, 2002; Kreijns et al., 2004; Roberts, 2005; Daradoumis et al., 2006; De Laat et al., 2006b; Gallivan & Benbunan-Fich, 2006; Stahl et al, 2006, Arbaugh et al., 2009; Arbaugh et al., 2010). This is a challenge for educators, administrators, technology providers and students.

This paper presents our effort to address all of the above dimensions and to develop a richer CSCL approach by conceptualizing it as a system. By this we mean looking, reflecting and acting upon them and their interactions and in relation to the learning context in which CSCL occurs. Our purpose is to improve CSCL and its underlying processes that make emphasis on collaborative learning. We develop a model to orient CSCL practice by considering different dimensions and challenges to make CSCL more effective in generating deep learning. This model can inform future designs, experiences and implementations of CSCL in a variety of contexts. As the paper reports, grounding this model on the idea of CSCL as a system helps us to identify a number of underlying factors and attitudes which could be better and more critically addressed in order to enhance students’ learning environment and their performance expectations and outcomes.

We start our paper by identifying current challenges in computer supported collaborative learning CSCL. We then suggest a number of dimensions to consider in CSCL as well as their inter-dependencies. We conclude by discussing implications of the use of our model in practice.

2. OVERVIEW

This section is organized as follow. First, it presents the main definitions about CSCL, collaborative learning, and virtual learning environments. Then, based on research discussions, some important factors associated to these definitions lead us to consider a number of challenges to address in our approach.

3. WHAT IS CSCL?

The use of information and communication technologies (ICT) in the field education is vast. Different forms of ICT to support education have been designed. Figure 1 identifies different types of learning-oriented uses of ICT in education including Computer Supported Collaborative Learning or CSCL. This figure is based on previous descriptions of VLEs presented by Harasim et al. (1995), Sharda et al. (2004), UNESCO (2004), Alexander (2006), and Allan (2002). As the figure shows, CSCL shares some common features with those other forms of virtual learning environments (VLE), including asynchronous learning network (ALN), virtual reality (VR) environments, and virtual or distance learning (VL-DL). All of these educational-technological models also share some research items with Human Computer Interaction (and the way of analyzing the role of learning “with”, “at”, “around” or “through” computers) (Strijbos et al., 2004). Specifically, CSCL shares common discussions with CSCW (Computer-Supported Collaborative Work) and in particular a quest on how to improve collaboration in the workplace (Newman et al., 1997). In our paper we leave aside looking for potential areas of overlap or differences between all these models of VLE. We focus on analyzing the role(s) of technologies in educational contexts, with collaboration as a foundation for learning. The table that follows shows characteristics of some of these models.

Figure 1.here

Traditional learning refers to practices focus on classroom in content, place, time, and the use of collaboration and computers is occasional (UNESCO, 2004). The figure also reflects the insight that different forms of learning using computers have originated a new version of e-learning called “blended learning”. It refers to a mixture of type of media used, time and space of interactions, and the activities designed to enhance learning (Allan, 2002; Arbaugh et al., 2010). This new approach

to learning and teaching processes shared the main factors, discussions and challenges of its relative's forms of learning, including CSCL.

Despite similarities of the above approaches, some differences can be found between them. CSCL is centered in collaboration and computer (collaboration is mediated by computers), its purpose is support classroom content, having people in different place and probably in the same time (Lipponen, 2002; Alexander, 2006; Stahl et al., 2006). ALN is opened to groups of people to learn together, with their own pace, place, and time, using computers to mediated interactions (Harasim et al., 1995; Hiltz & Turoff, 2002; Sharda et al., 2004; Alexander, 2006). VL-DL is based on all the media resources created to support distance learning, that can promote classroom content but without interactions (Sharda et al., 2004, UNESCO, 2004). VR is based on all the media resources created to generate immersive presence (videogames, online games, simulations). VR can support learning by playing (Sharda et al., 2004).

The term “Computer-Supported Collaborative Learning (CSCL)” was proposed to refer to a new educational paradigm where the use of ICT to support collaborative learning was fundamental (Roberts, 2005). Generally speaking, CSCL means the inclusion of technical artifacts to mediate and support peer interactions with the purpose of enhancing collaborative learning (Stahl et al., 2006).

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 (Lipponen, 2002; Kreijns et al. 2003). To achieve this, CSCL can be build through three levels of social infrastructure. According to Bielaczyc (2001) these layers are composed of 1) a cultural level (the philosophy and norms); 2) An activity level (practices), and 3) A tool level (technology). To Lipponen (2002) these layers have similar meaning but they are called: organizational, pedagogical, and technical challenges.

The synergies between these levels aim to meet the purpose of enhancing collaborative learning through the use of ICT. It follows that the pedagogical base of CSCL is collaborative learning. According to Dillenbourg (1999), collaborative learning is “a process by which individuals build knowledge, skills or attitudes occurring as the result of group interaction while solve a shared task or problem”. At the heart of collaborative learning is the need of analyzing learning as a social and active process: the learners play an active role in constructing their knowledge, where interaction is important to understand each other and to generate a common language to performance a task (Dillenbourg et al., 1996; Webb & Mastergeorge, 2003; Salkind, 2004).

The technological base of CSCL is the design of virtual learning environments (VLE) to support collaborative learning activities. Those VLEs has a structure that consists of:

- Knowledge – all the necessary information to learn
- Collaboration – real and virtual groups
- Consulting – the teachers or tutors who give the right direction for learning
- Experimentation – the practical work of the students in VLE
- Personal space – all user-related information

This structure is supported by several technological tools such as, e-mail, discussion forum, chat, personal profile, notes, etc. (Sheremetov & Guzmán, 2002).

4. CURRENT DEBATES ON FACTORS INFLUENCING COLLABORATIVE LEARNING AND CSCL

Having considered the conceptual bases of CSCL, we now highlight some of the main debates about CSCL design and analysis in order to identify a number of dimensions and challenges to address. We draw on discussions from the CSCL field in relation to its differences and elements from other types of learning approaches. We divide these into the following sections.

4.1 Discussions about the nature of the learning process

4.1.1 The concept of learning

Researchers have proposed two main theoretical perspectives to support CL process within CSCL: Piaget's socio-cognitive and socio-constructivist perspective and Vygotsky' socio-cultural approach.

Although Piaget acknowledged the relevance of social factors, he emphasized the child's contribution to thinking and cognition. That is to say, Piaget focused on what the child does (explore, discover, rediscover) while he/she interact with the environment and how the child exports his/her cognition to the environment. From the Piaget's point of view, it is important to put the children into a context that permit them to explore different structures of the physical world and then, they can construct abstractly. So, the focus is on the children construction of the reality (Hergenhahn & Olson, 1997). For example, children can play with marbles and then, construct abstractions about how you can add "carrying". After that process, children can construct more abstractions based on their previous knowledge (Newman & Newman, 2007).

In contrast to Piaget and from a socio-cultural perspective, Vygotsky argues that development can only be understood within a social-historical framework. Vygotsky emphasized the contribution of the child's culture. Therefore, Vygotsky's perspective points out that cognition emerge from social interactions and the use of cultural tools (technologies, language, beliefs, social relationships,

patterned of customs, values, etc.) which are gradually internalized. Activities are socially constructed and have cultural meaning and value. So, culture is seen as a promoter of cognitive structuring or shaping. For example, for Vygotsky is important that children interact with peers and adults so, they can generate knowledge (Salkind, 2004).

Both Piaget and Vygotsky argue that language and thought play important role in cognition, in other words how a child apprehends and assimilates things and thus prepares him/herself to face future events (Ertmer & Newby, 1993; Hergenhahn and Olson, 1997; Webb & Mastergeorge, 2003; Salkind, 2004; Newman & Newman, 2007).

Both the Piagetian and Vygotskian perspectives embody constructivist and social views of learning. First, the learners play an active role in constructing their knowledge. Second, learning is considered a social process, where interaction helps individuals to generate a common language to performance a task as well as understandings between them (Dillenbourg et al., 1996; Webb & Mastergeorge, 2003). For example, in Piaget's constructivism, children interact with each other in pursuing the construction of their individual knowledge. This interaction can generate conflicts between different approaches to construct knowledge in groups. Nevertheless, interaction helps children to understand each other, solve their cognitive conflicts, and actively construct their knowledge (Salkind, 2004). In the case of Vygotsky, he presents the "zone of proximal development", that is, the zone that shows the difference between what a child can achieve independently and what he/she can achieve with help of a more capable peer. With the help of a more-skilled person, a process of negotiation and transformation enables the less-competent person to carry out a task or solve a problem (Webb & Mastergeorge, 2003).

Although Piaget's theory focuses mainly on individual aspects in cognitive development, he inspires the formulation of a new approach which aims to generate better understandings about how social interactions affect individual cognitive development. This approach is called "socio-constructivist approach" and it is characterized by enhancing the role of interactions between an individual and others, rather than the role of action itself (Dillenbourg et al., 1996; Dillenbourg, 1999). Here there is a variation to the constructivist approach that focuses on social interaction.

These two perspectives are the building blocks to enable better conceptualizations of collaborative learning because they establish the need of learning as a social process where the learner has an active role as he/she interacts. While the socio-cognitive and socio-constructivist approaches focus on individual development in the context of social interaction, the socio-cultural approach focuses on social activity, from which individual mental functioning develops (Salkind, 2004; Dillenbourg, 1999). Although these two perspectives differ, they are both necessary for an improved and richer understanding of the social dimension(s) of learning (Lipponen et al., 2003; De Laat & Lally, 2003; De Laat & Lally, 2005). Socio-constructivism leads us to seek evidence in learning activities of the cognitive, metacognitive, social, and motivational and attitudinal interactions, as well as on the meaning of these interactions. In contrast, the socio-cultural

perspective leads us to seek evidence of the influence of the child's context on his/her learning processes.

Current debate focuses on how we can organize a coherent theoretical and practical background to support CSCL processes. This would require among other things, to make it explicit that which educators and students have in mind as their learning purpose(s) and activities. Questions regarding the type of knowledge and skills that are going to be developed, the means by which learning is to be promoted, and activities facilitating it are key in CSCL (Kreijns et al., 2003; Strijbos et al., 2004b, Arbaugh et al., 2009) should be included in discussing about concepts of learning.

4.1.2 The meaning of "collaboration"

There are several discussions about what 'collaboration' means. Collaboration can describe a situation in which particular forms of interaction among people are expected to occur, which would trigger learning mechanisms, but there is no guarantee that the expected interactions will actually occur. Here, the main purpose of collaboration is the generation of explanations (building and delivering an explanation) (Dillenbourg et al., 1996; Dillenbourg, 1999; Roberts, 2005).

Other authors state that collaboration is a process by which individuals build knowledge, skills or attitudes occurring as the result of group interaction while solve a shared task or problem. This process of knowledge construction can be obtained via interactions, regardless of whether their main focus is learning or not (Haythornthwaite, 2001; Kreijns et al., 2003). The interactions are expected to generate equal contributions and participations (De Laat, et al., 2006) and should include actively search for information, engage in critical discussion, ask questions, discuss answers, make proposals, and reply to other proposals (Alexander, 2006). Whether the purpose of a collaboration is to enhance interactions or build knowledge is an element that is being currently debated.

4.1.3. Collaboration vs. cooperation

For some authors, cooperation involves division of tasks, solve sub-tasks, individually and then assemble together (Strijbos et al., 2004b; Alexander, 2006; Stahl et al., 2006) or a structure of interaction for well structure knowledge domains (Slavin, 1995; Strijbos et al., 2004; Alexander, 2006). Collaboration implies negotiation and sharing meaning in group (not individual) activities (Stahl et al., 2006), or a philosophy to guide interaction in ill-structured knowledge domains (Slavin, 1995). A key discussion here is on how research can deal with these similarities and differences in the process of analyzing collaborative learning environments. Research could help in identifying and describing differences in the design and implementation of CSCL processes. For example to support cooperative learning, CSCL should provide structured tasks, several arrangements of different types of discourses, as well as enabling the management of groups and individual roles (Strijbos et al., 2004b; Alexander, 2006). To support collaboration, less structuring in these aspects should be promoted.

4.1.4. Group factors

Previous studies have found that group size should be small in order to better guarantee work of all members and the greater to guarantee diversity and creativity of ideas and skills. Group of 3 to 6 members have been recommended (Harasim et al., 1995; Bordogna and Albano, 2001).

In addition, group composition should consider diversity and homophily. Heterogeneous groups rely on the learners' socio-cultural characteristics, their skills, beliefs, among others. This kind of group promotes more stimulating thinking due to its diversity. Some advocates of group diversity conject that people have different ways to represent and to approach a given problem, and this diversity (affected by training, experience, and socio-cultural characteristics) can produce good results in groups (Page, 2007).

In contrast to diverse groups, homogenous ones are said to promote more cohesion and satisfaction (Slavin, 1995; Graham, 2002; Sharda et al., 2004). Homophily theory predicts that people are more likely to interact with individuals similar to themselves in respect to a variety of qualities and characteristics such as age, gender, education level, and values, among others (Yuan & Gay, 2006).

Social network theory (Wasserman & Faust, 1994) identifies some additional factors that could be included in understanding the influence of groups in collaborative learning. This theory focuses on studying emergent social structures that are generated through the relationships between people (Sanz, 2003). Social network analysis has its focus on the social network positions. It refers to the relation between learning performance, knowledge building, and the position occupied by the learner in the network (Wasserman & Faust, 1994). Previous studies have found that the network positions have significant impacts on individual and group outcomes because the structure of social interactions promotes or restricts access to information, feedback, strategic information, and social support, among others (Haythornthwaite, 2001; Lipponen et al., 2003; Hurme and Järvelä, 2005; Daradoumis et al., 2006; Hurme et al., 2006; Cho et al., 2007). So, the way network structures promoted by CSCL activities should be aligned with the purpose of the learning.

Therefore, design of CSCL activities should pay attention to group composition, influences within and outside the group and their impact on the learning purpose and outcomes.

4.1.5. Attitudes

Students and teachers' beliefs and attitudes affect the learning process (Markauskaite, 2007; Strijbos et al., 2004b; Arbaugh et. Al, 2009). Students build their beliefs about the learning content, the learning activities and the technical support through their experiences. Attitudes shape students' behaviors in ways that have extraordinarily powerful (and often negative) consequences (Schoenfeld, 1990; Strijbos et al., 2004). They highly contribute to determine the amount of time that people are willing to devote to learning (Sharda et al., 2004; Joiner et al., 2005; Arbaugh & Benbunan-Fich, 2006; Finegold & Cooke, 2006; Dewiyanti et al., 2007; Imhof et al., 2007). The challenge for educators in CSCL is to be able

to identify and address changes in students' attitudes in order to make appropriate decisions about the learning that is being promoted.

4.1.6. Engagement

A key expected outcome of CSCL is deep learning because it seems to promote sharing and knowledge construction through discussions within groups, where people have to reflect about new information and previous knowledge (Newman et al., 1997; Suthers, 2006). To achieve deep learning, CSCL should effectively contribute to engage learners and teachers in this process (Stahl et al., 2006). "Engagement" is "active involvement". It refers to encompass attitudinal and cognitive aspects of learning process. It can be affected by factors like those mentioned previously (social interactions, task characteristics) (Helme and Clarke, 2001). Engagement includes not just accessing and receiving continuous technical support for CSCL. It should also involve developing appropriate levels of ICT Literacy in learners and teachers, as well as developing new pedagogical strategies, which often require more amount of time dedicated to the learning processes at hand than traditional strategies (Lipponen, 2002; Lehtinen, 2003; Markauskaite, 2006): From the students' perspective, engagement in CSCL requires not only abilities to develop the task, but also acquiring and maintaining if not developing further ICT skills (i.e. use of computer and Internet, analysis of information and communication), and communication skills. Engagement in CSCL also requires extra-time for discussions with peers. From the teachers' perspective, the design of CSCL tasks, the control, monitor, feedback processes demand more time and new ICT skills than a class designed to be 'executed' only in the classroom (Arbaugh et al., 2010).

4.2 Discussions about Technological aspects

The inclusion of technology in education has presented new challenges to the collaborative learning field. Aspects such as the design and analysis of VLE which can result in changes in pedagogy need to be better understood and managed to effectively support collaborative learning. Regarding the design of VLE, this implies several aspects:

- According to theories of technology design such as social presence and media richness (Kreijns et al., 2003; Kreijns et al., 2004; Sharda et al., 2004), the virtual learning environment should guarantee a "social space to interact", as real as in face-to-face interactions (Hiltz & Turoff, 2002; Kreijns et al., 2003; Kreijns et al., 2004; Strijbos et al., 2004). This social space can be a set of virtual interactions or a mixture between face-to-face and virtual communication (Benbunan-Fich and Hiltz, 1999; Sharda et al., 2004; Strijbos et al., 2004a; Strijbos et al., 2004b; Alexander, 2006). The design of the virtual environments must be simple. In other words, it should not be overloaded with visual images. The VLE should be easy to use and useful, should accomplish the purpose for what was design (Sharda et al., 2004). To ensure this kind of requirement is met is a challenge for researchers and practitioners.
- There may be asynchronous or synchronous interactions. The asynchronous interactions promote deeper reflections and creative analysis; the synchronous

interactions generate more consensus (Harasim et al., 1995; Benbunan-Fich and Hiltz, 1999; Alexander, 2006). Both need to be supported with technology.

- As we mentioned before, CSCL has Collaborative learning as a key educational strategy that makes emphasis on the ‘group’ as a vehicle for learning. With the availability of technology, this aspect can be supported and enhanced. In CSCL therefore computer mediated interaction gains importance as it can contribute to support group-based activities which in turn can foster collaborative learning. However, CSCL is not only applying technology, but implementing ways of learning with both human and technology support (Kirschner et al., 2004). Both of these aspects are to be considered interlinked and in relation to the context of application, so that appropriate strategies to design and support group-based activities make the most of appropriate technologies.

4.3 Discussions about the context of application of CSCL

Previous challenges related to learning process and use of ICT in education lead us to consider another challenge in relation to the context in which CSCL is used and managed. These do not belong to other areas of discussion or are not directly considered in CSCL activities. Attitudes to the CSCL process itself, as well as previously acquired habits towards ICT have become relevant to consider in the analysis of CSCL processes (Clayborne & Steefeldt, 1991; Galvis, 1998; Imhof et al., 2006). These factors also relate to wider socio-economic considerations. For instance low levels of income and education, access (or lack of it) to ICT (computers and Internet), costs associated, distance and accessibility to educational sites to take part in CSCL activities and family support seem to influence CSCL processes and outcomes. Consideration of these and other factors and their treatment during CSCL should be paid; assessment of what can be managed and what is outside of the control of educators and managers should also be made.

As illustrated by the discussion, there are different aspects that need consideration and which are related. Technology can facilitate and enhance collaborative learning, but at the same time, this type of learning needs to be carefully designed and managed. Both technology and learning aspects can then be matched, but again, careful consideration of the context of learning and use of technologies needs to be made. This type of context should be considered in terms of the people that are to be involved as well as of institutional and other constraints that could affect and be affected by CSCL efforts. Inter-connectedness between aspects, technologies, ways of learning, and groups of individuals is to be continuously fostered and encouraged.

5.0 A SYSTEMS-BASED NOTION OF CSCL

Having considered the different dimensions of CSCL, our purpose now is to integrate them so that we can address them in a coherent and consistent way, enabling us also to design activities in each of the above dimensions and consider the potential inter-relationships between them.

The idea of a system as a set of inter-connected parts whose interaction generates a number of emergent properties is not new. In the realm of education, this idea has been used to promote a radical rethinking of what we define as useful learning. Banathy (1992) encourages educators, students and administrators to think of how educational systems should respond to demands from the 'outside' or the environment of these systems, considering feedback from both the inside and outside of them. Systems' stakeholders should endeavor to help students co-design and learn what is relevant to such an environment so that theory and practice are strongly related and reflected upon. The idea is valuable, although a key barrier to its implementation is the existence of institutional constraints and ways of educating that, according to Ackoff (1981), can result in privileging senior managers and educators rather than students themselves; the latter get at least an approval to go and learn what is relevant in a job; lack of relevance about what is taught can be seen as a lack of incorporation of feedback from the systems' environment.

At a micro-level, the idea of a system is used as a metaphor to facilitate understanding of how student groups work and how their interactions can be supported so that they can engage more effectively in collaborative learning and deepening a group's learning capabilities (Homans 1957; London and Sessa 2007). In this regard, the notion of a system can be used to organize an educational effort, look at how elements (technological and non-technological) and their interactions can be managed. It can also be used to promote attention to, coupling or adaptation to groups' immediate surroundings or environment, and to reflect on internal and external factors that influence learning processes. Feedback from how each element of a group or a programme contributes to the whole activity of education can be collected from inside and outside and incorporated in improving educational initiatives or activities.

We now approach CSCL as a learning system whose composing elements produce improvements in learning through collaboration and supported by the use of ICTs. A proposed learning model of this system is presented in figure 2. This model takes into account previous proposal models to approach interactions and technology artifacts in CSCL (i.e. Sharda et al., 2004; Strijbos et al., 2004). Besides, this model adds to those models other dimensions of CSCL processes. In summary, this model considers each element as addressing the dimensions and challenges identified.

Figure 2: in here

The model takes into consideration different aspects of CSCL as described above: collaborative interactions (with factors such as group composition and nature, frequency, and evolution of interactions), attitudes of people involved towards the CSCL process, technological aspects of design, and the context of application (in use). The model shows that there are inter-dependencies between these aspects, so that any action in one aspect has (or will have) impacts in each other. Embedded in the model is an assumption that it helps align and monitor each aspect or dimension and its connections to the others. Feedback process between dimensions helps people responsible for CSCL to assess what happens in one dimension and take appropriate changes.

6.0 IMPLICATIONS FOR PRACTICE

Looking at these inter-dependencies in more detail and in relation to implications for practiced in implementing the above model, the first consideration it brings is the learning purpose(s) that CSCL should serve. Questions and reflections on this dimension will affect what is designed and implemented in the others. For example, if the purpose of using CSCL is to promote discussions about a particular topic in order to help students understand the meaning of certain concepts, then CSCL activities (duration, type), their interactions (social, technologically mediated), group composition, individual and group attitudes should be aligned with. The design of technological support (i.e. VLE) should be oriented to facilitate discussion at different levels according to the levels of difficulty of concepts to be taught. Group diversity should be considered, and positive attitudes could be promoted according to the topic being discussed.

Furthermore, there also are inter-dependencies within and between each dimension. Table 1 (appendix) shows the different aspects to be considered, their inter-dependencies and some important questions about issues to be considered. For example:

- Technological aspects of the VLE (forums, chats) can promote more effectively social or task-related interactions. Additionally, designer should consider the VLE the same direction that the type of interactions that they want to promote: for example, deep conceptualizations about a subject in forums or brainstorming ideas to create some solutions in chat rooms. If those interactions are going to be within groups or between groups is another consideration to take into consideration (relation between dimension #2 and #4 of the table).
- Attitudes towards collaborative learning activities or technological aspects could affect to, or be affected by, collaborative interactions or technological aspects, or the learning process (relation between dimension #1, #2, #3, #4). These attitudes should be monitored by surveys or the content of the interactions.
- The type of collaborative interactions (in general, dimension #2) is related with the content and activities of the learning process (dimension #1).
- Some characteristics of the context of application (in use) can affect CSCL activities. For example, language of the participants, cultural barriers, schools dynamics, computer and Internet access, participants socio-economical level can affect technological aspects, attitudes, and collaborative interactions (dimensions #2, #3, #4, #5). All of those aspects can affect the learning purpose (dimension #1).

The complete set of interdependencies is described in the table below. As we mentioned before, there is a dimension called “context of application” that helps to understand external factors that facilitate or inhibit the learning process. Feedback from what happens in this dimension, in other words from external factors to CSCL which affect it is relevant to alter the course of CSCL activities to respond to such

factors. Regarding this particular dimension, it is important to recognize that we need to be vigilant about some of those contextual factors that can be addressed by working in the other dimensions and other factors that are out of scope of the CSCL processes. Those contextual factors should be discussed openly with the relevant actors of the CSCL process.

Regarding the aspect of discussion with relevant actors of the CSCL process, although the literature review does not precise if these points are discussed in a flexible manner (i.e. with students' participation and with the possibility of changes throughout the process), this model allows discussing these aspects with students, teachers, researchers, and designers. Our model allows analyzing learning process from different dimensions in a broad, interdependent, coherent, and flexible perspective, evaluating engagement and deep learning depending on the mentioned factors and making decisions accordingly.

Finally, the model can serve a threefold purpose. First, it can be a framework to guide the design and implementation of CSCL processes by educators, technology designers, students and other actors. Secondly, it can also help those responsible for CSCL management and improvement to analyze, monitor, and modify CSCL activities in relation to the fulfillment of the intended learning purpose(s). Thirdly, it can facilitate assessment of how CSCL is contributing to students' engagement and with it to a deeper and future degree of learning.

One potential limitation is that model assumes that by working on the identified dimensions, an emergent outcome from their interaction is that of engagement. Engagement can then be considering as emerging from the use of the model or as a result of different (and possibly separate) decisions made throughout the CSCL processes. We hope that by working on the dimensions and interactions of the model, people can have better opportunities to engage, to use and reflect on previous knowledge, to interact and collaborate and to increase their learning opportunities. There is a need to continuously monitor the progress of learning in the discussions and reflections that students engage with. Further research could enhance opportunities to enable a deeper degree of reflection about the impact of this model in practice and to facilitate its further refinement in contexts of its application.

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Learning Environments	Different aspects to compare learning environments			
	Place	Time	Collaboration?	Type of “learning content”
Traditional	Same	Same	Almost never	Curriculum based
VL-DL	Different	Different	No	Curriculum based
VR	Same or different	Same or different	No	Learning by playing
ALN	Different	Different	Yes	Curriculum based or others (topics or interest)
CSCL	Different	Same	Yes	Curriculum based

Figure 1. Comparison between CSCL, LN, VL, VR and Traditional Learning according to different aspects

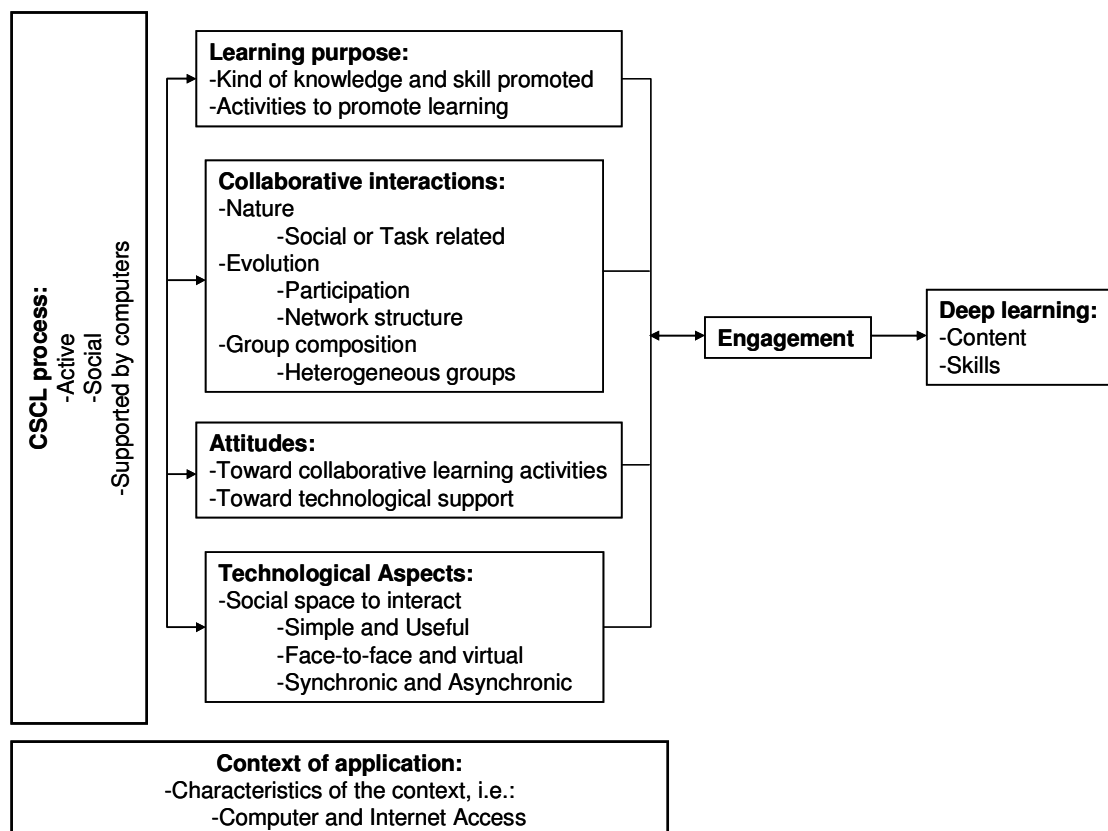


Figure 2: Initial proposal model of CSCL process

Dimen- sions	Sub-dimensions	Interdependencies (explanations for one direction of the relation)	Questions – Issues to be considered in CSCL
1. Learning purpose	1.1 Knowledge, skills to be promoted and activities related to them	(2.1, 2.3) There is a need to design and analysis the nature of interactions and group composition accordingly, to guarantee the CSCL objective.	What is the objective (knowledge and skills to be promoted) of the CSCL that is going to be implemented? What activities are more appropriate to promote that objective? Are the other dimensions aligned to the learning purpose(s) being pursued?
2. Collaborative interactions	2.1 Nature of interactions	(2.2) The evolution of interaction should inform about the changes or patterns in the nature of interactions.	Are going to be pre-established categorization of interactions or not? If yes, what kind of categories should be promoted? How can it be characterized those interactions categories?
	2.2 Evolution of interactions	(3.1, 3.2) The evolution of interactions (which are related to nature of interactions) can inform about changes in attitudes towards the whole CSCL process. (5.1) The evolution of interactions can be affected by contextual factors (socio-economical level, different cultural backgrounds).	Is there any evolution pattern in interactions? If there is any, how can it tell us about attitudes, engagement, deep learning? Participation and different roles in the network (central actors) are related to attitudes, engagement, deep learning?
	2.3 Group composition	(2.1, 2.2) Different group composition can affect the nature and evolution of interactions based on gender, new group-mates, etc. (3.1) Group composition also can affect attitudes toward CSCL activities. (5.1) Contextual factors can influence the way the decision of group composition is made.	How can groups be organized? What should be the criteria to compose groups? How can the impact of group on learning be measured?

3. Attitudes	3.1 Toward collaborative learning activities	<p>(1.1) Attitudes toward CSCL activities are related to learning purpose and the way that purpose is promoted by the activities.</p> <p>(3.2) Attitudes toward CSCL activities can be related to technological aspects (no pedagogical) of CSCL.</p> <p>(5.1) Contextual factors can influence the attitudes toward CSCL activities.</p>	<p>What are the students' attitudes toward collaborative learning activities?</p> <p>What are the students' attitudes toward the learning purpose?</p> <p>How can we monitor the evolution of those attitudes?</p> <p>What kind of activities should be designed to promote positive attitudes?</p>
	3.2 Toward technological aspects	<p>(4.1) Attitudes toward technological aspects are related, in fact, with those technological aspects being a way used by the learners to show their satisfaction about the computer support.</p> <p>(5.1) Contextual factors can influence the attitudes toward technological aspects.</p>	<p>What are the students' attitudes toward technological aspects of CSCL activities?</p> <p>How can we monitor the evolution of those attitudes?</p> <p>What kind of activities should be designed to promote positive attitudes?</p>
4. Technological aspects	4.1 Social space: -simple and useful -face-to-face and virtual -asynchronic and synchronic	<p>(1.1) The computer support to be designed should be aligned with the CSCL purpose and activities.</p> <p>(2.1, 2.2, 2.3) Technological aspects should be considered to guarantee collaborative interactions in groups</p> <p>(5.1) Contextual factors can influence the technological aspects to be designed.</p>	<p>How should be the VLE designed to support the CSCL purpose and activities?</p> <p>What kind of interactions should be allowed (face-to-face, virtual, asynchronic, synchronic, or blended)?</p> <p>How should be the VLE support to monitor activities?</p>
5. Context of application	Factors such as different socio-economic background, different types of classes and schools' dynamics	<p>(1.1) The learning purpose (CSCL content and activities) should be having into account contextual factors to make the decisions and monitor accordingly.</p>	<p>What kind of considerations should be taking into account regarding the context of application of CSCL activities (i.e. technological access, different socio-economical level of participants, class dynamics)?</p> <p>Can these factors be addressed by working in the previous other dimensions? Which of these can be managed, or out of the scope of the CSCL processes or activities?</p>

Appendix: Table 1. Dimensions of the CSCL process to take into consideration in the design and analysis

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Ricardo-Abad Barros-Castro is Industrial Engineer (2003) and MSc (2005) from Universidad de los Andes, Bogotá, Colombia. Currently he is a doctoral student in the School of Engineering at Universidad de los Andes. His research interests include systems thinking, collaborative and virtual learning environments, and organizational management. He has been a visiting researcher at the school of management, Royal Holloway, University of London and currently visits the centre for systems studies, business school, University of Hull.

José-Rodrigo Córdoba is a senior lecturer in technology and information management at the school of management, Royal Holloway, University of London. His research interests include the use of systems thinking to explore sustainability, adoption of information technologies and electronic government. He is currently the departmental director of the Master of Science in Business Information Systems (BIS).