DISTRIBUTED LEADERSHIP COLLABORATION FACTORS TO SUPPORT IDEA GENERATION IN COMPUTER-SUPPORTED COLLABORATIVE e-LEARNING

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Abstract: *This paper aims to identify, discuss and analyze students' collaboration factors related to distributed leadership (DL), which correlates with interaction quality evident in idea generation. Scripting computer-supported collaborative e-learning (CSCeL) activities based on DL can scaffold students' interactions that support collaboration and promote idea generation. Furthermore, the associated tools can facilitate collaboration via scripting and shed light on students' interactions and dialogical sequences. Such detailed planning can result in effective short e-courses. In this case study, 21 MSc students' teams worked on a DL project within a 2-day e-course at the IT Institute (ITIN), France. The research methods involved a self-reported questionnaire; the Non-Negative Matrix Factorization (NNMF) algorithm with qualitative analysis; and outcomes from the Social Network Analysis (SNA) tools implemented within the forums. The results indicated that scripting DL based on the identified distributed leadership attributes can support values such as collaboration and can be useful in supporting idea generation in short e-courses.*

Keywords: *distributed leadership, e-Collaboration, CSCeL, idea generation, scripts, CSCeL tools.*

INTRODUCTION

Education as a discipline was initially anchored in cognitive psychology and pedagogy, and only recently have educators and researchers considered the sociocultural aspects of learning through the use of tools. Nowadays, the Internet and e-learning platforms support the collaborative

dimensions of working and learning in groups and can be implemented in short e-courses. The quality of such collaboration is essential in order to achieve group common goals based on the naturally developed or intentionally designed group roles. One of these roles is leadership. Chemers (1997) suggests that leadership is the process of social influence in which one person can enlist the aid and support of others in the accomplishment of a common task. However, in today's globalized world, the concept of just one person leading a group does not seem to apply. For this reason, new approaches such as top-down and bottom-up leadership within interactive groups (distributed leadership, DL) seem to provide the frameworks to understand, analyze, and enhance groups' enterprises.

This paper aims to identify, discuss, and analyze the DL factors that support group effectiveness in a global environment. It presents a single case study as part of a series of workshops and e-courses specifically developed for the IT Institute (ITIN) at Cergy University, Paris, France. ITIN's mission is excellence in preparing technical engineers to be project managers capable of working efficiently within intercultural teams. Therefore, ITIN's main role is to help employees (i.e., students learning within apprenticeships) in companies that belong to the Chamber of Commerce and Industry of Versailles, France. The students need to develop their knowledge in various practical areas, as well as develop their knowledge about their knowledge (metacognition; Morin, 2000). The curriculum is aimed at helping the student professionals achieve specific credentials for their working environment. Thus for the IT students in ITIN, the knowledge acquisition and building of students' individual expertise and skills can lead them to becoming CEOs or members of an organization's board of directors.

In observing economic globalization (Friedman, 2007; Stiglitz, 2007) and information systems globalization (Raivola, Kekkonen, Tulkki, & Lyytinen, 2001), it is vital to prepare the students to become actors in international value chains and intercultural team projects. For this reason, the e-courses at ITIN are oriented towards developing the "soft skills" that students need in the global labor marketplace. Such skills also are essential in distributed leadership (DL). Human factors such as global collaboration and team leadership are the 21st century skills required to effectively work in both environments.

The acquisition of knowledge and its relation to students' competencies has been suggested as the major change in education in the 21st century (Wenger, 2010). For this reason, we explore briefly the progression in educational practices, and in collaborative learning in particular, so that this need is made explicit.

The paper is developed as follows: The first section addresses the pedagogical approach, such as the importance of the sociocultural perspective in computer-supported collaborative eLearning (CSCeL) and DL. The next section is dedicated to the tools used to promote CSCeL and DL within the course being studied. This is followed by a presentation on scripting within the e-learning design. We then discuss the methods, data collection, and analysis used in this case study, which is then followed by the results and discussion. We end with conclusions and suggestions for future research.

The Sociocultural Perspective

From the last century up to the present day, a series of pedagogical epistemological paradigms have emerged (Kuhn, 1962). During the modern transition, a behaviorist approach

based on both the positivist philosophy (Comte, 1830–1843) and the Darwinian theory came to the fore. The learning process was seen as a cognitive reflex in response to specific stimuli. The more recent cognitive approach (Piaget, 1988) reflects, in essence, rationalism (Boudon, 1995), by addressing an individual's choices as rational and able to be reduced to reason. Here, the predominant paradigm was ontological: It was believed that knowledge is something that exists in oneself and can be taught and transmitted to others.

The constructivist approach (Lemoigne, 2003) followed, with the perception that knowledge is man-made, that is, constructed. Therefore, this knowledge can be developed and nourished by personal experience and the learner himself or herself. For constructivists, the actual "acting out" allows for experimentation and, as a result, acquisition of knowledge (Berger & Luckmann, 1966; Jonassen, Davison, Collins, Campbell, & Bannan Haag, 1995). The complementary idea that man learns as a result of social interaction led to the socioconstructivist approach (Jonnaert, 2002; Vygotsky, 1978).

Collaborative activities and learning in groups appears to be the new trend in 21st-century education, due in part to the capabilities that social media tools provide. However, collaborative activities and group learning are not new ideas. Johnson and Johnson (1987) provide an overview of the historical perspectives on cooperative learning within the past 400 years. For example, in the early- to mid-1600s, Comenius believed that students benefit from both formal teaching and being taught by other students. In the late 1700s, Lancaster and Bell made extensive use of cooperative learning groups in England, while Colonel Francis Parker used cooperative learning procedures in public schools in Quincy, Massachusetts, in the US. Cooperative learning appeared in the work of Rousseau and Pestalozzi in the 18th and 19th centuries, respectively, while in the 1930s, John Dewey promoted the use of cooperative learning groups as part of his project method. Peer interaction also was central to Vygotsky's sociocultural learning. In 1940s, Deutch proposed a theory of cooperative and competitive situations. Other researchers note that scholarly discussion during the 1990s often suggested that Piagetian constructivism did not take interpersonal relations into account (Crook, 1994; Mercer, 1995). However, Piaget himself suggested that "cooperation … eliminates the process … of egocentric thought" (1995, p. 208), since cooperation is defined as "all relations between among more equal, or believed to be equal, individuals, that is to say, all social relations in which no element of authority or prestige is involved" (p. 200). Bruner (1986, p. 127) admitted, "I have come increasingly to recognize that most learning in most settings is a communal activity, a sharing of culture."

The recent sociocultural interest in education has arisen from the ideas of Soviet scholars—Vygotsky, Luria, and Leontief—who established learning as primarily socially and culturally achieved rather than an individual process. The internalization and externalization processes (Vygotsky, 1978) were proposed as continual dual dialectic processes whereby humans construct both themselves and their culture primarily through language. Therefore, both people and culture are constantly changing over time (Jarvis, 1992).

Despite the interplay of internalization and externalization, ultimately the individual's cognitive processing depends on his/her own cognitive processing and whether the collaboration context favors it. This also means that both ontological and constructivist approaches are of equal importance and need to be supported in the learning design via activity descriptions.

Nowadays computers and the Internet are integrated into education as never before. Educational organizations are forced to support a new wave of networking and collaboration

directed by Web 2.0 applications, which fused the borders between the classroom environment, the workplace and home. According to Clark and Mayer (2007), the use of technologies in the classrooms is increasing and converging, as blended learning replaces traditional classroom teaching. In both modes, student engagement is central to learning; the lack of it, also known as disengagement or alienation, has been a particular research interest (Carini, Kuh, & Klein, 2006). Students' engagement is evident in the appearance of excitement, enthusiasm, and commitment to their studies as hard work and investment in learning. As a result, student engagement is encouraged in national educational policies.

Newmann (1992) defined engagement as the student's psychological investment in an effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote. Fredricks, Blumenfeld, and Paris (2004) suggested three types of engagement that can be used here as evidence of collaboration: (a) behavioral engagement, (b) emotional engagement, and (c) cognitive engagement. One of the most promising approaches to deal with the engagement and collaboration requirements in this educational context and the increasing demands for 'Net- and Web-based education is computer-supported collaborative e-learning (CSCeL). This approach, used in DL, will be discussed next.

Distributed Leadership

DL is the process of top-down and bottom-up social influence among the members of a group, community, or even nation in order to create and achieve something that none of the members could do alone. It has become popular due to the action and influence of people at all levels of hierarchy (Bolden, 2008). Due to the creative nature of group achievement, DL has been reported to enhance co-creativity and innovation (Agbor, 2007; Ancona & Bresman, 2007). In their interpretive review of the DL literature, Bennett, Wise, Woods, and Harvey (2003) referred to DL as "an emergent property of a group or network of interacting individuals. This contrasts with leadership as a phenomenon which arises from the individual" (p. 7). Other than introducing the open network in leadership and the major roles of groups and communities, those authors also suggested that varieties of expertise are distributed across the many, not the few. The variable features identified in this literature review are: control and autonomy; the organizational structure; the sociocultural context; and the source of change. Such a bottom-up approach is informal leadership, based on the dynamics of teamwork and conflict resolution; these are spontaneous forms of leadership and team collaboration. In this way, more opportunities are developed for the group and community, and the members' skills are enhanced. Therefore, co-creativity and innovation as applied creativity can be enhanced via learning DL by doing DL (Silva, Gimbert, & Nolan, 2000), in other words, as learning in practice.

In the e-course used within our study, DL was considered twofold: within international teams of students and in DL as participatory decision making. The first was related to the associated and appropriate e-learning course design and the second in the provision of appropriate instructions and tools to enhance interpersonal trust, empathy, and collaboration towards co-creativity for new ideas generation. In DL in particular, collaboration skills are extremely important for developing initial trust and empathy between and among team members; encouraging collaboration; sharing information and experiences; observing others' activities as ways of learning and working; and, lastly, enhancing idea generation based on information provision, emulation and argumentation, and idea generation.

The sense of presence has also been considered important for communication, team coordination, and collaboration. There is a need to "see thyself and others" in order for the group to react, act, and anticipate appropriately. Short, Williams, and Christies (1976), working on studies about discussions on the phone, defined social presence as the "degree of salience of the other person in a mediated communication and the consequent salience of their interpersonal interactions" (p. 65). They also referred to the concepts of immediacy as the psychological distance (see also Weiner & Mehrabian, 1968) and intimacy as the interpretation degree of interpersonal interactions (see also Argyle & Dean, 1965). Later, social presence was defined as the degree by which a person was perceived as real in an on-line conversation (Meyer, 2002, p. 59). For this reason and to facilitate empathy, the construction of students' profiles was obligatory (Lambropoulos, 2009). Also new tools aimed at enhancing social presence and copresence in CSCeL were used with the intention of raising the students' involvement in the course, thereby increasing their engagement and participation and, ultimately, their collaboration in CSCeL.

COMPUTER SUPPORTED COLLABORATIVE E-LEARNING (CSCeL)

Based on the literature presented earlier, it appears that collaboration is a very important and required cognitive and motivational force in fostering learning. Two terms have been used interchangeably in the collaborative learning history: cooperation and collaboration. *Cooperation* is the basis for sociability: "acting together, in a coordinated way at work, or in social relationships, in the pursuit of shared goals, the enjoinment of the joint activity, or simply furthering the relationship" (Argyle, 1991, p. 15). *Collaboration*, on the other hand, "is a principle-based process of working together that produces trust, integrity and break-through results by building true consensus, ownership and alignment" (Marshall, 1995, p. 15). Schrage (1990, p. 40) defines collaboration as "the process of shared creation: two or more individuals with complementary skills interacting to create a shared understanding." In order to facilitate research and analysis, Teasley and Roschelle (1993) proposed a distinction between cooperation and collaboration:

> Collaboration is a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem…. Cooperative work is accomplished by the division of labour among participants, as an activity where each person is responsible for a portion of the problem solving. (p. 235)

Lambropoulos and Culwin (2010a) provided their definitions based on learners' skills. Cooperation is related to the process of joint activity. Two or more individuals bring complementary skills and knowledge to a task. Each contributes his/her particular skill to the common purpose. Accordingly, an individual can depart once his/her contribution has been made. Collaboration, however, is related to the process of joint creation. Two or more individuals bring overlapping skills and knowledge to a task. Ideally each contributes equitably, if not equally, to the common purpose. Accordingly, an individual remains engaged until the task has been completed. The confused understanding of the distinction between these two terms extends beyond the literature to the participants themselves. An individual may both cooperate and collaborate in a task, and yet be unaware of his/her contributions.

UNESCO also provided a definition. Collaborative learning occurs

> when learners work in groups on the same task simultaneously, thinking together over demands and tackling complexities. Collaboration is here seen as the act of shared creation and/or discovery. Within the context of electronic communication, collaborative learning can take place without members being physically in the same location. (n.d., third defined term)

UNESCO's definition also supports the context of electronic communication breaking the borders of physical locations, thus providing definitions for both on-site and on-line collaborative learning. The electronic shared space, such as groupware, becomes a frame of reference for the collaboration and provides an environment in which collaboration can occur (Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukonen, 1999). The description of such environment is described next.

Computer Supported Collaborative eLearning (CSCeL) Research

According to Dillenbourg, Baker, Blaye, and O'Malley (1996), as well as Fischer and Mandl (2005), the computer-supported collaborative learning (CSCL) has been studied to exhaustion in research in which the individual is the focus. However, limited studies focus on the ways teams function and the interrelated factors that affect knowledge convergence. The transition of the research focus from the individual to group and community learning was evident in the influential review conducted by Dillenbourg and colleagues (1996). They suggested that the development of an understanding of collaborative learning began with the learner as an individual and moved to group learning in a more sociocultural mode. During the 1970s and early '80s, research concentrated on the individual's learning processes. The context of their interaction with others was seen as a backdrop rather than a research topic in its own right. When the group became the unit of analysis, the focus shifted to the social construction of knowledge; however, this was still based on the study of individuals. In terms of empirical research, the focus was on comparative processes to establish whether and under what circumstances collaborative learning was more effective than individual learning.

Because CSCL and e-learning environments (CSCeL), in particular, are inherently complex, it was almost impossible to establish causal links between the conditions and the effects of collaboration. Therefore, Dillenbourg and colleagues (1996) indicated the need for new tools and methods for observing and analyzing interactions to increase understanding of the collaborative learning social mode. Dillenbourg (2000) also stressed the social aspect of learning as a designed information space where learners are actors, that is, they co-construct the information space and their learning context. In other words, collaboration among peers needs to be designed and shaped based on the CSCeL environment (Dillenbourg, Järvelä, & Fischer, 2009). CSCeL tools provide collaborative settings aiming at fostering conceptual advancement and facilitating learning. Such tools would shed light onto these processes and support CSCeL activities.

CSCeL Technologies

Designing e-learning tools to support CSCeL has methodological advantages. The variety of CSCeL tools (Hoadley, 1998) allows explicit control of the learning process and supports a

variety of interactions that scaffold the learning process. For example, there are tools to aid coordination, such as project management, and tracking and scheduling software. There are also tools to aid communication, such as e-mail, bulletin boards, teleconferencing, and real-time messaging systems. Other tools support educational content, such as tools for learning objects. And lastly tools can enhance cognitive processes, such as tools based on argumentation models.

We present briefly now three CSCeL tools examples that are widely used by the CSCeL community and also are connected to dialogical sequences that are the focus of this study: SpeakEasy, Belvedere, and MessageForum. SpeakEasy (Hoadley, Hsi, & Berman, 1995) has two intended effects on the user: (a) to allow the user to internalize and learn from the knowledge held by other members of the discussion community, and (b) to augment the community's knowledge (i.e., construct new knowledge) by synthesizing new ideas. Hoadley et al. found that students participated more often and more equitably in SpeakEasy than in off-line discussions. Moreover, their conceptions advanced as a result of these discussions.

Belvedere (Suthers, 1998) facilitates and supports constructing and reflecting on diagrams of one's ideas. It prompts students' cognitive activity by giving them a graphical language to express the steps of hypothesizing, data gathering, and weighing of information supporting collaborative learning through the ability to share diagrams. Suthers (1998) found that Belvedere proved to be helpful for higher order social interaction and, subsequently, for better learning in terms of deep understanding.

MessageForum (Jeong, 2005) supports on-line dialogical argumentation. One tool within MessageForum is ForumManager, an Excel application for downloading and analyzing text messages (which Jeong conducted in Blackboard-threaded discussion forums using the Internet Explorer browser). Jeong (2005) found that the visibility of the structure helped learners' reflection: More replies elaborated previous ideas, users showed greater gains in knowledge acquisition fewer unsupported claims, and greater knowledge of argumentation processes.

When building tools to support educational activities, the educational task needs to be connected with the tool's functionality. In other words, the direct fit between educational task and the method chosen to pursue it is essential (Lambropoulos & Culwin, 2010b). Anchored in Järvenoja and Järvelä (2009), this means that tools need to support learners' socially constructed self-regulation and enhance their socially shared regulation strategies. For our study, three such tools, drawing on the research provided by Hoadley et al. (1995), Suthers (1998), and Jeong (2005), were built and are now hosted on Moodle.[1] Thus, in order to support DL factors for collaboration and idea generation towards group accomplishments, the forums were enhanced with tools based on co-creativity. One approach we developed was called Hybrid Synergy, which is a five-level non-linear collaborative creativity analytical framework for analysis and a high order cognitive model that facilitates and enhances e-learners' metacognitive awareness. The designed tool based on this approach, modeled specifically for the Moodle environment, was the HySynTag, (Lambropoulos & Kampylis, 2009). The other two tools were the Participation Avatars (Lambropoulos, 2009; Lambropoulos & Culwin, 2009, 2010b), and the Visualisation Interaction Tool (Lambropoulos, Kampylis, & Bakharia, 2009).

The HySynTag tool (Figure 1, left) allows discussion participants to attach to their posts qualitative metadata based on a specific cognitive model, and thus get an overview of their cognitive levels on an individual and group basis. This visualization can occur on three levels: the actual unfolded discussion, the posts, and the overall view of the discussion (threaded view in Moodle). More specifically, participants have the opportunity to tag their

posts in accord with various Hybrid Synergy high order thinking levels: social, inform, explore, idea, evaluate, and summarize. When none of six levels of Hybrid Synergy seems to cover their argumentation, users can tag their post "other."

Users have the option to tag their posts or not, although they were encouraged to do so throughout the course. The tool, placed below the Reply button, can also aid metacognition because the tags can be inserted when replying, or after finishing the posting message. The overall view of the thinking levels via the tags in one discussion on both individual and group basis can enhance the spiral and nonlinear creativity mobility, allowing the "Aha!" experience to occur. The HySynTag tool also provides a twofold real-time thematic analysis that encourages the students to build upon their arguments. An added benefit is that researchers can analyze the messages in real time.

In assessing the participants' presence and/or activity within the on-line community, the researchers employed two perspectives. *Null passive participation* is defined as the absence of activity: The on-line participant registers, but takes no further actions whatsoever. *Passive participation* is defined as users visiting and reading posts, but without posting themselves. It is categorized into three levels—low, medium, and high—as defined by the number of days when at least one visit is made, with respect to the length of the course. Low passive participation is where the average number of days is one fourth or less of the duration of the course. High passive participation is more than three fourths of the duration, and medium passive participation is between these two categories.

Measuring passive participation is a challenge because the users do not click on items and so the interface does not recognize or log any action. Therefore, we assessed passive participation based on registration days rather than the actual activity recorded in the logs, as would occur in active participation. We then created a second tool to provide an assessment of activity, that of *on-line active participation*, which is defined as the presence of activity: The participant registers, reads, and posts. The tool employed in our study course involves graphical representations of levels of active participation, known as avatars (Figure 1, center). The avatars are initially grey and change color depending on the level of participation (bottom, top and head). The avatars appear on the left side of the interface and provide the most recent activity by members of the community. Active participation is categorized into three levels—low, medium, and high—defined through a comparison with the most actively posting e-learner. Low active participation
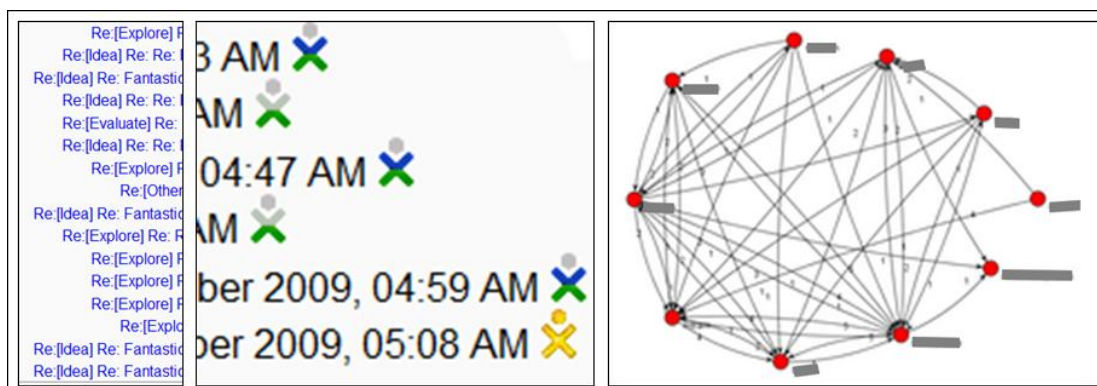

Figure 1. Outputs of the collaboration tools, left to right: HySynTag, avatars & visualization interaction tools.

is where the average number of posts is one fourth or less of the total posts from the most active e-learner. High active participation is more than three fourths of the posts, and medium active participation is between these two categories.

The third embedded tool uses social network analysis (SNA) (Figure 1, right) to visualize communication and relationships between and among people and/or groups. It uses diagrams to depict social relationships between a set of actors (Baroudi, Olson, & Ives, 1986). The diagrams consist of nodes (the actors of study) and their relations (the strands between actors). The patterns produce subgraphs that describe the degree of centrality or isolation of each actor within one particular forum. When researchers examine descriptive SNA during data analysis, it refers to structural and positional analysis of the actors.

The lagging nature of the process, however, makes it suitable only for post-hoc analysis. In order for the information contained to be useful to an e-learner, it would have to be immediately available to them. This implies that the data would have to be captured and processed automatically if it were to be used for moderating or self-organization purposes. An SNA real-time tool can support a learner's social awareness and depict an actor's locality within the group, making visible the participant to him/herself and others almost immediately.

Bakharia (2008) discovered a process for acquiring data from discussions forums in nearly real-time. She used GreaseMonkey, a Mozilla Firefox add-on that allows users to install scripts, that is, to inject client-side JavaScript code. This process extracts forum post–reply data and exports the social relationships data in a format that allows the SNA desktop application NetDraw to produce visualization graphs. The visualization of the Social Network tool was further developed by Bakharia and Dawson (2011).

These three tools were used in the course to enhance the e-learners' co-creativity based on the DL values of quality interaction and collaboration by increasing awareness of others' intentions and actions. It needs to be noted that the group work represented 30% of the students' assessed grade in this particular course. In addition to the tools, the course was specifically built to support DL based on the following learning design.

BENDING TIME IN E-LEARNING: SCRIPTING IDEA GENERATION IN DL

Other than meeting the ITIN curriculum objectives by a careful learning design, the e-course that served as the case for this study needed to be flexible enough to enhance students' individual DL skills. This goal becomes feasible by embracing students' shared meanings and team-determined plans by creating their own space and background of interaction. Therefore, a detailed e-learning plan was developed, anchored in both initial organizational activities and learning activities, and based on pedagogical design and the use of associated tools. In order to ensure idea generation, the learning approach was anchored in (a) both individualistic and collaborative learning, and (b) the multidimensional role of the e-tutor as moderator and orchestrator of activities, as well as being a model him/herself to the e-learners (Bandura, 1977). This process suits the relatively new use of scripts in the CSCL literature. In their literature review, Dillenbourg and Tchounikine (2007) found that the term *script* has been used previously in cognitive psychology and refers to the mental representation of procedures we use in everyday situations, such as entering a restaurant, and has also been used for describing methods that structure face-to-face collaborative

learning. Thus, in regard to pedagogy, a script is the predescription of the learning activities for the learning context organization and knowledge convergence (Dillenbourg et al., 2009).

In CSCeL's aim to support learning design by structuring it, collaboration scripts provide one of the most important design elements. A script describes the manner in which students have to collaborate, through task distribution or roles, turn-taking rules, work phases, deliverables, and so forth (Dillenbourg & Jermann, 2007). According to Kollar, Fischer, and Hesse (2006), collaboration scripts consist of at least five components: learning objectives, types of learning activities, sequencing, role distribution, and types of representations. Moreover, collaboration scripts are sequences of phases, each characterized by the following five attributes: type of task to be accomplished, group formation (and composition), distribution of the task within and among groups, type and mode of interaction (e.g., co-located vs. remote, synchronous vs. asynchronous, text-based vs. voice-based, etc.), and the timing of the phase.

There are two types of scripts, micro and macro:

- *Microscripts* are dialogue models, mostly argumentation models, which are embedded in the environment and which students are expected to adopt and progressively internalize (Dillenbourg & Hong, 2008). We used the Hybrid Synergy model as implemented in the HySynTag (see the Appendix). Finer grained scripts follow a more psychological approach on an individual level (Dillenbourg & Tchounikine, 2007).
- *Macroscripts* are pedagogical models, that is, they model a sequence of activities to be performed by groups. For instance, argumentation can be triggered by collecting students' opinions and pairing students with conflicting opinions (Dillenbourg & Hong, 2008). These scripts aim to increase the quality of interactions that take place among group members, linking the social part of learning with the actual learning (Dillenbourg & Tchounikine, 2007).

In addition, the internal and external script definitions served as the initial proposition for internationalization and externalization of knowledge related to both ontological and constructivist approaches. According to Kollar et al. (2006), the term *external script* refers to the pedagogical scenario that students are asked to play, while the term *internal script* describes the mental representation that students construct of the external script (Dillenbourg & Jermann, 2007). In other words, the external script functions as the course's storyboard and the internal script refers to the students' mental structures that may have existed before the e-course.

The dialogical part of the microscript also is presented in the Appendix. The following sections describe the macroscripts components for the DL e-course: resources, participants, groups and group formation, roles, activities, component distribution, and sequencing.

METHODS

A 2-day course on DL was selected for study. ITIN uses merged learning (on-line and on-site): Typically, the students and the teacher are physically present in the classroom but the in-class experience is based on simultaneously work both on-line and on-site. On some occasions, the teacher works from a remote location although the students are always located in ITIN's fully equipped classrooms. If students are absent from a class, they can visit the on-line environment

and complete at home their assignments, which include in addition to in-class information, the out-of-the class teaching and learning experience.

In this case course, students were present in the ITIN classroom and the tutor was in London, teaching in real time. The communication media were the Moodle tools that provide synchronous and asynchronous interaction (chats, forums, wikis), as well as simultaneous Skype and e-mails.

Participants

The 21 students who form the data for this study are employed full time in various fields and come to ITIN regularly to study towards a master's degree (6 times in one year to complete their MSc). For this reason, the teacher expected these particular students to bring rich working experiences to their exchange, as compared to traditional university students. The students belong to the SIBA (a master's-level degree program on bank and insurance information systems; in French, Systèmes d'Information pour la Banque et l'Assurance) group. SIBA students had studied information technology (IT) for 4 years. By following this option, they earn a double competency on banking and insurance systems, primarily regarding concepts and processes; only 5% of their studies focus on IT. In this e-course, the students were physically within the classroom, although they worked exclusively on-line within the Moodle mediated environment. The course also involved 1 e-tutor (the first author of this paper), 1 technical support person, and 2 ITIN representatives (the ITIN pedagogical coordinator and the third author as the ITIN director). All of the students are native French speakers, although the MSc studies are presented in English.

Dynamic Group Formation and Roles

Based on the number of students ($N = 21$), three groups were formed based on their special interest at the start of the course: the self-named FT1, IMAGES, and Dream-ITIN-Team. Each team elected a leader for the duration of the course. The process of dynamic group formation was employed because it increases flexibility by promoting group evolution that fosters positive interdependence. For this course, we employed role play, which initiated the group forming, but also continued as the framework of the groups' activities throughout the balance of the 2-day course. The students pretended they came from different cities and countries and enacted various roles, as for example, team leader, developer, usability expert, and so on. Throughout the course, the tutor orchestrated activities and intervened in the groups' work only when it was absolutely necessary. The role-play scenario was the same in all groups and it was taken from their real working environment. Each team had to create a vision statement, determine the location of their pretend organization's headquarters, and designate members' roles within that organization. This information was sent to the tutor, who uploaded the information to the learning management system, namely Moodle.

Resources

Several diverse educational resources were used in the course, such as PowerPoint presentations, videos, archives, community discussions, as well as tools related to DL, for example, mind tools and social network analysis. These were provided by the tutor, but the resources also included

materials from previous students in the course, which were used as examples of related work. Additionally, current students were encouraged to submit their own resources. More importantly, the students were required to exchange information and experience within the discussion forums that were provided separately for each group so the team leaders could develop their own discussion topics. This served to aid in the construction of their own group narrative, which provided the background for the elaboration of their ideas based on the DL study materials and taking into consideration the tools actual measurements. The resources were coordinated by their integration within the e-learning activities sequences. In this way, the whole course was designed for the tutor to intervene only if the group narrative was interrupted or changed direction completely. The tutor's redefined and multifaceted role is presented in the next section.

The Role of the E-Tutor

During the post-modern era (Lyotar, 1984), the main preoccupation of pedagogical research was complexity (Morin, 2005), uncertainty, and controllability, with serious limitations for nonphysical problems and the inability to control the learning process (Taleb, 2007). To control such limitations within a CSCL environment, the teacher orchestrates collaborative activities for the students. Orchestration is the process of productively coordinating supportive interventions across multiple learning activities. It covers various forms of student and learning coordination related to (a) activities at different social, contextual, and media levels; (b) scaffolds at different social levels; (c) self-regulation and external regulation, and (d) individual motivation and social processes (Fischer & Dillenbourg, 2006). Thus, while working with the newest learning tools, the e-tutor follows four overlapping stages of pedagogy as an expert in the field of study (Brown, Collins, & Newman, 1989):

1. Modeling (demonstrating expert performances). At the modeling stage, the expert proceeds slowly, commonly separating the task into separate subcomponents and using a simplified version of the task as illustration for the learners.
2. Coaching (expert guidance and help). The coaching stage involves the tutor/aid paradigm: The expert can either act as a tutor and provide direct instruction or can act as an aid and provide hints.
3. Fading (expert assistance is gradually withdrawn). With the gradual withdrawing of expert involvement, learners are encouraged and supported in completing the tasks.
4. Reflecting (students' self-monitoring and reflecting upon past performances). Self-monitoring and reflecting is related to self- and group- regulation of activities, also facilitated by the newest tools and thus, supporting metacognition.

The activities were structured in a detailed way to facilitate the work and learning flow. First, the learning goals were clarified and articulated, meaning after the completion of this particular course, the ITIN e-students would be able to

1. Work within DL principles
2. Create international teams with a competitive edge
3. Successfully lead global virtual teams
4. Become team players: actively participate in on-line collaboration and presentations.

The learning objectives/outcomes were visible on the interface. Assessment was associated with the learning objectives: 35% of each student's final grade represented individual

coursework and active contribution to the group, 35% was drawn from the group project product and presentation, and 30% came from the individual's self-evaluation.

The activities sequence for the 2 days was displayed on the interface. The first day was dedicated to learning about DL, becoming familiar with the Moodle interface, and developing students' social intelligence skills, presence, and copresence. The students used the enhanced on-line forums to follow the scripting procedure; for example, the team leader posted appropriate messages and moderated the discussion to generate ideas. During that time, the e-tutor's role was changing from an instructor, providing information and advice, to the orchestrator of the collaborative learning activities. During the second day, the students worked individually and collectively within their teams to construct a new project, based on what they learned the previous day. The tutor remained present on-line, although she intervened only when coordination problems occurred. Late on the second day, the groups presented their projects to the class.

Component Distribution

The components described above were distributed according to the evolving teaching and modes of learning related to roles and associated activities. For example, during the teamwork process, the students worked on both the jigsaw puzzle (independently on various parts of the project) as well as collaboratively (on the same of the project), depending on their roles and associated tasks within the team.

Organizational Convergence: Coordination and Sequencing

Coordinating and sequencing CSCeL activities and resources are important in reaching a flow towards organizational convergence, especially in short e-courses. For this reason, limiting the degree of coercion and tackling unpredictability is a delicate design process (Dillenbourg & Tchounikine, 2007). Scripting such sequences can scaffold students' social and learning interactions in such a way so as to achieve peak collaborative and idea generation performance within each group. This course design used a specific linear sequence of activities and resources, as well as repetition of activities with minor variations. Traverse and rotation were used in the three groups. The former is the repetition of the same educational material in the same order looped through, with only one element being in use at a time; the latter rotates the elements in a given set towards the same direction.

The relation between the responsibility for activities by the tutor and by the students was inversely reciprocal. Thus, the students gained experience in various steps in the DL activities, the tutor gradually faded into the background regarding her direct support.

To conclude, the e-learning design was scripted in detail, which allowed the structuring to promote individual and group flexibility, which in turn enabled students to act and collaborate on both an individual and group level. In this way, the students knew in advance about the educational material and the basic structure of their activities and roles as well as tutor's role used in each phase, but experienced an open scenario in which to grasp the intended learning goals. Consequently, transaction cost and time was significantly saved and the e-course finished successfully on the second day. The next section presents the scripting implementation in a case study and the results between the script description and what actually happened.

Data Gathering and Analysis Process

We used quantitative and qualitative data gathering methods, as well as the data extracted from the implemented tools. Causal research methods alone (effect intervention) do not provide the holistic view (Andrews & Haythornthwaite, 2007) needed for this study. Consequently, diverse evaluation methods and tools aided in the identification, development, improvement, and validation of the e-learning design defined by the scripts. The students completed a self-reported assessment questionnaire (i.e., what they learned about DL since DL was a relatively recent course introduced into the MSc curriculum).

The extracted data comprised texts from each group's forum. All these texts were run through an algorithm called Non-Negative Matrix Factorization (NNMF; Lee & Seung, 1999), because this algorithm is able to discover patterns within text. NNMF has proved successful in text clustering evaluation studies (Xu, Liu, & Gong, 2003). In the context of this study, NNMF was able to uncover the main themes, the main words used in the theme, and the messages linked to the theme. As a comparison to the automated output of the NNMF, we also conducted a qualitative analysis of the forum discussion texts only in ATLAS.ti, using the Collaborative eLearning Episodes Matrix (see the Appendix). ATLAS.ti is a commercial software product that supports qualitative data analysis by allowing researchers to manually attach codes (concepts) to text segments. Lastly, we compared the above results with the data extracted from the HySynTag (counting the provided tags), the participation Avatars (counting the different participation levels), and the SNA tools (describing and analyzing the visual data). Lastly, we compared the student-coded data (from the HySynTag analysis) with the researcher-coded data (from the Atlas.ti analysis) to determine if it was possible to assess differences in perspective between the researchers and the students. A side benefit of this was the ability to involve the students within the research project.

RESULTS and DISCUSSION

Due to the diversity of the investigated issues, this section presents both results and discussion in order to avoid confusion if discussion was a separate section. The results briefly presented in this section are grouped into quantitative, qualitative and tools-based data (quantitative, qualitative and visual data). Quantitative data were collected with the NNMF algorithm directly from the forums, while the qualitative data were extracted from the forums, saved, and analyzed separately. The tools-based data arise from the HySynTag, the avatars, and the visualization network (the latter provided the visual data).

Self-Reported Questionnaire

Since the students had no previous knowledge of DL, the assessment questionnaire checked whether the students actually acquired the DL principles and were able to articulate them in their own words. Despite the fact that the French students had some small problems with the use of English language, the results showed that all students grasped the DL principles. For example, Participant BD said,

@ *First, even if we work far away from each other, it is possible, using distributed leadership, to communicate as fast as if we were in the same room. Then, distributed leadership is making you build a database knowledge. To finish, DL means share your ideas with people from different cultures, and that's very good for innovation.* [2]

The open question on the self-reported survey regarded what the students will change in their professional practice, based on what they learned from the e-course. Some directly quoted extractions include,

- *That a one-man leadership is not always the solution to bring a project to the end; distributed leadership can be an interesting choice to manage a project.*
- *DL can be used effectively because the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem.*
- *Knowing people is a very important step for team works, for this, communication is the key.*
- *Communication is very important for good management.*
- *The importance to have a team communicating and dynamic.*
- *The tools which permit to succeed a project.*
- *The efficiency of collaborative tools for international project. All the online tools we discover in this lesson are very powerful and are a precious advantage for work as a team.*

In addition to learning the DL principles, these extracts show that the students attached importance to the human factors, such collaboration and coordination, the distribution of tasks, working on the same task, clear communication, diversity among the team members, and the use of tools as the technical factors to facilitate DL. Other than the qualitative data, quantitative data offer a different viewpoint about the quantity of the posts. Table 1 presents the overall number of messages and words used within the discussion forum, as a quantitative measure.

The average number of posts was 31 per discussion and 8.9 posts per learner, whereas the average number of words was 1,080 per discussion and 308.4 words per learner. The length (depth) of discussion posts varied in the number of replies. Also, it appears from the table results and analysis that the team leaders actively engaged their team members, resulting in the absence of lurking; in other words, passive participation was zero. However, more detailed analyses are needed to correlate the factors that contributed to the successful implementation of the short e-course. For this reason, both automated (the NNMF algorithm) and manual approaches (behavioral coding of messages extracted from the forum via the Atlas.ti) were employed.

Table 1. Discussion Forum Summary, with Two Forums for Each Group.

Discussions	FT1		Dream-ITIN-Team		IMAGES		Total	
#	On DL	New DL Tools	On DL	New DL Tools	On DL	New DL Tools	#	Average per discussion
Replies	34	18	27	18	35	55	187	31
No. of Words	1,011	651	1,359	667	1,368	1,422	6,478	1,080

Theme Discovery within Discussion Forums: Non-Negative Matrix Factorization

NNMF (Lee & Seung, 1999) has two features crucial to the application of the algorithm within a collaborative discussion context. Firstly, participant posts are allowed to correspond to multiple themes; this is essential because participants quite naturally may address or refer to multiple themes and concepts in a single post. Secondly, NNMF produces readily interpretable results. The main keywords, as well as the top participant responses within a theme, are produced as the output from the algorithm. The input to the NNMF algorithm is a matrix with forums posts and the counts of words for each word found in the forum post. The NNMF algorithm outputs themes and the main keyword within the theme by relative weight, which indicates the keyword's strength within a theme. The output can be interpreted as a tripartite graph, which maps words and documents (in this case forum posts) to themes where the weights represent the link strength.

Themes discovered by NNMF are not automatically labeled (that is, given a title). However, labels can be manually determined by analyzing the prominent keywords and posts within a theme. The algorithm also is not able to automatically detect the number of themes present within a forum. It is up to the researcher to interactively specify the number of themes and review the results in order to find the best fit. A tool known as the Thematic Explorer was developed by Bakharia for this study to facilitate the required interaction with the NNMF algorithm within Moodle forums. While NNMF is able to group participant posts into coherent themes based on word usage, interpretation and further refinement of the results by the researchers is essential.

Table 2 provides an illustration of the themes from one specific forum. As with all of the themes and main keywords outputs from NNMF, the themes were determined by the word usage within the forums (i.e., the most-used descriptive words served as the titles). This exemplar shows the "Find new tools for DL" forum that was setup for each of the three groups as part of the activities on Day 1.

Analyzing the students' posts from each of the forums processed by NNMF provided a high-level overview of the distributed leadership tools being discussed within a group. Such outputs

Table 2. Themes Derived from Non-Negative Matrix Factorization.

Distributed Leadership Course			
Group Work Day 1			
Discussions	**Identified Themes**	**Keyword Weights > 1**	
FT1: Find new tools for DL			
#Messages	18		
	Facebook	facebook [1.73] people [1.06]	
	Group Forum Discussions	discuss [1.01]	
	Instant Messaging		
	Wikis and Information Sharing		
Dream-ITIN-Team: Find new tools for DL			
#Messages	18		
	Social Networks	friend [1.25]	
	Management and Distributed Workflows		
	Friend Whell (tool)		
	Discussion and Facebook	discuss [1.18]	
	Distributed Leadership Resources		
IMAGES: Find new tools for DL			
#Messages	55		
	Project Management Software and Bug Reporting Software	PMS-BR [1.71]	compani [1.38]
	Open Source Collaborative Products	product [1.40]	
	Tools for Monitoring Tasks/Progress	task [1.68]	
	Accessible Software	softwar [1.16]	
	Time Management	time [1.31]	

allow us to compare the content being discussed by each group. The FT1 and Dream-ITIN-Team groups primarily discussed social networking tools and social software. The IMAGES group, on the other hand, was more focused on project and time management software.

The data from this focused analysis of this initial discussion of the e-course, as depicted in Table 2, show that the most productive group, in terms of number of posts, was IMAGES. This discussion was directed towards the implementation of the DL tools, since 2 of the 5 themes refer to IT and time project management, whereas the rest were focused on social tools for international collaboration, which is an aim of DL. The main keywords found in the "Find new tools for DL" theme were 17% for the word project; 13% for idea, team, and company; 9% for inform; 6% for discuss and system; 5% for user; 4% for share and wiki and 2% for people. The most frequently used words and percentage of appearance from the previous table were management (29%), tools (28%), idea (20%), collaboration (20%), and physical space (3%). Taken together, the keywords and most frequent words reflect the DL values of collaboration and decision making based on dialogue, as well as the software tools used towards idea generation.

Qualitative Analysis Using ATLAS.ti

The data from the forums that were used for the NNMF algorithm were inserted into ATLAS.ti in order to observe any differences in the ways the NNMF algorithm treated the data as compared to the manual coding by the researchers via the ATLAS.ti. The information is presented in several tables to follow. Due to lack of space, results only from Day 1 (169 messages and 20 idea generation cycles) are presented in Table 3.

Table 3. Researchers' Code Network in Day 1 (ATLAS.ti).

CeLE Level	Number of Codes	Total	%
Social	36	36	9
Information	53		
Question	39	98	24
Answer	6		
Explanation	25	25	6
Agreement	40		
Justification	16	60	15
Disagreement	4		
Exploration	69	69	17
Evaluation	64		
Justification	28	92	22
Ideas	20	20	5
Summary	9	9	2
Total		409	100

When comparing the results from the algorithm and the argumentation analysis (i.e., the qualitative analysis via Atlas.ti), it appears that the former provides evaluation of the macroscript while the latter does the same for the microscript. In other words, the algorithm was able to acquire the most used words from a great amount of data, thereby verifying the success of the macroscript and, by extension, the success of the CSCeL pedagogical design. For example, throughout the course, the students used social software, IT, and timeline-based project management tools. Their work therefore reflected collaborative behaviors, and their discussions of this work involved words such as *team*, *idea* or *discuss*. This naturally resulted in the themes surfacing in the forums, which in turn indicated collaboration.

However, the algorithm alone cannot provide enough information in support of the microscript; this means, we needed more evidence of cognitive and psychological development within the scenarios that reflected the outcomes of the discussion design. It appears that the students concentrated on the DL educational material of the course rather than on social exchange, since they knew their peers already. Thus, they focused on initial information provision based on the educational material, their own experiences, and information derived from the Web in order to explore the materials and decide upon their usefulness. Moreover, based on the researchers' previous experience with similar research, the percentage of correspondence on idea generation (5%) was relatively high (Lambropoulos, 2009; Lambropoulos & Kampylis, 2009). However, because each group and each case study are unique events, this may simply suggest an evolution in our approach in using collaborative learning scripts, or that the DL approaches and tools may have resulted in better collaboration and thus evidence of increased group co-creativity and idea generation. Table 4 provides selected excerpts from message exchanges within the IMAGES team and their unique forums that evidence DL principles.

Table 4. Excerpts from IMAGES Team Evidencing Understanding of DL Principles.

Stanza Number	Participant	IMAGES Forum	Tag	Comment
Stanza17	BDR	Forum#5	INFORM	*"in DL, the language is very important to avoid misunderstood."*
Stanza46	JD	Forum#5	EXPLORE	*"And with IM* [Instant Messaging], *you lost the human contact between people and the work become monotonous."*
Stanza75	PE	Forum#5	EXPLORE	*"Well, it's pretty expensive but I think I'm gonna propose this tool in my team"*
Stanza80	JB	Forum#5	EXPLORE	*"You're welcome my friend!"*
Stanza19	MB	Forum#2	[none]	*"Open plan is the best and the simple way of exchanging informations of any type. But it's not the best solution, the confidentiality of datas and informations are in danger in that kind of organisation. I think the best solution is a mixed organisation"*
Stanza202	MB	Forum#2	[none]	*"Yes of course, Many of companies used this system (collaborative). It permits to keep contact and share the documents, which we want to expose for partners and then applicate many rights (read only, write only...)"*

Note. Stanza numbers are created automatically by Atlas.ti.

Table 5 provides feedback messages, drawn from the FT1 team. In this conversation, it appears that participants generally did not consider tagging the social messages, possibly because such tagging was not helpful to them in their discussion evolution towards idea generation.

Table 5. Comments from FT1 Team That Reflect Feedback Messages.

Stanza Number	Participant	FT1 Forum	Tag	Comment
Stanza184	CBDV	Forum#1	[none]	*"Have we great answered the question?"*
Stanza185	XD	Forum#1	[none]	*"I think it's great!"*
Stanza186	SK	Forum#1	[none]	*"I think it's a very good answer!"*

The following short social messages exchange (Table 6) enabled team members of the Dream-ITIN-Team to elaborate on their contributions. Because the students knew each other, they often used their names in their interactions, although the names have been redacted here. It is also interesting to note that Participant JW copied the structure of JD's explorative message.

Table 6. Social Exchanges from the Dream-ITIN-Team Regarding Discussion Contributions.

Stanza Number	Participant	Dream Forum	Tag	Comment
Stanza122	JD	Forum#3	[none]	*"In our company, in one hand, we can use collaborative website as Intranet, or forums which relate our discussion about projects to improve productivity and answer about problems. In other hand, we can separate task in several leader. For example, one leader create planning, distribute tasks and role in the project, and the other leader execute the leader on his team.* *"I share the same opinion with my team leader."*
Stanza124	DB	Forum#3	[none]	*"Thank you for your help J![...]"*
Stanza125	JW	Forum#3	[none]	*"I can say that in my campagny I have many roles: In the one hand, my main goal is to write codes lines (for news projects, news moduls or plug-in).But in a second hand, my manager can give me some responsibilities: lead my own project from the begining to the end: planning, ressources, an available software (for instance)...To conclude with my opinion: we can give many role or responsibilities to an employee to lead a project!"*

In the discussion extract in Table 7, the students in the IMAGES team exchanged experiences using examples in order to help their peers to understand their viewpoint and also increase their knowledge on the subject. Peer feedback and a reciprocity effect also are evident, as a team member reciprocated the initiated communication and argumentation style, indicating peer vicarious learning. Moreover, this exchange demonstrates that students repaired meanings (Sacks, 1992) to achieve a common understanding.

Sharing and repairing meaning is extremely important in CSCeL, as an indicator of common ground and creating the basis for common knowledge in a group. Stahl (2010) suggests

Table 7. Clarifications, Feedback, and Communicative Repair Examples from the IMAGES Team.

Stanza Number	Participant	IMAGES Forum	Tag	Comment
Stanza91	PE	Forum#5	EXPLORE	*"Excuse me Ja, but your question isn't clear, can you precise??Thx"*
Stanza92	JB	Forum#5	EXPLORE	*"I'm sorry. The question is: Is this software easy to use?"*
Stanza93	ES	Forum#5	EXPLORE	*"It's a good question Jb, but i'can't answer you directly, beacause i don't know very well this produt. Ask to P."*

that meaning making is essential in learning since learning is a social activity that is conducted collaboratively. He advocates that meaning making depicts individualistic and social learning.

One primary benefit of DL, particularly in the business arena, is idea generation. Table 8 provides examples of how members of the Dream-ITIN-Team went about the process, with Stanzas 127 and 128 of focus here. These discussion extracts provide evidence of students' active engagement, knowledge acquisition of the DL topic, learner-generated text as the background for going beyond information given, and co-creativity as idea generation. Referring

Table 8. Idea Generation Exchange in the Dream-ITIN-Team.

Stanza Number	Participant	Dream Forum	Tag	Comment
Stanza126	DB	Forum#3	EXPLORE	*"In the DL, I think that everybody must be equal. Actually, if you have a manager who works on the same office as you, I don't think it has something to do with DL. Do you agree?"*
Stanza 127	GE	Forum#3	EXPLORE	*"DL put the focus on the team working. The main fact is to give to every member of the team the possibility to express their opinions. It's permit to reduce the Hofstede's Power Distance! DL purpose is to give responsabilities to every members of the team. It's permit to forget the idea of leaders/followers."*
Stanza128	DB	Forum#3	EXPLORE	*"I think you are right. You talk about the power distance. DL gives the same hierarchic level to anyone in the team. What do you think about that? Personaly, I think that every project team should have a manager, otherwise everyone in the team tries to show that his idea is the better one. Don't you think? Talking about Hofstede's system, do you think that masculinity is an important factor in DL ?"*
Stanza129	JD	Forum#3	EXPLORE	*"The problem if there is only one leader is when he is missing, the team can't work at 100%. In the case where a decision must be do, nobody would to take the responsability to put the company in danger. So, if you use the DL, you can manage the project for all situation…"*

to Hofstede's (1967-2009) power distance concept, the discussion was enriched by many contributions about hierarchical and security levels, as well as team members' skills and experiences in their professional careers. Participants' active involvement in the discussion is evident in, for example, the use of exclamation marks in the eureka experience ("*It's permit to reduce the Hofstede's Power Distance!*"), critical thinking in arguments, and asking for their peers' feedback their own thoughts about the topic. Furthermore, engaging multiple perspectives, particularly through exploring the pros and cons of a particular concept, were products of critical thinking in favor of DL.

Overall, the results from the researchers' qualitative analysis showed that the depth of the discussion allowed multiple ideas in various subtopics to occur. Moreover, the learner-generated text provided larger quantities of and diversity in information, allowing increased knowledge acquisition from the educational resources as well as from the argumentation cues. The data also evidenced peer support and vicarious learning, as well as fewer unsupported claims. Finally, the students' evaluations and summaries indicate team convergence towards consensus.

HySynTag Tool Codes and Analysis

The student-coded HySynTag results are summarized in Table 9. Note that not all messages were tagged and some messages were tagged twice, depending on the e-learners' choices. Because HySynTag provided information in real time, it made the argumentation structure visible to the learners by facilitating their cognitive presence and co-presence. However, when we compared

Table 9. HySynTag Results from Two Forums from Each Group.

Discussions	FT1		Dream-ITIN-Team		Images		TOTAL	
	On DL	New DL tools	On DL	New DL tools	On DL	New DL tools	#	%
Social	0	0	0	0	0	0	0	0
Inform	0	12	5	7	0	20	44	29
Explore	1	10	6	6	13	50	86	57
Idea	0	0	0	6	2	2	10	6
Evaluate	1	3	4	0	0	0	8	5
Summarize	1	1	1	0	1	1	5	3
Other	0	0	0	0	0	0	0	0
Total	3/34	26/18	16/27	19/18	16/35	73/55	153/187	100

Note: The split figures in the total represent then number of tagged messages out of the total messages posted to that forum. Initially the students were not tagging the messages because some students needed time to familiarize themselves with the tools and their utility. This resulted in just 3 of 34 messages tagged in the earlier On DL forum. However, the learning curve is evident in the New DL Tools forums, where the students demonstrated knowledge of how to use multiple tags for compound messages.

the data outputs of researcher-coded Atlas.ti analysis to the data outputs of the HySynTag analysis, it became clear that the researchers produced more coded data than did the students with their tags. This can be due to several reasons.

First, the HySynTag tool is simplified to improve usability, which resulted in fewer distinct categories in the students' results. Also, the students could not tag different parts of the same message but they could tag the same message in more than way if they wanted to make that effort. Finally, as noted in the previous subsection, the students did not tag any of the social messages; perhaps they did not considered them important in their interaction on tasks.

Avatars

An overview of the levels of participation, as depicted by the avatars in Day 1, is provided for each student for two discussions per group (see Table 10). The teachers' messages were attributed to the highest poster who also was the group-elected team leader. These individuals are noted in the table with boldface text and their participation level was the standard by which other participants were rated.

It appears that the participants kept the same participation level in both discussions, even though the participation level was increasing throughout the course. This may be an indicator of person's presence, copresence, self-regulation, or engagement. It also suggests the idiosyncratic character of the students and consequently the coexistence of different interaction and learning styles. In other words, it can be implied that learning is a by-product of both passive and active participation and the feeling of being engaged in the course.

Visualization Network

Until recently, real-time SNA was rarely used in education, although in this study that emphasizes DL as a means for co-creativity and co-learning, we found it useful and informative both during the discussions and in analysis. In this paper, only one sample is displayed due to the

Table 10. Participation Levels (Indicated by Avatars) for Two Group Discussions (Day 1).

FT1			Dream-ITIN-Team			IMAGES		
Participants' Coded Name	1	2	Participants' Coded Names	1	2	Participants' Coded Names	1	2
AA1	M	M	**BD**	**H**	**H**	AA21	L	L
AA20	L	L	BDRDM	L	L	AM	M	M
BS	L	L	DJ	M	M	BM	M	M
BDVC	**H**	**H**	EG	L	L	**CC**	**H**	**H**
DX	L	L	LFG	L	L	EF	L	L
JA	L	X	SJ	L	X	LM	L	L
KS	M	M	WJ	L	L	SE	M	M

Note: There were 6 unique, mutually exclusive discussions, two for each group. Participation levels are **L**ow, **M**edium, and **H**igh, with highest individual in each group (indicated in bold) also serving as the team leader. See p. 80 for explanation of the various levels. The X indicates that those participants were absent during that discussion.

lack of space. We selected one discussion from the IMAGES group; this particular discussion contained had four ideas over 55 messages. This representative example of Visualization Network data is presented in Figure 2.

The red dots in Figure 2 represent the discussants, the lines represent the interaction via posted messages, with the directions to individuals indicated as arrows, and the numbers indicate the number of message exchanged. Other than the interaction visualization, it is interesting to observe reciprocity as a structural property between the participants on a dyadic level. However, other than self-explanations and one-way interaction, the social reality in e-learning lies beyond dyadic interactions to the total communication among all group members, since all members are exposed to all messages. It is also a clear depiction of early collaboration evident in the distributed discussion.

It appears that the use of SNA in educational research—both real-time and after-the-fact—can depict several perspectives of a discussion at a glance. It can become a valuable and fundamental resource for understanding student interaction and active (as well as passive) participation and the feeling of engagement, particularly in real time. Such real-time knowledge subsequently can lead to an improvement in teaching techniques and methodologies (Martínez, Dimitriadis, Rubia, Gomez, & de la Fuente, 2003). Also, it has been reported that high interactivity is more likely in environments where trust and cooperation are evident (Sparrowe & Liden, 1997). In other words, students' interactions dynamics starting from social interaction, information, and information exploration, and leading to group knowledge building and idea generation can be inferred to be related to students' creativity and innovation in DL.
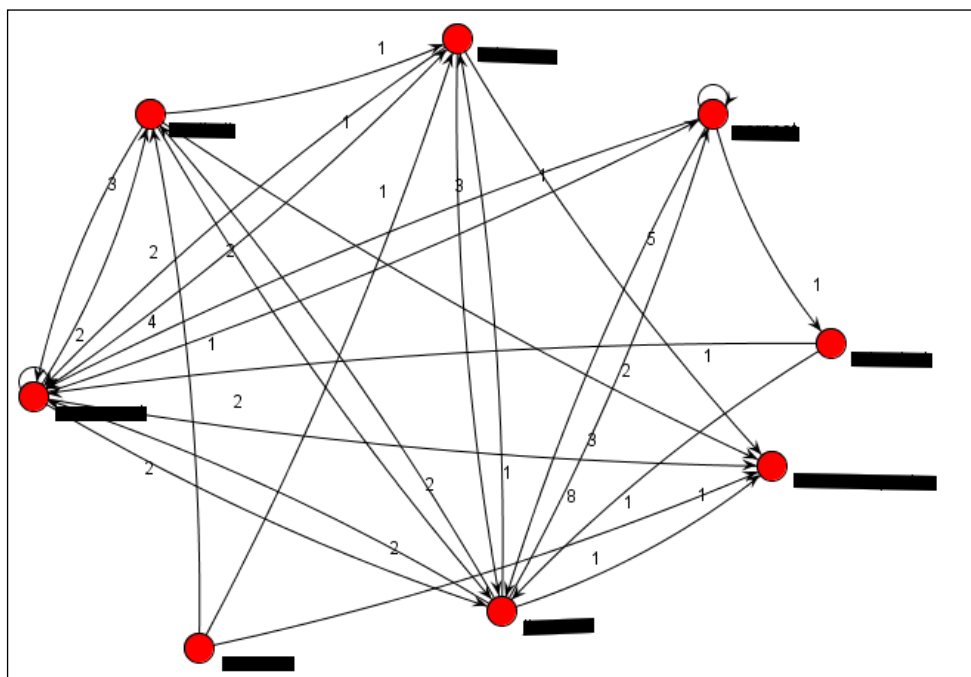

Figure 2. A screenshot for the SNA visualization of CSCeL participant relationships.
Note. The participants' usernames have been redacted through the use of black lines to protect personal data.

Reflections on the Totality of the Data

Based on the accumulation of the various data, collaboration was observed in all students' activities. Following Fredricks et al. (2004), all three types of engagement as evidence of collaboration were present: (a) behavioral engagement, through students' passive and active participation and the feeling of engagement; (b) emotional engagement, through students' positive feelings towards their e-course and their peers, in particular, as well as the e-learning environment in general evident in the active and increased participation in the course; and (c) cognitive engagement, evident in that the students made efforts toward acquiring comprehensive knowledge and skills, as demonstrated in the discussion visualization and the qualitative analysis of the messages contents.

In regard to technological factors, the tools facilitated presence and co-presence. The students reported at the end of the course that the tools helped them to reach such awareness; however, they were also aware of their constraints. Traditional tools implemented in Moodle or other learning management systems often are oriented more toward teacher implementation than student use. Furthermore, such learning platforms do not include tools that visually display interaction patterns, something the data from our research have shown is instrumental in facilitating active participation. Rather, most learning management systems provide access statistics (usually in terms of page views) for the teachers, researchers and/or policy makers to consider, but such data do not take into account students' reflections anchored in their awareness based on these results.

Lastly, in regard to research methodologies as such, when all results are triangulated, then a more holistic view of the discussions is possible. This can result in a high level of learning and understanding, as for example indicated in our data by the high number of messages exchanged (quantity) and number of ideas generated (quality). Furthermore, the attempt to use the same codes and SNA interaction subgraphs by all e-learning participants (e.g., teachers, students and researchers) can be found useful in the way each group interprets the user-generated data in the discussions. However, more detailed research in multiple contexts is needed in order to find the best level of agreement of such codes for all frameworks.

As with all research projects, this study has limitations. First is the nature of this e-research, due to the lack of control of several parameters in this study, such as the resources of information and individual interaction, as well as several problems of technical nature. Additionally, our sample was not representative and relatively small, and thus the conclusions drawn from this research has no generalizability to larger groups or to learning in alternative contexts. Further, the limited research in the field of measuring the motivation to implement DL as well as using the specific tools does not allow extended comparison of the results. Of course, researchers in intervention studies must always consider the Hawthorn Effect, a condition where participants change their behavior because they are being studied. And, lastly, the propositions need to be further tested and developed in different contexts to ensure their validity and reliability.

Nevertheless, this study makes contributions to the field in regard to observing how DL can facilitate both interaction and learning within a CSCeL environment. Methodologically, this study demonstrates the need for a variety of tools—many offered in real-time—which can provide not only an important means for the students and teacher to gauge the level and quality of interaction, but also to allow researchers the ability to gather data instantaneously,

which might facilitate researchers' efforts in employing other data-gathering methods to triangulate or enrich the data.

To conclude, this study supports the growing realization that using solely traditional research methods cannot provide a holistic view of discussion topics in a dynamic learning environment. Therefore, we note that, in the circumstances of an e-course, a diversity in evaluation methods and tools, both real-time and at the completion of the course, aids in the identification, development, improvement, and validation of the e-learning design defined by macro- and microscripts.

CONCLUSIONS AND FUTURE TRENDS

This paper presents a case study focused on students' rich collaboration in a short e-course. The e-learning design of a DL course over 2 days was scripted in order to facilitate the flow of students' learning and work, as well as the tutor's changing roles during the e-course. The effectiveness of the course was measured by the students' creativity and productivity, that is, the quality and quantity of students' texts that provided the background of their own learning based on idea generation as the indicator of achievement. In this way, the students had to take responsibility for their own learning. Diverse quantitative and qualitative data analysis methods and tools were used in order to provide multiple perspectives of the same data, and thus a more holistic approach in data interpretation and triangulation.

The results show that the use of the NNMF algorithm, a quantitative analysis tool, can provide evaluation of the macroscripts, whereas the qualitative analysis, avatars' active participation levels representation, the HySynTag, and subgraphs of SNA can present a rich picture of interaction between and among the students. Peer support was also evident. In addition, real-time tools can provide formative feedback that supports self-regulation and critical self-reflection. Also these tools and techniques can scaffold the different learning modes occurring within an e-learning environment. Consequently, they can help tutors deal with diversity in e-learning environments by adjusting their pedagogical approaches and orchestrating students' activities. An important finding in peer meaning making suggests that both individualistic and social learning exist in collaborative learning (Stahl, 2010), which in turn is related to the internalization and externalization of knowledge. Furthermore, meaning making in collaborative learning, in combination with the idea generation, supports the significance of CSCeL scripts and associated tools.

Flexible macroscripting in this DL short e-course appeared to support learners' passive and active participation and the feeling of being engaged as vital in reaching organizational and personal objectives. Further improvements in e-learning design can focus on (a) comparing in detail the different effects of students' individual ways of learning resulting from students' learning styles and teachers' pedagogical approaches, depending on the length of an e-course; (b) the differences between real and blended learning environments as compared to e-learning courses on the same time scale; and (c) whether DL scripts can be implemented in an adaptive system in order to completely eliminate the need for instructional intervention by the teacher, whose focus then can be on his/her activities orchestration.

This experience of DL worked here within specific pedagogical situations: CSCeL, local teams, and simple IT deliverables as learning outcomes. In future research, we aim to explore

these frameworks in actual working situations, meaning actual IT projects, entrepreneurship projects, intercultural teams, and geographically distributed teams. Such real-world situations could allow for deeper exploration of various aspects of teams working on projects with actual IT deliverables and constraints. The use of CSCeL macro- and microscripts within teams cooperating during the creativity and innovation phases of an entrepreneurship project would also benefit from further investigation.

Contemporary project managers must be able to juggle the variety of activities within a project amid multiple constraints, such as a specific timetable, financing, and material and personnel resources, to name a few. Additionally, such activities require them to deal with technical and cultural issues, as well as challenges related to the unpredictability and the complexity of contexts. Therefore it would be valuable to explore how learning DL principles and practices through the application of DL principles and practices can have a wider impact on the lives and professions of students. In other words, can employing DL in learning environments intended to teach about DL simultaneously facilitate behavioral changes in the students by their employing DL competencies within their professional environments? We believe that this study provides a firm foundation for continuing the exploration of how CSCeL tools, frameworks, and techniques, coupled with the tenets and practices of DL, can further collaboration and idea generation in actual working environments.

ENDNOTES

1. The open access, open source innovation management e-course is available at http://www.intelligentq.net/e-learning/
2. All of the quotes from participants are provided without editing.

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APPENDIX

In Table A1 the levels of abstraction follow the stages of research analysis. Level 1 involves classification of concepts and Level 2 identifies the analytical definitions. Finally, Level 3 provides the overall umbrella for classification and design attributes.

Table A1. Collaborative e-Learning Episodes Codes Matrix for Idea Generation/Identification.

Levels of Abstraction

	Level 3	Level 2	Level 1
	Collaborative e-Learning Episodes Elements	Analytical Corroboration Definitions	Indicators for Classification
0	Initiation & Social Cues	Initiations, additions or superficial amendments, repetitions, uncritical information, social cues, etc.	*Information, statement, definition, emoticons, abbreviations, lexical items, quoting, images, audio etc.*
1	Question – Information	Question, proposition, instruction, opinion, history of something, etc.	*Recommendation, question, bullet points, I think, I believe, instruction, I know, have worked, I prefer.*
2	Explanation	Explanation and self-explanations, requirements, examples, summaries, etc.	*Because, this is why, thus, therefore, example, further explanation, help, nice behavior & suggestion.*
3	Agreement	Agreement, confirmation, corroboration, etc.	*It is very interesting, refer-to-a-name, same, Yes, I agree & you are right.*
3a	Disagreement	Disagreement, difference, discrepancy, flaming, etc.	*But, however, on the contrary & different.*
4	Exploration	Hypothesis, comparison, example, argument, resource interdependence, critical information, competition of ideas, reasoning, argument, etc.	*Alternative, I have an idea, something else, what about, what do you mean, I tried,* *if, might, could, would, should, think & suggestion.*
5	Evaluation	Comparison, assessment, best practice, etc.	*Best, it is important, comparison, easiest, worst, unfortunately & having no meaning.*
6	New ideas – Co-construction	Strategy, plan, method, plan, procedure etc.	*New idea, innovative approach, new solution.*
7	Summarize	Synthesis	*Summary, overall, we agreed & finally.*