Computer-Supported Collaboration: Simulation-Based Training Using LEGO®

Full Paper

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Abstract

Learning the effects of proximity and distance in collaborative work and comprehend the challenges and possibilities of information technology use in distributed teams can be challenging for students. The present paper describes a LEGO® simulation-based training (SBT) and shows how the use of LEGO® bricks and a videoconferencing platform can help students experiment first-hand computer-supported collaboration (CSC). Students who participated in SBT sessions adopted different work coordination and information sharing strategies. The working patterns observed during three different SBT sessions were analyzed and put into perspective using the literature on collaborative work. Findings show that, using LEGO® bricks to recreate a "real-life" situation, allow students to immediately immerse in the challenges faced by "virtual workers" and enable them to more easily and deeply understand and integrate theoretical concepts related to collaborative work and computer-supported collaboration.

Keywords (Required)

Collaboration, distributed team, communication technology, simulation-based training, LEGO®

Introduction

Distributed collaborative work between distant individuals, through information technology (IT), has been a key phenomenon of interest in several academic disciplines, particularly in the fields of information systems (Yang et al. 2015), education (Siebdrat et al. 2009) and computer supported cooperative work (Schmidt and Bannon 2013). Distributed collaborative work has changed how individuals work together. More and more organizations are exploring new approaches to collective work to access specialized human resources and decrease travel costs. Virtual teams, outsourcing agreements and offshore projects are some examples of new forms of collective work (Thomas and Bostrom 2010). Innovative, design and/or creative project teams are increasingly dealing with working structures and environments which can be geographically, temporally, culturally and/or organizationally distributed (Johns and Gratton 2013).

Therefore, students enrolled in business schools should be exposed to the difficulties/possibilities associated to these new collaboration modes. They should understand the impacts that these new forms of collective work entail on individuals, organizations and working environments. Prospect IT managers will need to evaluate, select, implement and support collaborative IT platforms and ensure that they are properly used and deployed in the workplace. Rhe competencies required to conduct such tasks are based on: 1) an awareness of the effects of distance and proximity in collaborative work (Kraut et al. 2002) and, 2) a detailed understanding of the opportunities and limits of IT regarding actions coordination and information sharing (Navarro 2001).

To help students acquire these competencies, we have developed and tested a simulation-based training (SBT) of computer-supported collaboration (CSC), in synchronous mode, using LEGO® bricks. Salas et al. (2009) define SBT as "any synthetic practice environment that is created in order to impart competencies that will improve a trainee's performance (p.560)". A SBT is a teaching/learning technique that replicates real-life situations where students play different roles. During a SBT, students must analyze the simulation context[1], make decisions and take actions. As a SBT unfolds, time periods are dedicated to reflect on the decisions made and actions taken as well as for sharing experiences (Tiwari et al. 2014).

Studies have shown that active learning techniques, such as SBTs, 1) bridge the gap between the classroom and "real-life" contexts, 2) offer realistic and complex learning environments, 3) let reality be simplified and manageable, 4) are safe and risk-free environments, 5) generate greater motivation, 6) promote a better understanding and 7) facilitate integration and retention of knowledge compared to so-called traditional methods (Dekkers and Donatti 1981; Léger 2006; Salas et al. 2009; Tiwari et al. 2014). In the proposed LEGO® SBT of CSC, students must design and build two different models using LEGO® bricks. Students are alternately assigned to two collaborative contexts: 1) collocated team and 2) distributed team mediated through a videoconferencing platform. By experiencing both contexts, students will identify the underlying impacts and opportunities of each working mode and compare their characteristics.

The paper describes the objectives of the LEGO® SBT of CSC, its modalities and discusses its learning potential for competencies development. First, we justify why LEGO® bricks and the Adobe® Connect™ videoconferencing platform were chosen. Then, the SBT modalities are described. The objective is to provide sufficient information to help instructors integrate and adapt this SBT into their courses. Next, observations of three SBT sessions with graduate students and data collected are presented. Collaborative work literature is used to put into perspective the observed patterns. The learners' impressions regarding the LEGO® SBT of CSC are presented.

LEGO® Bricks and Videoconferencing: Tools to Immerse in "Real Life" Contexts

While LEGO® bricks are associated with children learning activities, they are also used in university classrooms (e.g. Donovan and Fluegge-Woolf 2015; Freeman 2003; Ramiller and Wagner 2011) as well as in professional trainings (e.g. Kristiansen and Rasmussen 2014). Numerous motives support the decision to use LEGO® bricks in the SBT of CSC. First, building with LEGO® bricks immerse students in an experiential learning mode where they use concepts they have learned or learn new ones as they build. Kolb (1984) defines experiential learning as a "holistic integrative perspective on learning that combines experience, cognition and behaviors (p.21)". By creating "real-life" contexts, the LEGO® bricks' design projects proposed in the SBT serve as a "practical" basis for reflection, discussion and knowledge formation (Freeman 2003). Using the LEGO® bricks allow students to go through Kolb's (1984) full learning cycle: experiencing, reflecting, thinking and acting as well as to focus on two elements which are often missing in traditional classroom settings: experiencing and acting (Kolb and Kolb 2005).

Second, manipulating LEGO® bricks stimulate numerous brain's sectors as well as the "hands-on, minds-on" connections, which foster deeper and more meaningful learning (Wilson 1998). By manipulating LEGO® bricks, students become dynamically involved in their own knowledge development. Such involvement accelerates the establishment of links between new and existing knowledge (Papert 1993). As LEGO® bricks are associated with play, the SBT of CSC playful aspect should increase students' curiosity and involvement as well as help them to give up some prejudices and habits (Brown and Vaughan 2010). Thus, the SBT of CSC is part of the "serious games" movement, which promotes active learning, innovation and creativity (e.g. Roos et al. 2004; Statler et al. 2011).

Two separated classrooms, equipped with computers on which the Adobe® Connect™ videoconferencing web platform was configured, were used to recreate a distributed collaborative work environment. This platform allows team members to collaborate remotely using a virtual meeting room (Bull Schaefer and Erskine 2012). For the SBT, five functionalities of the platform were activated: 1) videoconference, 2) document exchange, 3) chat, 4) common notes and 5) shared whiteboard. The Adobe® Connect™ platform[2] was selected due to its: 1) ease of access, i.e. it is a web-based platform accessible via a web browser, 2) ease of use, i.e. it has an intuitive and user-friendly interface, and 3) technological reliability. Adobe® Connect™ also allows recording of the videoconferencing sessions, which was useful to revisit the SBT and analyze the simulations. Each SBT session started with a five minutes' overview of the videoconferencing platform and the activated functionalities. Students were free to experiment with the various functionalities.

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[1] Salas et al. (2009) define simulation as "any artificial or synthetic environment that is created to manage an individual's (or team's) experience with reality (p.560)".
[2] Adobe® Connect ™ software was chosen for logistical and functional reasons. However, the SBT presented in this paper can also be performed using other web videoconferencing software like Skype or Google Hangout.

CSC Simulation-Based Training with LEGO®: An Overview

The LEGO® SBT of CSC was conducted with graduate IT students during three different semesters in 2014 (8 students), in 2015 (7 students) and in 2016 (10 students). Prior to the SBT sessions, students did not have any prior training with the Adobe® Connect ™ platform, although they were all familiar with similar solutions such as Skype or Google Hangout.

The SBT was developed to stimulate students' learning, reflection and thinking regarding collective work, distributed teams and IT communication. After participating in the SBT, students should be able to:

1. Identify and compare the impacts of "physical" vs. virtual distance in collective work;
2. Explain how physical proximity facilitates (or not) collaboration; and
3. Indicate the ways in which collocated work attributes are reproduced (or not) by collaborative technologies, i.e. the videoconferencing platform used in distributed teams.

The proposed SBT, which includes two feedback and discussion sessions, lasted around three hours. This simulation offers an opportunity to analyze various issues and challenges as well as to address concepts and theories related to distributed collaborative work such as 1) the distinctions between spatial proximity and functional proximity (Festinger et al. 1950); 2) social presence and media richness (Daft and Lengel 1986); 3) collocated teams vs. virtual teams (Bull Schaefer and Erskine 2012; Taras et al. 2013); 4) communicational "common ground" development (Clark and Brennan 1991; Fussell et al. 2000); and 5) the relations between the nature of the tasks and the types of information exchanged (Navarro 2001).

LEGO® Simulation-Based Training of CSC: Scenarios, Roles, and Plans

The LEGO® SBT of CSC is divided into two scenarios, scenario #1 (S1) and scenario #2 (S2), which are deployed one after the other in time. The underlying logic of the two scenarios is the same: each team must design and build a prototype using LEGO® bricks which respect functional and technical specifications. In S1, the objective is to build the prototype of a train and its station, while in S2; students must build a dump truck prototype and three of its components separately. Building these prototypes is relatively complex due to the technical specifications combined with the short period allowed, i.e. 40 minutes in S1 and 25 minutes in S2[3]. In both scenarios, half of the students work in "collocated" teams while the other half work in "distributed" teams using the Adobe® Connect™ platform. When switching from S1 to S2, students' roles were reversed so that those who worked in the collocated teams can experience distributed collaboration, and vice versa. Table 1 shows the roles distribution in each team for both S1 and S2.

Team Letters	Team compositions
A: Collocated	**A:** A minimum of two participants in the collocated teams
B: Distributed	**B1**: A minimum of two members in the distributed teams - Site # 1
	B2: A minimum of two members in the distributed teams - Site # 2
C: Observers	**C:** At least one observer per team, i.e. team A and team B. Observers may move between sites.

Table 1 - Participants' Roles Distribution

"A" teams, collocated, consist of, at least, two students working face-to-face in the same room. "B" teams are formed by a minimum of four students, divided into two subgroups physically located in two different rooms and communicate only through the videoconferencing platform. "C" teams are formed of students who play the observer role. They document what is happening in the SBT and answer to the questions listed in the observation grid[4] using an ethnographic approach. At the end of the simulation, observers prepare a report and present their observations to the rest of the class.

Table 2 describes S1 and S2, as well as the SBTs' functional and technical specifications, which need to be met by the teams. In both scenarios, prototypes construction requires coordination and information sharing related to the key "contact points". For instance, in S1, a train and its station need to be built on the same site by the collocated teams (A teams) and, in the distributed teams (B teams), the train and the station are built on separate sites. However, the technical specifications stipulate that the station must be

[3] Two different LEGO® kits, from the LEGO® Serious Play series, were used in this SBT: 2000430 and 2000431.
[4] The observation grid could be provided by the authors on demand.

built proportionally to the train's size, respecting its length, width and height. These three specifications represent the three "contact points" between the train and the station. Thus, the station's dimensions depend on those of the train, and vice versa. Without these contact points, it becomes impossible to deliver the prototype in accordance with the technical and functional specifications.

In S1, team members working in the collocated teams (A teams) can coordinate the design and building of their trains and stations more easily since they have direct, unlimited, visual and physical access to the decisions and actions of other team members. Therefore, during the building phase, team members can make mutual adjustments and integration tests in a non-intrusive and non-disrupting way. As for distributed team members (B teams), they are physically separated over two sites and their communication channel is restrained to the videoconferencing platform functionalities. The distributed teams are split into two subgroups: the B1 subgroups oversee building the stations, while the B2 subgroups oversee building the trains. As they cannot physically meet, they must find ways to coordinate actions and share information on the contact points more explicitly, either orally, visually and/or in writing via Adobe® Connect™.

S2 complexity level is deliberately higher than S1 from a technical point of view, i.e. in terms of building challenges. Indeed, students are asked to build a dump truck with a moving dump (i.e. truck's tipper) and an articulated truck frame. Complexity has been increased because students can take advantage of the feedback session following S1 and the experience acquired in S1, to improve their working and communication methods, especially in terms of planning, roles allocations, actions coordination, information sharing and time management.

	Scenario #1 – S1	**Scenario #2 – S2**
Context	Design and build the prototype of a train and its station	Design and build the prototype of a dump truck and with three separated components
Constraints	Prototypes should meet technical and functional specifications as well as the time allotted	
Priority	Compliance with: Technical and functional specifications as well as with time	
Technical and functional specifications	**Train's specifications:** 1. Build at least one locomotive and a passenger car 2. Locomotive capacity: Allows at least one driver (i.e. a LEGO® Minifigure) to sit 3. Passenger car: Allows a minimum of 5 passengers to sit. **Station's specifications:** 1. Build at least one boarding platform with a length identical to the train's length 2. Build up the rails so that the train cannot derail 3. Build at least a gateway so passengers can pass over the rails and trains	**Dump Truck's specifications:** 1. Build a dump truck, which has at least a moving dump (i.e. a truck tipper) 2. Dump truck must have a cockpit that can accommodate at least one driver 3. Dump truck must be articulated, i.e. it must have two moving parts (i.e. truck frame) **Three components specifications**: 1. Build three components separately: 1) truck's dump, 2) truck's cockpit with engine and 3) truck's articulated chassis 2. Each component must be identical (i.e. same scale, colors and parts) than those, which are on the dump truck prototype
Construction Responsibilities	Team A: Train and Station Team B1: Train Team B2: Station	Team A: Dump truck and three components Team B1: Dump truck Team B2: Three components
Building Time	40 minutes	25 minutes

Table 2 – Scenarios' Descriptions

S1 and S2 are followed by a feedback session period where students present their prototypes and share their experience. A discussion and questions from the instructor help students make connections with concepts they have learned previously in the course and begin to anchor new ones[5].

Teams Dynamics: Comparing Two Collaborative Contexts

While students received clear instructions regarding the prototypes' specifications and constraints, they were left "free" to deploy any collaborative strategies they considered appropriate. Thus, the students adopted diverse "working" strategies based on the opportunities and constraints offered by each scenario, i.e. collocated and distributed. For each scenario, working patterns regarding four different aspects of the

[5] Due to space limitation, the complete teaching note is not provided here but could be provided by the authors on demand.

teams' dynamics were identified: 1) tasks and roles distributions, 2) coordination mechanisms, 3) information sharing strategies and 4) negotiation approaches used during the SBT sessions (see Table 3).

Collocated Teams' Dynamics: Some Observations

When the stopwatch was launched in S1, most students in the collocated teams instantly reached for the LEGO® bricks and start building. Almost no vocal and/or written information was exchange except, maybe: "I build the train, and you build the station". Much of the information sharing was done through observations and visual cues. For instance, the same pattern occurred in several sessions: one student started building the train, and another did the station without having clarified the roles or responsibilities a priori. Physical proximity and direct eye contact enabled students to know instantaneously what the other team members were doing and if they needed help (e.g., a student interrupted her work when she saw that a colleague had difficulty finding specific LEGO® bricks). Collocated team members also adopted a trial and error coordination mode as they adapted their actions to those of their colleagues as time went by.

Information sharing was performed when needed in collocated teams, such as when a team member needed a length or height to build his/her part, asked questions or seek for feedbacks. During S1 sessions, student have almost never exchanged orally until they realized that their interpretations of the functional and technical specifications were divergent. For instance, members of one collocated team realized, once the construction of both the train and the station were almost finished, that they had forgotten to validate and clarify their overall understanding of the technical specifications. Indeed, their train and station could not fit together because the train's width was misinterpreted. As team members noticed this situation relatively late and realized they were running out of time, they had an argument and the sense of urgency arose because of this time awareness. It forced the team members to formalize the tasks distribution, to establish priorities and to determine validation checkpoints.

Distributed Teams' Dynamics: Some Observations

As the stopwatch was launched, distributed team members rapidly realized that clear roles and responsibilities needed to be established to meet the prototypes' specifications and respect the time constraint. Being physically separated, not having easy access to visual cues of members located on the other site and observing progress through a videoconferencing platform have "forced" the distributed students to explicitly establish working modes. In S1 and S2, the first actions taken was to formally nominate a "coordinator" on each site whose role was to ensure that: 1) relevant information was exchanged between sites, 2) time was respected and 3) building tasks conducted on each site were harmonized. The building tasks needed to be aligned, coherent, and had to respect the technical and functional specifications. In the distributed team members, the other students were "builders" and their role was to build the prototypes' parts that have been assigned to them by the coordinator.

Once the roles and responsibilities were established, all distributed teams followed the same sequence of actions as they 1) did an inventory of the LEGO® bricks available, 2) agreed on the main building tasks and the time assigned to each task, 3) determined the key validation points and 4) used the "shared whiteboard" functionality to draw sketches of their prototypes. Some distributed teams used the "common notes" functionality to write down the main tasks, the allocated time and the validation points. One team also established a reference frame to ease information sharing and develop a shared understanding. Indeed, they selected one LEGO® brick as a measurement unit to facilitate communication referring to the prototype's length, height and width. They also agreed on communication signals to help capture the other members' attention and facilitate the oral exchanges.

Most distributed teams initially used the camera to focus on team members' faces to share information on the prototypes' mains design features, the development tasks and their sequences. Once these elements were established and agreed, the cameras' focus changed and were directed on the prototypes themselves so that members located at opposite sites could follow the development progress and ask questions instantly if clarifications were needed. This working strategy allowed teams to avoid being too advanced in their development before adjusting the models they have built. Indeed, students realized that it is always easier and more efficient to make small adjustments along the way rather than large ones at the end.

At each validation checkpoints, the teams' coordinators confirmed that all team members were still in accord. Videoconferencing functionality was used by coordinators to validate, with one another, that the building tasks were aligned and coherent. Each coordinator described and presented, from different angles, the prototype's parts to his/her counterpart, using the web camera and the microphone, and asked for validation. Thus, video was used to share information related to the prototypes rather than to capture visual or physical cues from the other team members working at the other site.

Most distributed teams had to deal with a difficult situation when all team members intervened orally simultaneously, which created a cacophonous environment. In such environment, communication, coordination and information sharing become very challenging. At one time, distributed team members on one site temporarily closed their computer's speakers to be able to concentrate and work on their construction tasks. This situation forced members on the other site to make exaggerated gestures, on the camera, to draw the other team members' attention. Since it was not working, they decided to use their mobile phones to reach them. Furthermore, builders on the two sites were continuously interrupting each other because they frequently had to stop building to explicitly present what they have done to the camera's field of view to allow their distant counterparts to adjust. It was impossible for members of one site to see all the actions and/or building realized by members on the other site without bring them closer to the camera and seek for their attention. These disruptions seem to have break the builders' construction flow (Csikszentmihalyi 2008) and even created some frustration because of the time, attention and energy needed to communicate through the videoconferencing platform.

Teams dynamics	**Types of team**	
	Collocated teams	**Distributed teams**
Tasks and Roles Distribution	1. No, or minimal, tasks and roles distribution a priori 2. As team members become conscious that times progressed, the formalization of tasks division and the establishment of priorities became critical	1. Clear identification of roles and responsibilities at the scenarios' outset 2. Creation of two main two roles at each distributed site: Coordinator and Builder 3. Coordinator also play the "guardian of time" and the information broker
Coordination	1. Informal, by observing and adjusting to the actions of the other team members 2. Done in a progressively and non-intrusively way	1. The "coordinator" at each site had to ensure that tasks and outcomes realized by the builders at his/her site and the information provided by the coordinator at the other site were aligned and coherent 2. Frequent and disruptive interruptions of the building activities, between sites, to coordinate with the work done at the other side, using mainly the video and image 3. Communication signal to capture the other members' attention
Information Sharing	1. Done through eye contact, by asking questions and/or soliciting ad hoc feedback	1. Done using massively and sometimes cacophonously the "oral" (voice) channel 2. Further gestures on the screen are used by the coordinators to draw attention of the other team members 3. Use of personal mobile phone 4. Use the "common notes" of the videoconferencing platform to document decisions and validation points 5. Discussions and decisions from sketches drawn using the "whiteboard" function 6. Video was mainly used to share functional information rather than to capture physical or visual cues of the team members
Negotiation	1. Became necessary when students realized they had different interpretations of the specifications and problems	1. Established reference frame to facilitate shared understanding of the problem (e.g. chose a LEGO® brick as reference unit to measure their prototype).

Table 3 - Patterns Observed in Each Collaborative Context for S1 and S2

Observed Patterns: Some Theoretical Perspective

Some concepts from the literature on collaborative work has been mobilized to establish links between the observed patterns and some theoretical references, which can help us, explain and understand what happened during the SBT sessions. These concepts were discussed with students during the SBT feedback sessions to strengthen their appropriation of the domain knowledge.

First of all, the computer supported cooperative work literature has considerably studied the awareness concept, which refers to an individual's ability to stay attentive to the actions and words of others in order to obtain information that can be used as resources to conduct its own activities (Heath and Luff 1994). Studies conducted in various work contexts have revealed that much of the coordination between individuals is done implicitly, without interrupting ongoing tasks, when the environment allows co-visibility and co-audibility of what each team member is doing or saying. This phenomenon has largely been observed in coordination centers (e.g. air traffic control rooms, financial markets, call centers, etc.) where team members are all grouped in the same physical space (Heath et al. 2002). As observed in the LEGO® SBT of CSC sessions, coordination and monitoring of the collaborative work realized by collocated team members were done in a non-intrusive and non-disruptive ways, with limited or no interruption and interpellation of other team members. Thus, each team member could adjust his/her work and actions accordingly. However, in the distributed context, team members had to frequently interrupt, interpellate and sometime, shout at other members to coordinate through the videoconferencing platform. This situation has created some tensions.

Researchers have observed that some communication gestures, such as those deployed by distributed team members to capture the interlocutors' attention, do not pass well through video screens, as it was the case one SBT sessions (Heath and Luff 1992). Indeed, some students used their mobile phone to reach team members located on the other site. Thus, the SBT sensitizes students to the idea that distributed collaborative work realized through a videoconferencing platform forces them to explicitly describe and explain their actions, their decisions and their understanding which, in a face-to-face context, could remain implicit. Thus, in the distributed teams, an important portion of time must be dedicated to information exchange, via the videoconferencing platform, rather than on building their prototypes.

It is also important to take into consideration that, in both S1 and S2, the level of interdependency between each team member was reciprocal (Thompson 1967) because the parts built by one team member (i.e. the output) was used by another team member to build his/her own part (i.e. the input) and vice-versa. To be effective, such tight interconnections between team members' tasks required thorough and constant actions coordination and information sharing. However, a high level of actions coordination and information sharing was more demanding in terms of time, attention and energy in the distributed teams than in the collocated teams. Thus, the LEGO® SBT of CSC allowed students to realize that, depending on the level of task complexity and interdependency, some communication technologies might be better suited for certain types of tasks than other. There should be a fit between the complexity and interdependency level of a task and the richness of the communication technology used.

Bull Schaefer and Erskine (2012) argue that "one of the critical decisions students also need to practice making is determining which communication medium or technology is appropriate for different virtual meeting agendas so as to improve the chances of effective communication (p.799)". In the SBT, distributed teams were communicating via the Adobe® Connect ™ platform where five functionalities were activated: 1) videoconference, 2) document exchange, 3) chat, 4) common notes and 5) shared whiteboard. Out of these five, only the videoconference, the common notes and the shared whiteboard were used. The shared whiteboard was used by the distributed teams to sketch prototypes, the common notes was used to list the tasks, the validation points and to track various decisions made during the sessions whereas as the videoconference was used for presenting the prototypes, clarifying interpretations, communicating dimensions, etc. Thus, the SBT sensitized students to explore various communication functionalities and use those that best suited their needs.

Clark and Brennan (1991) developed a "common ground" model which highlight the importance of collectively, as a team, developing a shared understanding of specific context or problems. They identified and described several elements, which influence a team's "grounding" process, such as the objects manipulated, the visual expressions, the members' gestures, etc. The explicitness level of these elements should vary depending of the communication technology used. During the SBT sessions, distributed team members realized that, to be effective, they had to render certain elements explicit and develop standards and shared references. For instance, one distributed team agreed to use of a specific LEGO® brick as the unit of common measurement.

Furthermore, co-temporality, mutual visibility and audibility, rendered possible by the videoconference platform, were effectively used by the distributed teams to share information and coordinate actions. Fussell et al. (2000) have distinguished the various sources of visual information that can pass through a videoconferencing platform. On one hand, seeing the interlocutor such as his/her facial expression or non-verbal language can provide key *relational information*, i.e. information about the "presence" of the other person, such as his/her attention or understanding level. On the other hand, a videoconferencing platform can also provide *functional information* such as information on objects, on tasks, on what the interlocutor is doing such as his/her actions or real-time progress. While relational information help support conversation and negotiation aspects of team dynamics (Navarro 2001), the functional information play a greater role in tasks coordination (Fussell et al. 2000). Thus, the SBT sensitized students to explore and better understand the differences between relation information and functional information, as well as the challenges of communicating such information types using communication technologies.

Finally, the SBT allows students to go throw a double-learning loop (Argyris 2002). In a single loop learning, students try to solve a problem or decide without receiving any feedback to adjust their decision-making rules. During S1, students go through a single loop learning. However, in the feedback session following S1, students share their experiences and the questions from the instructor help them make connections with key collaborative concepts. Thus, students can modify their mental model and adjust the decision-making rules they apply in S2 by modifying their actions and decisions. Such opportunity represents Argyris' (2002) second loop and should help students increase their collaborative competence and sensitize them to the opportunities and challenges associated to computer-supported collaboration.

Students' Learning Impressions

After each SBT session, students were interviewed to capture their learning impressions and get their feedback. For most students, the LEGO® SBT of CSC was their first experience with this type of teaching/learning method. All of them enjoyed very much the simulation and wanted to see such teaching methods used in other courses. Indeed, the students mentioned that the SBT help them apply what they had previously learned in the course and they had the impression the learning was quicker and deeper because it was "hands-on". They also appreciated the fact that the SBT sessions sensitized them to the practical implications of collective work and the use of technological tools to support such activity. Students had also the impression that, after the SBT, they had a more accurate and "real" representation and understanding of the challenges associated with distributed collective work mediated through IT. The SBT also helped students develop their analytical skills and decision-making competence. Finally, student greatly appreciated the two rounds (S1 and S2) structure because it allowed them to improve what they have done in S1 and apply it in S2.

In the last SBT session, students completed a questionnaire before and after the simulation. Questions were related to the students' background, their level of self-efficacy with collaborative technology (Compeau and Higgins 1995), the team dynamics and their satisfaction level (Barki and Hartwick 2001). Even though the sample was limited and the time between the two measures was short, we observed a 15% increase in the students' levels of self-efficacy with collaborative technology between before and after the SBT. Thus, the SBT seems to help student increase the extent to which they believe in their ability to use collaborative technology which, in today work environment, is a key competence (Chakravarty et al. 2013). Regarding team dynamics, the conflicts level was 32% higher in distributed team, than in collocated team. As for the satisfaction level with the team dynamics, students who worked in the collocated teams were 72% more satisfied than those who worked in distributed teams (Barki and Hartwick 2001). Finally, since each student experienced both the collocated and the distributed contexts, they were asked to compare them on different dimensions. The results show that the collocated teams completed the work faster, better respected the technical specifications and their coordination and information sharing was simpler and clearer. As for the distributed team, the results show that they had to share more verbal information, that they faced more challenges and that they experienced more conflicts.

In the questionnaire completed after the simulation, students were asked to provide impressions and comments on their satisfaction level. Here are some representatives quotes: *"I appreciated that the workshop made me aware of the challenges of distributed work, the importance of establishing clear and frequent communication in a team, especially when the technologies are used to communicate"* (S3); *"The simulation was very interesting because when we discuss theory afterwards we can link it a concrete experience shared by all the students"* (S7) and *"Very satisfied because it shows on a small scale the difficulties of real-life collaborative work. Moreover, the results are direct and unambiguous"* (S10).

Students were also asked if they learned things that they could transfer in their professional and/or academic activities: *" I realized that the selection of collocated or distributed approach should be based on the complexity and interdependence levels of the tasks performed"* (S4); *"Distributed work requires far more preparation than collocated work. Coordination as well as roles and responsibilities clarification are crucial in distributed work. Milestones should also be planned at the beginning and validated at each stage"* (S8) and *"During distributed work, I realized the importance of a pre-project meeting to ensure that the objectives, constraint and expected results are well understood"* (S9).

Conclusion

The LEGO® simulation-based training of computer-based collaboration developed in the present paper shows how LEGO® bricks and a videoconferencing platform, such as Adobe® Connect ™, can help students better learn the effects of proximity and distance in collaborative work as well as understand the challenges and opportunities of using IT in distributed teams. Indeed, students who participated in the SBT sessions adopted different strategies for coordinating their work and sharing information. Observations of working patterns were analyzed and put into perspective using the literature on collaborative work. One interesting aspects of the SBT is that using LEGO® bricks allows immediate immersion in the collective work since the bricks serve as a metaphor to represent "real-life" situations (Morgan 2006). Researchers who have previously used LEGO® bricks in their research have reported the potential risk related to the cynicism of the participants generated by the playful aspect of using bricks (Grienitz et al. 2013). However, the students were very open to the approach and welcomed the sessions with great interest, concentration and curiosity. They have described their experience as intensive, challenging and very beneficial.

One of the challenges in pedagogy is the appropriation of theoretical concepts. The students who participated in the SBT sessions have highlighted that the using LEGO® bricks facilitated their understanding and anchoring of theoretical concepts which, otherwise, might have been to abstract for them. The goal with this paper was to contribute to the discussion regarding the evolution of management education by showing that the use of SBT with LEGO® bricks can support the development of innovative learning experiences.

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