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EXPERIENCING COMPUTER-SUPPORTED COLLABORATION: A LEGO® SIMULATION-BASED TRAINING

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Experiencing Computer-Supported Collaboration: A LEGO® Simulation-Based Training


ABSTRACT

The computer-supported collaboration (CSC) LEGO® simulation-based training (SBT) described in the present paper shows how LEGO® bricks and a videoconferencing platform can help management students learn first-hand about the effects of proximity and distance in collaborative work and understand the challenges and possibilities of information technology use 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, which occurred during the SBT sessions, were analyzed and put into perspective using the literature on collaborative work. The preliminary findings presented here show that using LEGO® bricks allows immediate participants' immersion in the challenges facing workers in a virtually connected world and facilitates the appropriation of theoretical concepts since the bricks serve as a metaphor to represent "real-life" situation.



Keywords: Collaboration, Distributed team, Lego

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## Abstract

The computer-supported collaboration (CSC) LEGO® simulation-based training (SBT) described in the present paper shows how LEGO® bricks and a videoconferencing platform can help management students learn first-hand about the effects of proximity and distance in collaborative work and understand the challenges and possibilities of information technology use 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, which occurred during the SBT sessions, were analyzed and put into perspective using the literature on collaborative work. The preliminary findings presented here show that using LEGO® bricks allows immediate participants' immersion in the challenges facing workers in a virtually connected world and facilitates the appropriation of theoretical concepts since the bricks serve as a metaphor to represent "real-life" situation.



## Keywords

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

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Distributed collaborative[1] work between remote actors, through information technology (IT), has been a key phenomenon of interest in several academic disciplines, particularly in the fields of education (Siebdrat et al. 2009), information systems (Dubé and Robey 2009) and Computer Supported Cooperative Work – CSCW (Schmidt and Bannon 2013). This phenomenon has also changed the way work is realized in many professional sectors, where a growing number of organizations are experimenting with new ways of accomplishing collective work in order to decrease travel costs and have access to specialized and limited human resources. Virtual teams, which are also known as a geographically dispersed team or distributed team (Powell et al. 2004; Thomas and Bostrom 2010), offshore projects (Dedrick et al. 2011) or outsourcing agreements (Aubert et al. 2011) are some examples of these new forms of collective work. Notably, teams conducting innovative, design and/or creative projects are increasingly dealing with working structures and environments which can be geographically, temporally, culturally and/or organizationally distributed (Chudoba et al. 2005; Vacherand-Revel 2007).

[1] It is important here to clarify the distinction that we make between cooperative and collaborative work. In a cooperative mode, work is fragmented into different tasks, so that each team member is individually responsible for one or more tasks performed in parallel and "pooled" at the other end (Lonchamp, 2003. Thompson, 1967). In a collaborative mode, there is no work division among team members and all members contribute in various ways to the development of anticipated result in a common way, merging and integrating individual contributions throughout the work interactions. Collaborative work is characterized by "reciprocal" interdependency and is supposed to lead to a result, which would be unobtainable individually. While we have designed our simulation-based training (SBT) to guide students to a collaborative mode, their actual practices are on a continuum from a cooperative mode to a collaborative mode depending on the decisions and processes they deployed during the SBT.

In this context, students enrolled in business schools and/or management programs must be sensitized to the opportunities and challenges associated with these new forms of collective work. They need to understand the changes and the impacts these new modes of collaboration entail, among other things, on the organisational structures and their working environments. In particular, future IT managers will have to identify, evaluate, select, implement and support technological collaborative platforms, but also ensure that these platforms and new modes/forms of collective work are effectively used and deployed in the workplace in order to generate the anticipated benefits. The competencies required to conduct such activities are primarily based on: 1) an awareness of the effects of proximity and distance in collaborative work (Kraut et al. 2002; Michinov 2008) and, 2) a detailed understanding of the possibilities and limits of IT regarding actions coordination and information sharing (Navarro 2001).

In order to enhance the acquisition of these competencies, we have developed a computer-supported collaboration (CSC) simulation-based training (SBT), in synchronous mode, using LEGO® bricks. Salas et al. (2009) define simulation-based training as "any synthetic practice environment that is created in order to impart competencies (i.e. attitudes, concepts, knowledge, rules or skills) that will improve a trainee's performance (p.560)". A SBT is a teaching/learning method designed to replicate, as closely as possible, real life situations in which students usually have to play different roles. As a SBT unfolds, students have to analyze the simulation[2] context, i.e. the information and objectives provided to them, make decisions and take actions. Usually, during a SBT, some time is dedicated for reflecting on the decisions made and actions taken as

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[2] Salas et al. (2009) define simulation as "any artificial or synthetic environment that is created to manage an individual's (or team's) experiences with reality (p.560)".

well as for sharing experiences between participants (Tiwari et al. 2014). Studies have shown that active learning techniques, such as SBTs, generate greater motivation, are safe and risk-free environment, offer realistic and complex learning environments, bridge the gap between the classroom and "real-life" context, let reality be simplified and manageable, enhance team development, promote a better understanding and facilitate integration and retention of knowledge that so-called traditional methods (Dekkers and Donatti 1981; Léger 2006; Salas et al. 2009; Tiwari et al. 2014).

During the SBT described here, students have to design and build two different projects using LEGO® bricks. They are alternately assigned to two different collaborative contexts: 1) in a collocated team and 2) in a distributed team mediated though a videoconferencing platform. By experiencing both contexts – collocated and distributed -, students can compare the working modes that characterize each of them and have the opportunity to identify their underlying impacts and opportunities.

The present paper describes the SBT's objectives, its modalities and discusses its potential for learning and competencies development. In the first section, we explain why we decided to use LEGO® bricks and the Adobe® Connect ™ videoconferencing platform. Then, a detailed description of the SBT's modalities is presented. Our goal is to provide enough details to allow other instructors to understand how they could integrate and adapt this SBT into their courses. Afterwards, observations arising from the completion of two SBT sessions with graduate students are presented and the literature on collaborative work is used to put into perspective the observed patterns. The last section presents the learners' impressions in regard of the SBT sessions.

## LEGO® Bricks: A Tool to Facilitate Immersion in "Real Life" Contexts

Although we tend to associate LEGO® bricks with children's learning activities, they are also used with university students (e.g. Donovan and Fluegge-Woolf 2015; Freeman 2003; Ramiller and Wagner 2011) as well as in professional training in public and private organizations (Kristiansen and Rasmussen 2014). Several reasons support our decision to use LEGO® bricks in our CSC simulation-based training (SBT). First of all, using LEGO® bricks put students in an experiential learning mode where they can apply concepts they have learned or learn new ones as they build with the bricks. Kolb (1984) defines experiential learning as a "holistic integrative perspective on learning that combines experience, cognition and behaviours (p.21)". By recreating situations that are representative of "real-life" contexts, the LEGO® bricks design projects proposed in our SBT serve as a "practical" basis for reflection, discussion and knowledge formation (Freeman 2003). Thus, using the LEGO® bricks allow for students to go through Kolb's (1984) full learning cycle, i.e. experiencing, reflecting, thinking and acting, but also allow to focus on the two elements which are often missing in the traditional classroom setting: experiencing and acting (Kolb and Kolb 2005).

Secondly, the manipulation of LEGO® bricks activates simultaneously several parts of the brain and stimulates the "hands-on, minds-on" connections, which help to anchor learning in a more deeper and meaningful way (Wilson 1998). Furthermore, by handling the LEGO® bricks, students are actively involved in their own knowledge development, which facilitates the establishment of connections between existing and new knowledge (Papert 1993).

Furthermore, since the LEGO® bricks are associated with game, the playful aspect of the SBT also increases the involvement and curiosity of participants who are then more likely to give up certain habits and prejudices (Brown and Vaughan 2010). These educational opportunities associated with LEGO® bricks have been mobilized by Per Kristiansen and Robert Rasmussen in the development of LEGO® Serious Play methodology to stimulate strategic and organizational development (Kristiansen and Rasmussen 2014). The SBT described in the present paper is part of the "serious games" movement, which is associated with active learning, innovation and creativity (e.g. El-Masri and Tarhini 2015; Roos et al. 2004; Statler et al. 2011).

## Videoconferencing: Creating an Information Sharing Space

In order to recreate a distributed collaborative work environment, two separated classrooms where equipped with a computer (each had a web camera and a microphone) on which the Adobe® Connect ™ web videoconferencing software was configured. Adobe® Connect ™[3] is a commercial solution that allows team or group members to collaborate remotely via a virtual meeting room (Bull Schaefer and Erskine 2012). Besides the videoconferencing functionality, which allows synchronous, verbal and/or visual interactions, the Adobe® Connect ™ platform offers a variety of functionalities for real-time collaboration. For our SBT, we activated the functionalities of: 1) videoconference, 2) document exchange (i.e. synchronous direct document transmission), 3) chat (i.e. synchronous and instant text-based communication), 4) common notes (i.e. synchronous, text-based, shared document development) and 5) shared whiteboard (i.e. synchronous, drawing tool for shared design development).

At the beginning of each SBT session, the instructor did a 5 minutes overview of the videoconferencing platform and presented each of the five activated functionalities. Then, the students were free to experiment the various functionalities offered by the Adobe® Connect ™ platform. The choice of this platform lies in its: 1) ease of access, i.e. this videoconferencing platform is web-based and can be accessed via a web browser, 2) ease of use, i.e. its interface is intuitive and user-friendly, and 3) reliability and technological stability. In addition, our business school offers institutional support and troubleshooting in case of problems. Finally, Adobe® Connect ™ allows the possibility to record the videoconferencing sessions, which was useful to revisit the SBT and analyze the details.

## CSC LEGO® Simulation-Based Training: An Overview

The simulation-based training (SBT) was conducted with graduate students enrolled in the "Collaborative Work: Fundamentals and Tools" course during the fall semesters of 2014, with eight students, and of 2015, with seven students. This course is offered to graduate students in the IT and management programs. Prior to the SBT sessions, students did not have any training with the Adobe® Connect ™ platform, although they were all familiar with similar solutions such as Skype or Google Hangout.

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[3] Adobe® Connect ™ software was chosen for logistical and functional reasons. However, the SBT presented in this

## Learning Objectives

The CSC LEGO® simulation-based training was developed to stimulate students' learning as well as reflection and thinking regarding collective work, distributed teams and communication technologies. Thus, after having participated in this SBT, students should be able to:

1. Identify the impacts of "physical" 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, in distributed teams.

The proposed SBT, which includes two feedbacks and discussion sessions, lasted around three hours and took place in the morning. The afternoon was devoted to the deepening of concepts and theories as well as to the analysis of various issues and challenges of distributed collaborative work. Among other things, the afternoon discussion focused on 1) the distinctions between spatial proximity and functional proximity (Festinger et al. 1950); 2) social presence (i.e. immediacy, intimacy, sociability) and media richness (Daft and Lengel 1986; Michinov 2008); 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 information types exchanged (Navarro 2001).

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paper can also be performed using other web videoconferencing software like Skype or Google Hangout.

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

The CSC LEGO® simulation-based training (SBT) is divided into two scenarios, scenario #1 (S1) and scenario #2 (S2), which are deployed one after the other in time. The first hour and a half is devoted to the execution of S1 and the other hour and a half to S2. The underlying logic of the two scenarios is the same: each team must design and build a prototype in LEGO® bricks in accordance with the functional and technical specifications provided and the time allotted. The objective of S1 is to construct the prototype of a train and its station, while in S2; the objective is to construct the prototype of a dump truck and three of its components separately. The construction of these prototypes is relatively complex, mainly due to the technical specifications combined with the short period of time allowed for each scenario, i.e. 40 minutes for S1 and 25 minutes for S2. Two different LEG^O® kits, from the LEGO® Serious Play series, were used in this SBT, i.e. the “identify and landscape kit (2000430)” and the “connection kit (2000431)”.

In both scenarios, half of the participants worked together in "collocated" teams and while the other half worked in "distributed" team using the Adobe® Connect ™ videoconferencing platform. When switching from S1 to S2, participants' roles were reversed so that participants who worked in the collocated team can experience distributed collaboration, and vice versa. Table 1 shows the roles distribution in each team. This division applies both to S1 at S2. Participants are thus divided into three teams (A, B and C) as a result of a draw.

**---Insert Table 1 here ---**

Team “A” consists of two participants working in a collocated team, i.e. face-to-face in the same room. Team “B” is formed of at least four participants, divided into two subgroups that are physically located in two different rooms and can communicate only through the videoconferencing platform. As for team "C", it is formed of two participants who play the observer role. They use ethnographic approaches to document what is happening in the SBT and answer to the questions listed in the observation grid (see Appendix 1). The observers cannot intervene or interact with any team members. At the end of the exercise, observers prepare a report and present their observations to the rest of the class.

Table 2 describes both scenarios, i.e. 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 actions coordination and information sharing in relation to key "contact points". For instance, in S1, a train and its station need to be built on the same site by the collocated team (team A) and, in the distributed team (team B), the train is built on one site while the station is built on the other site. However, the technical specifications stipulate that the station must be built proportionally to the train's size, respecting its length, width and height. Thus, there are three "contact points" between the train and the station: the train's length, width and height. Indeed, 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 specifications and thus having a train that can travel properly in the station.

**---Insert Table 2 here ---**

In S1, the team members who work in the collocated team (team A) can more easily coordinate the design and construction of their train and its station since they have direct, easy, unlimited, visual and physical access to the decisions and actions of other team members. So, during the construction phase, the team members can easily make mutual adjustments and integration tests in a non-intrusive and non-disrupting way. As for the members in the distributed team (team B), they are physically separated over two sites and their communication channel is limited to the activated functionalities of the videoconferencing platform. Thus, the distributed team is split into two subgroups:  the B1 subgroup is responsible for building the train, while the B2 subgroup is responsible for building the station. Since they cannot physically meet, they must find a way to coordinate actions and share information on the contact points more explicitly, either orally, visually and/or in writing via the available collaborative functionalities of the Adobe® Connect ™ platform.

S2 is deliberately more complex than S1 from a technical point of view, i.e. in terms of building difficulties, because students are asked to build a dump truck with a moving dump (i.e. truck's tipper) and an articulated truck frame. The level of complexity has been increased because students can benefit from the experience acquired in S1 and adapt better working and communication methods, particularly in terms of planning and time management, roles allocations, actions coordination use as well as in terms of communication processes and information sharing.

Each simulation, i.e. S1 and S2, was followed by a plenary session period where participants described their prototypes and shared their thoughts on the experience. Feedbacks and discussions were also exchanged during these sessions. Questions from the instructor helped students make connections with concepts they have learned previously in the course and begin to anchor new ones (see Appendix 2 for the complete teaching note).

## Comparing Two Collaborative Contexts: Some Observations

Although participants were instructed regarding the models to build (i.e. the functional and technical specifications) and the constraints to respects (i.e. time, LEGO® bricks allowed), they were left "free" to use the collaborative strategies they considered most appropriate. Thus, the participants adopted different “working” approaches or modes depending on the specific opportunities and constraints offered by each collaborative scenario. At the completion of each scenario, we identified patterns regarding four different aspects of the teams’ dynamics: 1) tasks and roles distributions, 2) coordination mechanisms, 3) information sharing strategies and 4) negotiation approaches deployed by the participants during the SBT sessions. Highlights of these observations are summarized in Table 3.

**---Insert Table 3 here ---**

### Collocated Teams: Some Observations

During the S1, members working in the collocated teams almost immediately reach for the LEGO® bricks when the stopwatch was launched and started to build. They did not exchange much vocal and/or written information except, maybe: “I build the train, and you build the station”. Much of the information exchange was done through observations and visual cues. For instance, during the S1 sessions, the same pattern occurred: one participant started the construction of the train, and the other did the station without having any roles or responsibilities clarification a priori. The closeness and direct eye contact enabled the participants to know immediately what the other team members were doing and if they need help in order to intervene (e.g., a team member interrupted his/her work when he/she saw that his/her colleague had difficulty finding a specific LEGO® bricks). Team members of collocated teams also adopted a trial and error mode of coordination, by adapting to the actions of the other as they go (see Figure 1).

**---Insert Figure 1 here ---**

In the collocated teams, information sharing was performed when needed, such as when a team member needs a length or height to build his part or when he asked questions or seek for feedbacks. During the S1 sessions, team's members have almost not exchanged orally until the moment they realize they did not have the same interpretation of the functional and technical specification. For instance, members of one of the collocated teams realized, once the construction of both the train and its station were well advanced, that they had not validated and clarified their overall understanding of the technical specifications. Indeed, their train and station did not fit together because they had miss interpreted the train's width. This awareness by team members occurred relatively late and the team was running out of time. The team members had an argument and the sense of urgency that arise as a result of this time awareness, forced them to formalize tasks distribution, to establish priorities and to determine validation check points (see Figure 2).

**---Insert Figure 2 here ---**

## Distributed Teams: Some Observations

As the simulation's stopwatch was launched, distributed team members quickly realized that they had to establish clear roles and responsibilities in order 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 the videoconferencing platform have "forced" the distributed team to explicitly establish working modes. First, a "coordinator" was formally identified on each site. Their roles were primarily to ensure that relevant information was exchanged between sites, that the time was respected and that the construction tasks conducted on each site were harmonized, i.e. aligned and coherent, and were respecting the technical and functional specifications. The other distributed team members were "builders". Their roles were to construct the specific parts of the prototypes that have been allocated to them by the coordinator.

After having established the roles and responsibilities of each team member, all distributed team basically accomplished the same actions as they 1) proceeded to the inventory of available LEGO® bricks, 2) agreed on the main construction tasks and the time allocated to each task, 3) established the main check points and 4) used the "shared whiteboard" drawing functionality to perform sketches of their prototypes. Some of the distributed teams used the "common notes" functionality to document the main tasks, the allocated time and the checkpoints. In particular, one team also took the time to define a common reference frame to facilitate their shared understanding. Indeed, they have chosen a LEGO® brick as a template or reference unit to measure their prototype length, height and width. They also established a communication signal to capture the other member attention and facilitate the oral exchanges.

In most distributed teams, the camera was initially used to focus on the team members faces in order to establish the prototypes' mains design features, the development tasks, their sequences and the reference frame. Once these elements were established, the cameras were focused on the prototypes themselves so that team members located at the opposite site could follow the progress of the development and ask questions immediately if clarification was needed. This way of working has allowed teams to avoid being too advanced in their development before making adjustments. Indeed, they discovered that it is always better to make small adjustments along the way rather than large ones at the end.

After each main construction task, the teams' coordinators ensured they were always on the same wavelength. The coordinators mainly used the videoconferencing functionality to validate, with one another, that the construction 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 (see Figure 3). Thus, video was used mainly to share information related to the prototypes rather than to capture visual or physical cues from the team members working at the other site.

**---Insert Figure 3 here ---**

One challenge that distributed teams had, is that, sometimes, all team members intervened orally at the same time, which created a cacophonous environment. In this context, communication, coordination and information sharing became very difficult. At a certain moment, the B1 team members temporarily closed their computer's speakers to be able to concentrate and work on their construction tasks. This situation forced the B2 team to make exaggerated gestures on the screen to draw B1 team members' attention when they were not watching. Finally, B2 team members decided to use their personal mobile phones to join them. Also, the builders of the distributed teams were constantly interrupted in their construction tasks. Indeed, they frequently had to stop working on their construction tasks in order to explicitly present what they have done to the camera's field of view to allow their distant counterparts to adjust. It was practically impossible for the members of one site to see all the actions and/or constructions realized by team members on the other site without bring them closer to the camera and seek for their attention. These interruptions 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.

## Theoretical Perspective on Observed Patterns

Some concepts from the literature on collaborative work can be mobilized to put into perspective the patterns described in the previous section. In this regard, links will be established between the observed patterns and some theoretical references, which can help us, explain and understand what happened during the SBT sessions. The same concepts were discussed with students during the course following their participation in the SBT sessions to strengthen their appropriation of the domain knowledge.

First, the CSCW literature extensively studied the awareness concept, which refers to the individual ability to remain 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).

The studies conducted in various work contexts have shown 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 been mainly 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 it was observed in our CSC LEGO® simulation-based training, the coordination and monitoring of the collaborative work accomplished by the collocated team members was done in a non-intrusive and non-disruptive way 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 the other members to coordinate via the videoconferencing platform. This situation seems to have, at time, created some tensions.

Heath and Luff (1992) had observed that some communication gestures, such as those intended to capture the interlocutors' attention, do not pass through video screens, as it seems to have been the case our SBT sessions. Indeed, at a certain moments, participants used their personal mobile phone to reach team members located at to other site. Thus, the CSC LEGO® simulation-based training allowed students to realize that distributed collaborative work done via a videoconferencing platform forces the participants to explicitly describe and explain their actions and their comprehension, which, in a face-to-face context, could remain implicit. In the distributed teams, an important portion of time was indeed dedicated to information exchange, via the videoconferencing platform, with the other team members, rather than on building their prototype.

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, our CSC LEGO® simulation-based training allowed students to realize that, depending on the task complexity and the level of tasks interdependencies, some communication technologies might be better suited for certain types of tasks than other. There should be a fit between the complexity/interdependency levels of a task and the richness of a communication technology used (Venkatraman 1989).

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 CSC LEGO® simulation-based training, the 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 during the sessions. The shared whiteboard functionality was used by the distribute team for sketching the prototypes, the common notes functionality was used to list the tasks, the checkpoints and to track various decisions made during the sessions whereas as the videoconference functionality was used for presenting the prototypes, clarifying interpretations, communicating dimensions, etc. Thus, the CSC LEGO® simulation-based training allowed students to explore various communication functionalities and use those which best suited their needs.

In their "Common ground" model, Clark and Brennan (1991) showed the importance of collectively develop a shared understanding of specific situations or problems. They identified and described various dimensions or elements, which may affect a team's grounding process, such as the objects manipulated, the visual expressions, the members' gestures, etc. These elements are more or less explicit depending on the communication technology used. During the SBT sessions, distributed team members realized that, in order to be effective, they had to render certain elements more explicit and to develop standards and shared references. For instance, distributed teams agreed to use of a particular LEGO® brick as the unit of common measurement. Co-temporality, mutual visibility and audibility, rendered possible by the videoconference platform, were effectively mobilized 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 videoconferencing. On one hand, seeing the interlocutor (i.e. facial expression, non-verbal language) can provide key *relational information*, i.e. information about the "presence" of the other individual, such as his level of attention or his level of understanding. On the other hand, videoconferencing can also provide functional information, i.e. information about objects and tasks, on what the interlocutor is doing such as his actions or his real-time progress. While relational information is useful to support the 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 CSC LEGO® simulation-based training allowed 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.

## Students' Learning Impressions

At the end of each SBT session, students were interviewed to capture their learning impressions and to get their feedback. For most students, the CSC LEGO® simulation-based training in which they participated was their first experience with this type of teaching/learning method. All of them really enjoyed their experience and wanted to see more SBT used in other courses. Indeed, the students mentioned that the SBT help them apply what they had previously learnt in the course and that learning was faster because it was "hands-on". They also mentioned that the SBT sessions helped them develop their analytical skills and understand the practical implications of collective work. In addition, they said that they now had a more accurate and "real" representation and understanding of the challenges associated with distributed collective work. Finally, the participants really appreciated the fact that two rounds (S1 and S2) were played one after the other because it allowed them to apply in S2 what they had learnt in S1.

## Conclusion

The CSC LEGO® simulation-based training described 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 possibilities of IT use 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, which occurred during the SBT sessions, were analyzed and put into perspective using the literature on collaborative work. One interesting aspects of the SBT presented here, is that using LEGO® bricks allows immediate participants' immersion in the collective work since the bricks serve as a metaphor to represent "real-life" situation (Morgan 2007). 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, our participants were very open over 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 appropriation of theoretical concepts. The students who participated in our SBT sessions have reported that the use of LEGO® bricks facilitated the understanding and the anchoring of theoretical concepts which, otherwise, might have been to abstract for them.

Our aim was to contribute to the discussion regarding the evolution of management education by showing that the use of SBT with LEGO® bricks can lead to the development of innovative learning experiences. We hope that the present paper will guide and stimulate other management educators to experiment with new ways of teaching in their own programs and curricula.

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# Appendix 1 – Observation Grid

As observers, you have to use an ethnographic approach to document what is happening in the simulation by answering the following questions.

Please do not intervene in the teams' interactions, i.e. do not talk to them or ask them questions.

The observer names: ________________________________________________

Team observed (circle): A or B

Scenario (circle): Train-station or Truck

1. How were the roles and tasks divided?

2. How was coordination realized? What were the key coordination tasks and or structures?

3. Describe the negotiation tasks and solving problems, if any.

4. What information related to the work of one (or more) member (s), which are necessary for the work of other members? How are these information communicated? Which communication channels are used? For which information type (visual, oral, textual)?

5. At what moments do team members change the course of their action based on what others do?

6. How do team members give feedback?

7. What are the constraints they face in terms of communication? How do they manage these constraints?

8. Note the difficulties, in terms of understanding and interpretation, experienced by participants.

9. In the case of the distributed team, is the video function used to see the participants, the task or both (when and why they change the participants of view, if applicable)?

10. Were there any conflicts? If so, what kind? Tasks conflicts? Relational/emotional conflicts?

# Appendix 2 – CSC through a LEGO® Simulation-Based Training: Teaching Note

**Logistic Aspects**

1. Total duration:
    a. 120 minutes
2. Number of participants:
    a. Between 8 and 20 people in teams of 2-5
3. Materials:
    a. Two LEGO® Serious Play kits: Identity and landscape Kit (2000430) + Connection Kit (2000431)
    b. Two laptops with integrated cameras and microphones, on which access to the Adobe® Connect ™ videoconferencing platform have been previously configured
4. Places:
    a. 3 separate and private rooms located in the same area with access to Internet
5. Documents:
    a. Scenario 1 and Scenario 2 specifications descriptions including the functional, technical and temporal aspects.
    b. Couples of observation grids (appendix 1)

**Goal and learning objectives**

The simulation-based training (SBT)'s goal, its meaningful learning target, is to provide opportunities for student(s) to live two different collaborative work experiences in synchronous mode: One in collocated team and one in distributed team.

The educational objectives of this SBT are to make participants aware of the importance of the impacts of distance on collaborative activities and the implications for the design and use of collaborative technologies. After this SBT, students should be able to:

1. Identify the impacts of the "physical" distance on the collaborative 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 and its functionalities.

**Class organization**

Team "A" consists of at least two participants working in a collocated team, i.e. face-to-face in the same room. Team "B" is formed of at least four participants, divided into two subgroups that are physically located in two different classrooms and can communicate only through the videoconferencing platform. As for the team "C", it is formed of at least two participants who play the observer roles. They must use an ethnographic approach to document what is happening in the simulation, noting their observations and responding to the questions listed in the observation grid (see Appendix 1). The observers cannot intervene or interact with any team members. At the end of the exercise, observers should prepare a report and present their observation to the rest of the class.

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

A draw is performed to make the distribution of teams: each participant picks a LEGO® bricks in a bag containing bricks of three different colors, each color corresponding to a team.

## Scenario # 1 (S1) – The train and its station (90 minutes)

The instructor reads the following description, gives the trains and station specifications to teams A and B and gives one observation grid to each member of team C.

**Scenario description (S1)**
You work for a train-builder company and you are a member of the development team.

As part of a call for tender, your company has signed a contract for the development a high-speed train prototype and its train station.

TRAIN - Your team is responsible for designing and building a train prototype, which will include at least one locomotive and a passenger car (Building tip: Use the LEGO® truck wheels for your train). The locomotive must accommodate at least 1 driver and the passenger car must allow at least 5 passengers. The train's length, height and width are at your discretion.

STATION - Your team is also responsible for designing and building a prototype of a train station that will host this train. The station must have a boarding platform that is the same length as the length of your train (plus or minus one LEGO® unit). The rails must be able to accommodate the locomotive and car passengers without derailment (Building tip: Rails must "frame" the wheels of the train, that is to say that the wheels will not be on track but inside the rails. The rails do not need to have cross-linking). The track length should be at least twice that of the dock. Finally, a passengers' gateway is to be constructed in order to allow passengers to move over the rails and trains. As for rest areas, ticketing, benches or other facilities, everything is left to your discretion.

This contract is important for your company. Indeed, the winning builder will be offered an assembly contract of 350 locomotives and 700 passenger cars to equip Japan new version of the famous Shinkansen.

Priority should be given to the respect of functional and technical specifications rather than aesthetics. Before beginning construction, take a look at the available LEGO® bricks. This will tell you about the possibilities.

**Distribution teams and responsibilities**
Team A: All members are working in the same room and are responsible for performing the contract.

Team B: The team is split into two groups: B1 must construct the train prototype on one site and B2 must build the train station prototype at the other site. No face-to-face meetings and/or exchanges "physical" are allowed. Communications are performed through the Adobe® Connect ™ videoconferencing platform.

Team C: One member observes team A and another observes team B. They must observe the "builders" and take observation notes using the observation grid (see appendix 1) without talking or interfering with members of team A or B. At the end of the simulation, the observer will have to present their observations to the rest of the class.

**Completion time**
Duration: The teams have 40 minutes to complete the contract.
The instructor circulated in the three rooms and answer questions as needed.

**Interventions # 1 - After 10 minutes (optional, depending on the course)**
Objective: Putting pressure on students
Change announcement description:
1. An invitation was received to present the prototype to the next International Railway Exhibition to be held in Dusseldorf next month. It is no longer 40 minutes hat you have but 30 minutes. You therefore have 20 minutes left.

**Presentations and Discussion**
Duration: 20 minutes
At the end of the simulation, all participants gather in plenary session. Teams A and B initially present their prototypes and train station. Instructor has to verify compliance with the functional and technical specifications. Then, team C presents their observations to the rest of the class.

The instructor comments on the presentations to highlight the links between the simulation and theoretical concepts and by asking questions, such as:

1. What you do withhold from the simulation? What has impressed you?
2. What problems have you encountered? How did you overcome them?
3. What modes and means of communication were used? To communicate what type(s) of information?
4. Was the videoconferencing platform appropriate? What would you suggest to ensure a more efficient use (e.g. one team member plays a mediator/facilitator role)?
5. How did the time constraint affected your experience?
6. What possible solutions would you propose to better manage distributed teams?

## Scenario # 2 (S2) – The dump truck and its three components (75 minutes)

**Teams rotations**
A team rotation is performed to allow participants to experience another context:

1. Members of team C are divided into team A and B.
2. Members of team A are divided into Team B and C.
3. Members of team B are divided into Team A and C.

The distribution should give priority to the observers (team C) to give them the chance to experience the handling of LEGO® bricks in Scenario 2.

**Objectives**
S2 is more complex then S1 to test if, was has been learned in SI, has been transposed into S2. The presentations and discussion during S1's plenary session should allow teams to perform S2 differently and potentially more efficiently, especially in terms of

1. Planning and time management,
2. Roles assignment,
3. Videoconferencing platform use, and
4. Communication and information sharing

**Scenario description (S1)**
The instructor reads the following description, gives the dump trick specifications to teams A and B and gives one observation grid to each member of team C.

You work for a manufacturer-assembler of trucks and you are a member of the development team.

As part of a call for tender, your company has signed a contract for the development a dump truck prototype. Your team is responsible for designing and building a prototype of an articulated dump truck with a tipper and a cockpit with driver.

Three major components of this truck will be purchased from external suppliers. So you need to build a copy of the truck's three separate components: 1) truck's dumper, 2) cockpit with engine and 3) truck's articulated chassis. These three components must be identical in terms of size and colors those, which are found on the prototype.

This contract is important for your company. Indeed, the winner of the tender call will receive a contract to assemble 500 articulated trucks of the same type for the town of Montreal.

**Distribution teams and responsibilities**
<u>Team A</u>: All members are working in the same room and are responsible for performing the contract.

<u>Team B</u>: The team is split into two groups: B1 must construct the train prototype on one site and B2 must build the train station prototype at the other site. No face-to-face meetings and/or

exchanges "physical" are allowed. Communications are performed through the Adobe® Connect ™ videoconferencing platform.

Team C: One member observes team A and another observes team B. They must observe the "builders" and take observation notes using the observation grid (see appendix 1) without talking or interfering with members of team A or B. At the end of the simulation, the observer will have to present their observations to the rest of the class.

**Completion time**
Duration: The teams have 25 minutes to complete the contract.
The instructor circulated in the three rooms and answer questions as needed.

**Interventions # 1 - After 10 minutes (optional, depending on the course)**
Objective: To destabilize students and change teams dynamics
Change announcement description:
A restructuring took place in the company, which forces it to make changes in the teams compositions. A member of team A must exchange places with another member of team B. (Tip to instructor: Select key members, "leaders" who play a central role).

**Presentations and Discussion**
Duration: 40 minutes
At the end of the simulation, all participants gather in plenary session. Teams A and B initially present their prototypes and train station. Instructor has to verify compliance with the functional and technical specifications. Then, team C presents their observations to the rest of the class.

The instructor comments on the presentations to highlight the links between the simulation and theoretical concepts and by asking questions, such as:

1. Which simulation was the most complex? Why?
2. What was different for you between what you lived in S1 and what you lived in S2?
3. What have you learned from S1 that you put into practice in S2?
4. What problems have you encountered in S2? Where the nature of the problems different from S1?
5. What would have been different if, in addition to geographic dispersion, a temporal dispersion had been experienced by the distributed team (asynchronous work mode)?
6. What have been the effects of the team composition changes?
7. Which processes are critical to the performance of distributed teams?
8. Can you make any links between what we have seen so far in the course and what you have lived in the simulation?
9. What will you remember from this simulation?
10. What have you learned that you could put into practice?

# Tables and Figures

**Table 1 -** Participants' Roles Distribution

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

**Table 2 –** Scenarios Descriptions

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

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

| **Aspects teams dynamics** | **Types of team** | |
|---|---|---|
| | **Collocated teams** | **Distribute teams** |
| **Tasks and roles Distribution** | 1. No, or minimal, tasks and roles distribution a priori.<br>2. As team members become conscious that times progressed, the formalization of tasks division and the establishment of priorities became more important. | 1. Clear identification of roles and responsibilities at the scenarios' outset.<br>2. Creation of two main two roles at each distributed site: Coordinator and Builder<br>3. Coordinator also play the "guardian of time" |
| **Coordination** | 1. Informal, by observing and adjusting to the actions of the other team members.<br>2. Done in a progressively and non-intrusively way. | 1. The "coordinator" at each site has to properly organize and ensure that the tasks and the outcomes realized by the builders at his site and the information provided by the coordinator at the other site are aligned and coherent.<br>2. Frequent and disruptive interruptions of the construction work, between sites, to coordinate with the work done at the other side, using mainly the video and image.<br>3. A communication signal was established capture the other member 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.<br>2. Further gestures on the screen are used by the coordinators to draw the attention of the other team.<br>3. Use of personal mobile phone.<br>4. Use the function "common notes" of the videoconferencing platform to document decisions and important points.<br>5. Discussions and decisions from sketches drawn using the "whiteboard" function.<br>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 participants realized they did not had the same interpretation of the specifications and/or the problems. | 1. Established reference frame to facilitate shared understanding of the problem (e.g. chose a LEGO® brick as reference unit a to measure their prototype). |

|  |  |
|---|---|
| **Collocated Team during S1 (Fall 2014)** | **Collocated Team during S1 (Fall 2015)** |

**Figure 1 –** Observations and visual cues are used in collocated teams for information exchange and coordination.

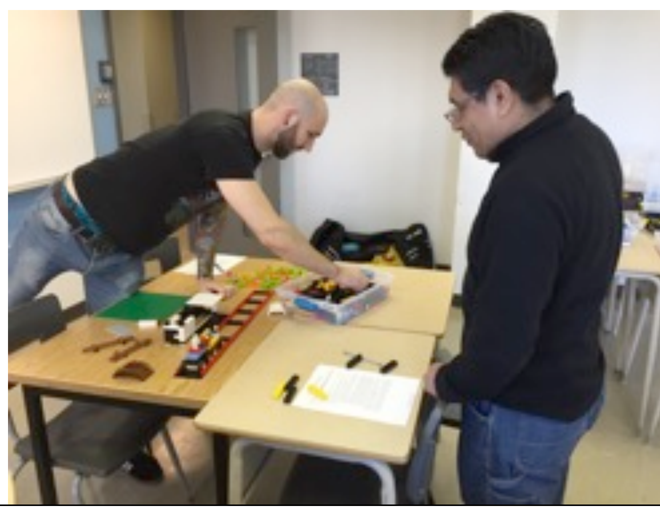


**Figure 2-** Lack of technical specifications clarification by collocated team members, at the outset, engendered an argument and forced them to formalize tasks distribution and validation.

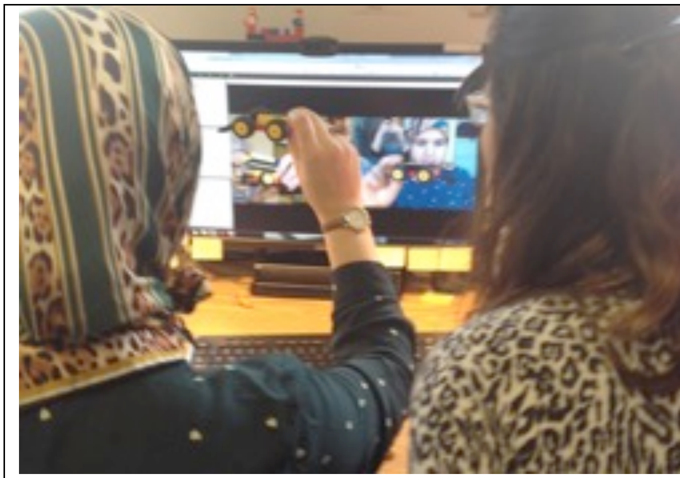
| | |
|---|---|
|  |  |
| **Distributed Team during S1 (Fall 2014)** | **Distributed Team during S1 (Fall 2015)** |

**Figure 3 –** Observations and visual cues are used in distributed teams for information exchange and coordination.