Learn to use and use to learn: Technology in virtual collaboration experience

By: Elena Karpova, Ana-Paula Correia, and Evrim Baran

Abstract:

This study examined how global learning teams utilized technology in a virtual collaboration to solve complex problems. The study offers an in-depth explanation of why and how the learning teams used technology to support computer-mediated communication. A model of technology application at different stages of virtual collaborative process is proposed. The model can be used to maximize potential of global teams and facilitate further integration of virtual collaboration into university curricula. Time difference and lack of nonverbal cues were identified as challenges the global teams faced. The benefits of virtual collaboration were the opportunities to: learn how to use technology in a meaningful way; practice using technology to solve problems; and broaden one's perspective by communicating with people from different cultures.

Keywords: teamwork | virtual collaboration | computer-mediated communication | global team | technology

Article:

1. Introduction

Learners of the 21st century should have an opportunity to experience virtual collaboration and teamwork, as they must be prepared to communicate across cultural and organizational boundaries using technology (Grosse, 2002). To address this need, instructors increasingly incorporate virtual learning environments in traditional classroom (Häkkinen & Järvelä, 2006). Learning while working together is becoming mandatory to meet workplace performance requirements, and it is important for students to have authentic experiences while earning a degree. Increasingly, colleges and universities are using pedagogies that allow for the development of transferable professional skills to meet expectations of prospective employers (Colbeck et al., 2000, Correia, 2008b). Another benefit of using virtual collaboration as a strategy to teach and learn is the ability to bring together heterogeneous participants and expose students to a diversity of cultures, opinions, and communication styles.

1.1. Virtual vs. face-to-face teams

Research indicates that online groups have to overcome more obstacles in comparison to face-to-face groups; and the former type of collaboration is not always successful (Jarvenpaa and Leider, 1999, Wilson et al., 2006). One of the reasons for that is ineffective use of technology for communication and building rapport among participants (Delport & De Villers, 2004). This challenge creates a major impediment to integrate virtual collaboration as a teaching and learning strategy. In most of the previous studies, virtual collaborators were restricted to limited technology they could use to support computer-mediated communication, usually a discussion board and/or e-mail (Weller, Pegler, & Mason, 2004). Such approach limits opportunities of the virtual collaborative process. Few studies examined computer-mediated communication that relied on multiple technologies (Weller et al., 2004). Moreover, the authors are not aware of a study where participants were free to choose any technology to support virtual collaboration. This study addresses the gap in understanding how and why virtual teams select and use technology, as well as participants' perspectives and opinions about such experience.

1.2. Global team

Kristof, Brown, Sims, and Smith (1995) defined global team as temporary (has no common history or future), electronically mediated (interaction mode does not rely on face-to-face communication), culturally diverse and geographically distributed. Advantages of using such teams for teaching and learning include: participants' exposure to a variety of ideas, perspectives, and approaches to problem-solving; generation of cognitive disequilibrium that is conducive to learning, creativity, cognitive and social development; and a gain of sophistication in building arguments, sense-making, position-taking, and consensus reaching (Johnson & Johnson, 2003). To establish effective communication, global teams need to quickly develop and maintain mutual understanding without face-to-face interaction (Mezgar, 2005). The increasing use of online and blended courses in higher education demands further examination of what technology and how global teams use to collaborate. Researchers argue that qualitative examination is needed to better understand what global team members perceive as challenging and rewarding (Finegold and Cooke, 2006, Song et al., 2004). Such understanding will help to develop strategies for making virtual collaboration in a learning environment a more satisfying experience for both students and instructors.

1.3. Research questions

The purpose of this research was to examine computer-mediated communication of global learning teams in a higher education context. The research questions included:

- What technology do global learning teams choose to support virtual collaboration? What are the advantages and disadvantages of different types of technology, as perceived by participants?
- What technology do global learning teams utilize at different stages of a virtual collaboration process?
- What are the challenges and rewards identified by members of global learning teams?

The ultimate goal of this study was to contribute to the development of strategies for incorporating virtual collaboration in university curricula by gaining a better understanding of computer-mediated communication experienced by global learning teams.

2. Pedagogical approach

It is important to engage students and instructors in the collaborative processes of learning and make them aware of the complexity and meaning-making of the entire experience (Kuure, Saarenkunnas, & Taalas, 1999). To achieve that, participants should get involved in social activities within the learning community because problem-solving process is impacted by the social conditions in which individuals are entrenched (Ahern et al., 2006, Billet, 1998). Leinonen, Järvelä, and Häkkinen (2005) argue that teamwork outcome depends on how successful teams are in managing cognitive and social factors, which are interdependent. Devaluing social practices may decrease the chances of success of any educational enterprise. However, an analysis of collaborative scenarios indicates that there are few strategies for inclusion, flexibility, and interaction in an online learning context (Liebig & Effelsberg, 2004). The use of technology adds another layer of complexity to global team's interactions (Correia, 2008a). At the same time, technology can serve as "a bridge to introduce new cultures, knowledge and people to students" (Davis & Cho, 2005, p.1). To design an inclusive, engaging, stimulating and satisfying learning experience for global teams, five inter-related dimensions were considered: authenticity, inclusion, ownership, resource leveraging, and socialization (Correia, Baran, & Yusop, 2007).

2.1. Project design

To provide authentic experiences, the learning tasks were focused on contemporary educational problems. Teams were asked to select an instructional problem, propose a solution to the problem, and virtually present the solution to other teams and instructors. The students (majoring in educational technology) faced a higher order task: they had to negotiate what instructional issue to focus on, and then come up with creative solution(s) through consensus reaching. It was expected that students and instructors would connect these problems to their own experience. As a result, every participant would act as a knowledgeable resource, while the technology could allow for resource leveraging and knowledge sharing. The project design aimed at engaging the learners as creators of the experience to address the ownership factor. Global teams were encouraged to select an educational problem as well as types of technology that better suited their needs, communication frequency, and work processes. The only requirement in terms of technology was to use a shared learning management system (WebCT) as a repository of the teams' computer-mediated communication so course instructors could keep track of the progress. Each team was expected to post a summary of the discussions conducted outside WebCT. For instance, teams that used chat in Skype posted their communication logs in WebCT.

WebCT (Course Tools) is an online proprietary learning management system that provides various tools (e.g., discussion boards, mail, live chat, assessment) for course management and delivery. In this project, it offered a learning space designed as a sharing platform where students could access resources, post contributions and chat logs, read and respond to discussion threads, store their work in progress, get feedback, inform the course instructors on team processes,

reflect on learning experiences, and socialize. "Private" discussion spaces were created for each team (accessible by other students only for reading, not posting). Instructors used WebCT to post resources and timelines, as well as offer support and guidance.

Special spaces were created for social interactions among participants and interactions outside the scope of the collaborative project were encouraged. In the beginning of the project, all participants met via a videoconference (using Acrobat Connect Professional), which allowed students and instructors to observe, listen, talk, be seen and share artifacts with each other. Each participant prepared one PowerPoint slide as an introduction. This introduction included professional background, interests and some personal information (e.g., hobbies, likes and dislikes). All presentations contained pictures. The instructors scheduled and delivered this kick-off meeting. The project concluded with the same format videoconference, where global learning teams presented their problems and solutions to other teams and instructors.

3. Methodology

To understand how and why virtual teams select and use technology and to explore participants' perspectives on such experience, a qualitative methodology was selected because it allows for obtaining in-depth, "rich" data directly from participants. Multiple data collection methods were used: background questionnaire, in-depth individual interviews, and postings on discussion boards.

3.1. Participants

Graduate students from two universities, one located in Denmark and another in the USA, participated in a 4-week virtual collaboration. The participants were educational technology majors. Eleven students, five from the USA and six from Denmark, were assigned to three- to four-member teams. To ensure team heterogeneity, the following criteria were used: (a) U.S.- or Denmark-based participants; (b) experience working as a virtual team member (high vs. low); (c) work experiences (extensive vs. not extensive); (d) age (older vs. younger), and (e) gender. Three global learning teams were formed: Team A (Ella, Lisa, James and Dan), Team B (Sara, Tim and Alex), and Team C (Ben, Kim, Alla, and William). To maintain confidentiality, participants were assigned pseudonyms.

Out of the eleven participants, four were female and seven were male students. The learners' ages ranged from 27 to 55. Most participants had no prior virtual collaboration experience. Only one of the U.S.-based students was born and raised in the USA. Other U.S.-based participants were international students from Eastern Europe, India, and Turkey. All communications among the team members were computer-mediated. It should be noted that participants had hardly any technological limitations: all of them had access to high-speed Internet both at the university and at home, as well as the appropriate hardware and software.

3.2. Data collection and analysis

Participants completed a demographic questionnaire and were individually interviewed. The semi-structured format of the interview was employed to ensure systematic approach to data

collection by using interview protocol. Face-to-face interviews were conducted with the U.S. students, while Danish participants were interviewed virtually using conference calls or videoconference, depending on participant preference. All participants were interviewed in English. Ten of the eleven students agreed to be interviewed for this study. The interviews were recorded with the permission of the respondents and later transcribed. All discussion board postings and individual interviews formed a narrative text that was analyzed for common themes. This analysis provided a "thick" description of participants' experiences (Spiggle, 1994, Thompson et al., 1990).

First, the narrative was reviewed and major areas of commonality and difference were defined by the researchers independently. The emergent themes were arranged to address the guiding research questions. During the next stage of the analysis, the researchers worked together to merge the themes into a consistent whole through a back-and-forth, part-to-whole process of interpretation (Spiggle). Any inconsistencies were resolved through discussion and reviewing the data together. While the number of participants in the study may appear to be relatively small, analyses of the narratives indicated saturation of the data (i.e., ideas, comments and opinions expressed by participants were repetitive). This suggests that larger sample size would likely not produce any additional new information.

4. Results

As a result of analysis and interpretation of the data, the two overarching themes had emerged: *Use of technology* and *Rewards and challenges of virtual collaboration*. Each theme has a number of subthemes that allow for an in-depth understanding of the learners' experiences with the technology and perceptions of the virtual collaboration process. The two themes with selected quotes from interviews are presented below.

4.1. Use of technology

This theme presents the case on the use of technology by global learning teams that collaborate to identify, formulate, research, and solve a complex problem. It summarizes participants' experiences related to decisions which technology to utilize for what tasks and the rationales behind these decisions. The learners' perspectives on advantages and disadvantages of various types of technology used in the project are presented. The theme consists of five sub-themes, by the total number of different types of technology employed by the global teams in this project (i.e., Acrobat Connect Professional, Google Docs, e-mail, Skype, and WebCT).

4.1.1. Learning management system (WebCT)

All three teams had utilized the discussion board extensively, reporting that "there were new postings in WebCT every day or every other day" (Lisa). The learners agreed that "WebCT was a good place to post information for everybody" (Ben) and for organizational tasks: "WebCT held us and our thoughts together" (Alex). However, all participants noted that WebCT was not well suited for discussion and reaching a consensus: "I think WebCT is a little heavy to work with discussion" (James). A common explanation offered was: "[i]t takes too much effort to write a good, sound argument everybody can understand in WebCT" (Ben). Teams A and C also

used WebCT to socialize beyond the project requirements; for example, to share their professional experiences and insights.

Because WebCT was the official platform for the project, the students felt the need to make more or less regular postings there: "We used WebCT because we knew everybody was looking at that, it was more formal, more project-related" (Sara). For the same reason, participants used more formal language for WebCT postings than when communicating through other types of technology: "On WebCT, your posts will be up the whole semester. But if you are posting something in chat room it can disappear in ten seconds. There are different social rules involved. There is a difference between the two environments" (Ben).

4.1.2. Skype

Skype is a free downloadable videoconference system that works via a peer-to-peer voice over internet connection. It offers point-to-point and multipoint chat, as well as multiple participant conference calls. According to participants, "Skype is free and easily available and super easy to use" (Dan). One of Skype's limitations was that "it could accommodate only four people" (Lisa). However, this was not an issue for this project because the largest number of team members was four, unless a team wanted to invite the instructors. Participants agreed that in comparison with discussion board, conference call was a more suitable tool for brainstorming, reaching consensus, and decision making. All teams relied on Skype for audio conferencing and expressed an overall satisfaction with the process: "Our talk over Skype was great. Even though it was in English, we talked very well together. And a lot of ideas came up there" (Alex).

From the learners' perspective, one of the conference call's shortcomings was the inability to see communicating parties, which resulted in difficulty managing conversations: "There was no one to guide the talking process, and sometimes there was silence. Sometimes you don't know when to begin talking because you don't want to interrupt" (Ella). All teams expressed the need to document audio conversations for future reference: "The disadvantage [of conference call] was that we could not record it. We had to trust our memory, and it was quite challenging" (Alex). Teams ended up using chat function to keep track of conversations' main points: "When we first started talking on Skype, it was audio only. You couldn't document anything. And I am that kind of person who forgets things easily. I wanted to document things. Then we started writing [in chat], talking and writing" (Sara).

When audio conference participants had difficulty understanding each other due to language barrier, they used the chat as an alternative: "We used chat couple times because Kim said something and we didn't know what she said, so she spelled it, then we read it" (Ben). Alex summarized advantages and disadvantages of chat conferencing as follows:

> Chatting is a good way of talking, because you can get a transcription of the chat, but it is also demanding because of the differences in our language. It is hard to write down our thoughts in chat because the answer is expected to come at once. And it can be difficult to keep one thread because of the speed in which you have to reply. But it is a very useful tool.

Team A went beyond audio and chat features, and also used Skype's video tool. The team members were very pleased with the experience: "I think it is a good tool. It would be very difficult if we just had to chat about different issues" (Dan).

4.1.3. Acrobat Connect Professional

Adobe Connect Professional is a web-based communication system that offers the following tools: white board for sharing applications and desktop and up to eight participants' videoconference that can be recorded. Users can join virtual meeting by following a link sent by moderator. The hosting party has to have license for using the application. Acrobat Connect Professional was utilized for the kick-off and closing meetings, arranged by the instructors. Even though in both meetings participants faced technical problems, overall, it was acknowledged that "Connect was a good choice. I don't really see how you could have done this otherwise" (James).

The following quotes illustrate that participants perceived this experience differently. Alex, while admitting specific shortcomings due to technical limitations, emphasized the powerful capabilities of this technology in terms of connecting people in dispersed locations:

> I found Acrobat Connect meeting a bit difficult. It was hard for me to hear and understand, and I think it took up to 4 or 5 seconds before the words had crossed the Atlantic, and then again 4 to 5 seconds back. It is not easy to communicate, but it was fun, and very nice to meet and see new people from another country.

In contrast, his team member, William had a different perspective: "Perhaps the problem with our first Connect meeting was when we had to share introductions using PowerPoint. The technology broke down. It was a shame."

Team A used this platform beyond the kick-off and closing meetings and appeared to be quite satisfied with the experience: "One meeting was on Acrobat Connect because we wanted to see our faces and at the same time use audio and PowerPoint" (Ella). Her team member notes: "We liked Connect better because it has whiteboard, and you can write on this whiteboard. You can draw a diagram or something like that. One starts and another member continues the idea, so you can actually write a sentence or a paragraph together" (Lisa).

4.1.4. Google Docs

Google Docs is a free web-based word processor that allows several authors to work in real-time on one document by keeping track of the changes and editing without downloading it to a computer. Team B benefited from Google Docs' unique function that allowed collaboratively creating and editing documents online without repeated downloading and uploading a file:

> We used Google Docs in the beginning to set up schedules because it has a very unique feature. You can post a document and three of you can work [together] on the document. When I go online, I can make changes to a document posted there and it says: "Revised by Sara." Then, other team members can just login and work on it, too. So, there is one

document which three of us can edit and save at the same time. Google Docs was really, really handy for us. (Sara)

This proactive strategy to schedule synchronous meetings made the team's interactions more efficient, thus reducing frustration when trying to set time for synchronous meetings. Participants were busy pursuing an advanced degree, in addition to having a family and full-time job responsibilities. To make things more complicated, team members were 7 h apart from each other. Team B members expressed interest to continue working with Goggle Docs in the future for other learning and work-related projects: "We used Google Docs. This tool I would like to work with again. It is very powerful" (Alex).

4.1.5. E-mail

All three teams had some communication through electronic mail. However, they employed it for different purposes. Teams A and C utilized e-mail during the introductory phase of the project to share personal information: "In the beginning we used mail to get to know each other" (James). Team B reported using e-mail for document sharing: "We were sending the PowerPoint slides sometimes by e-mail, but later on, we just put them in the WebCT. So we sent together two or three e-mails" (William).

4.2. Rewards and challenges of virtual collaboration

This theme addresses learners' perceptions of rewards and challenges that are associated with being a member of a global learning team. Two sub-themes summarize major benefits recognized by the participants. The project was perceived as an opportunity to learn from peers about new technology that could be used to support various needs of virtual collaboration. More importantly, it provided a chance to practice using the tools to solve a real problem. Participants agreed that this experience helped them learn about other cultures and cross-cultural communication, as well as broadened their perspectives about world-wide learning and teaching issues. Time difference and lack of nonverbal cues were perceived as major challenges.

4.2.1. Learn to use and use to learn

Learners acknowledged the benefits of being in a situation where they had to depend on technology to solve complex problems. Even participants who were experienced professionals accustomed to use technology for instructional purposes appreciated the opportunity to learn new skills: "I was learning technology. I have never used Acrobat Connect before, and I did not use Skype a lot. I spent two hours just trying to figure out what "presenter" can do versus "host" in Acrobat Connect" (Lisa).

Only two students appeared to be somewhat dissatisfied with technology-related experiences. One of them was overwhelmed by new technology he had to learn and use at the same time: "If the program we use is not familiar, there will be a lot of frustration and a lot of waste of the energy on the tool instead of the task. It is important that everyone is familiar with the tool" (Tim). In contrast, Ben felt frustration because he believed that other students were too slow in adopting new technology: "It was difficult: people were trying to set up their hardware with

software to get things work. And people couldn't figure that out. They couldn't even turn on and off their microphones to communicate with people."

However, other participants recognized the advantages of learning new ways to utilize technology for instructional purposes while using it. They argued that such experience takes the learning process to a higher and more meaningful level. Eventually, Tim commented: "The biggest advantage is that I learned how to use technology in a pedagogically meaningful way, which is more than learn how to use a new tool, for example, Acrobat Connect. I learned to collaborate over the Internet!"

4.2.2. Broadening perspective

Students agreed that it was very beneficial to work closely with their counterparts from different cultures: "It was very exciting to meet someone from another culture and to discuss education. We just talked about education in Denmark, U.S., and Ukraine. We shared a lot of information" (Dan). Beyond exchanging ideas and information related to the profession, some participants used this opportunity to learn about other cultures: "We learned about each other's cultures. That was the most interesting thing for me. I learned a lot" (Lisa). William describes this virtual collaboration as an intense intellectual exchange with colleagues from different cultures. He explains that it made him question some basic assumptions that he held prior to this experience and turned it into an opportunity to learn more about himself:

> Normally, when I work together with colleagues, it is people who are thinking the way I think and doing things the way I do. This experience was different because we were so different. This made me think about a lot of things in other ways than I normally do. When people are different, the collaborations will get a little further. I learned a lot from communication with different people. And I learned a lot about myself.

4.2.3. Time difference

One of the major problems identified by participants was the seven-hour time difference between U.S. and Denmark. The challenge was to schedule conference calls, which were deemed necessary for synchronous discussion and decision-making process: "With Skype everybody should have some free time at a particular moment. Sometimes it was difficult because of seven-hour time difference" (Lisa). Additionally, the time difference may result in contextual dissonances, as Ben explained: "You are not in the same environment. Let's say, I am drinking coffee. These guys can be drinking beer because they are going to sleep. They could be drinking wine or whatever to chill out while I am just getting warm up. That's a totally different context."

Inevitably, some students were not able to participate in all the team meetings due to schedule conflicts. For example, Ben attributed extra pressure to the time difference: "To make this collaboration even more difficult, there was a 7-hour time difference. Trying to find time when everybody can meet was very hard. Two or three times I couldn't even make it because I had a class." Despite this challenge, all teams were able to include in their busy schedules four to five synchronous meetings, some of which took more than 2 h. This indicates that for the four-week period, participants were fully committed to the project. Even though teams had to overcome the

time difference hurdle, they preferred to use synchronous discussions to reach consensus on important decisions rather than an asynchronous discussion board.

4.2.4. Lack of nonverbal cues

Students perceived the lack of nonverbal information and contextual cues when communicating via conference calls as a serious obstacle for establishing reciprocal understanding: "It is so difficult. You can't tell if you totally lost them, or they don't believe you, or if they are just not interested because there is so much [nonverbal] information just being lost. That was really frustrating" (Ben). Participants agreed that the inability to use nonverbal language in virtual communication made the interaction more challenging: "In face-to-face, you see that person, you see her mimics or body language, so you act based on the body language—you have that nonverbal communication. But in virtual teams it is not possible to use that language" (Ella).

Team A utilized video function as a way to minimize the impact of the absence of nonverbal cues. Even though the tool did not completely replace face-to-face interaction, it increased the number of contextual and nonverbal clues in the communication process: "It is more personal when you work in a videoconference systems like Skype or Acrobat Connect. You even can see the expression on your colleagues' face, their reactions" (Lisa). In contrast, Ben argued that even seeing a person via videoconference through Acrobat Connect or other program is not enough to develop reciprocal understanding:

> Important thing is making eye contact with somebody. When you look at webcams, it is impossible. You have four people on the screen. Even if you do see them, you don't make eye contact. So, you do not get reciprocal relationship. How do you do that with current technology? You can't. Everybody is looking forward.

For the remaining two teams, technical limitations prevented them from using the video and audio components at the same time. In that case, the only visual cue was the team members' picture, which nonetheless was considered helpful:

> It was not a moving picture, but it was a picture. If we could see people's nonverbal cues also, it would help a lot because then you can communicate more effectively. I missed some points which I would have taken if I would be in a face-to-face interaction with somebody—what are the facial expressions, what is the body language they are using? (Sara)

Participants were unanimous in recognizing that the intensive exchange of personal information and socializing with virtual teammates helped to partially compensate for the lack of nonverbal cues. The students attested that learning about team members by exchanging information allowed to create social and emotional bonds that greatly facilitated interactions among global team members: "First, you have to get to know each other and get as much information as possible to create social and emotional context, which helps develop reciprocal understanding of each other and to know how people work" (James).

5. Discussion and conclusions

In the borderless world, there is hardly any establishment that is not connected in some way or another with international collaborators, partners, customers, or suppliers. Governmental, educational, and business organizations depend more and more extensively on global teams to perform day-to-day operations and deal with complex, multidimensional, and dynamic problems. It is essential to understand how global teams operate and what challenges they face in order to facilitate effective and efficient teamwork processes. Global team members are expected to quickly establish and maintain reciprocal relationship with people from various backgrounds, relying on computer-mediated communication only. What type of technology is better suited to support such communication, and, more importantly, how should technology be used to leverage advantages of such teams? This research is an attempt to answer these questions. Specifically, the authors focused on global teams in a higher education context. Given the growing utilization of global teams for educational purposes and the associated challenges encountered by instructors, the goal of this study was to contribute to the development of strategies for incorporating virtual collaboration in university curricula.

The study examined "what, how and why" global learning teams use different types of technology for virtual collaboration when solving complex problems. The findings are summarized in the Table 1. With the exception of requesting the use of WebCT as a data repository, teams were encouraged to use any other technology to support virtual collaboration. As a result, none of the global teams relied on a single tool. Besides WebCT, teams chose between Acrobat Connect Professional, e-mail, Google Docs, and Skype to suit various needs at different stages of the project. In addition, students extensively used different features offered by each of these technological platforms, such as chat, audio, video, white board, document sharing, and shared document writing/editing. Each team utilized three to five different types of technology because, according to the participants, each of them had certain advantages as well as limitations. Team C used three communication platforms (i.e., Skype, WebCT, and e-mail), which is the smallest number in comparison with two other teams that employed four to five different types of technology (Table 1). In addition to Skype, WebCT, and e-mail, team B utilized Google Docs, while team A added Acrobat Connect Professional to the same list of the three platforms.

Table 1. Types of technology used by global learning teams to support virtual collaboration

Type of technology	Teams that used technology	Usage frequency	Reasons and purposes for using technology	Limitations/difficulties in using technology
WebCT	All teams	Every day or every other day	−Asynchronous: can be used at any time −Ability to retrieve messages and opportunity for reflection −To share information and resources −To post chat logs from synchronous meetings −To share ideas and provide feedback	−Not intuitive: takes time to learn −Not suited well for discussion −Asynchronous: might take long time to get response from team members −Not efficient/convenient for editing documents by multiple authors

Type of technology	Teams that used technology	Usage frequency	Reasons and purposes for using technology	Limitations/difficulties in using technology
Skype	All teams	Four to five meetings in 4 weeks	−For organizational/procedural tasks (e.g., schedule synchronous meetings) −For social interactions −Available at no cost	−Synchronous: difficulty in setting meetings due to time difference
Audio	All teams		−Easy to use	−Conference call feature accommodates only 4 people
Video	Team A		−Nonverbal communication (e.g., face expressions, body language) and contextual information (video)	−Videoconference feature accommodates only 2 people
Chat	All teams		−Synchronous: immediate feedback; more natural and spontaneous communication	−Absence of nonverbal cues (audio and chat)
			−Ability to save and later post chat logs on discussion board for future reference	−Difficulty in managing conversation (silent moments vs. several people talking at once)
			−To brainstorm and discuss ideas; to keep track of ideas	−Absence of eye contact: participants look straight into cameras (video)
			−To negotiate and reach consensus; make decisions	−Seeing own image via webcam can be distracting and intimidating
			−To assign tasks, delegate responsibilities	−Chat logs are choppy and have no meaning to outsiders (i.e., instructors)
			−To document major discussion points and team decisions	
			−To better understand spoken language	
			−For social interactions	
Acrobat Connect	Team A	One time	−Whiteboard: synchronous document creation and editing (e.g., collaborative design of PowerPoint slides for presentation)	−Not intuitive: takes time to learn
Audio	Team A		−Audio: see Skype for advantages	−Synchronous: difficulty in setting meetings due to time difference
Video	Team A		−For social interactions	−Audio: see Skype for limitations and difficulties
Whiteboard	Team A			
Google Docs	Team B	Several times a week	−Available at no cost −Easy to use −Collaborative document creation −Sharing calendars to schedule synchronous meetings	−None
E-mail	All teams	One to two times a week	−Available at no cost −Easy to use −To share documents −For social interactions at the beginning of the project	−Impersonal

Participants reported utilizing different types of technology for different tasks. To establish initial contact and exchange personal information, teams preferred to rely on a less personal technology, like e-mail or discussion board. To brainstorm ideas and formulate a problem to be addressed, teams favored audio/video conferencing with simultaneous usage of chat to keep track of the discussion and create a chat log. Teams found audio/video conferencing essential for making important decisions because it allowed for immediate feedback and real-time discussions. To share resources, information, and organizational procedures, teams utilized WebCT. All types of technology were used to support interaction and fulfill social needs throughout the project.

All teams relied extensively on WebCT. Despite its limitations, this system was perceived as a useful and convenient technology for collaboration, mainly, due to its asynchronous nature: learners could share ideas and resources, post their thoughts and feedback at any time, and not depend on the availability of their team members. Although conference call systems with simultaneous chat function, such as Skype and Adobe Connect, were utilized quite frequently (once or twice a week), participants agreed that it would be used even more if not the seven-hour time difference. In the process of global teams' communication, synchronous and asynchronous tools complemented each other. They served different needs and were employed at different stages of the collaboration, providing a higher degree of flexibility in the computer-mediated communication.

Participants recognized learning new technology while being part of a global team as an important benefit. Students were unanimous in agreeing that the collaborative project took the learning process to a higher and more meaningful level. Another benefit was the opportunity to learn more about diverse cultures, opinions, and communication styles. As a result, the expansion of ideas, processes and networks was a major gain reported by the learners. In agreement with previous research findings (Finegold and Cooke, 2006, Sproull and Kiesler, 1986), time difference and lack of nonverbal cues were identified as challenges of virtual communication process. As a way to overcome absence of non-verbal communication, whenever possible, global teams incorporated additional cues (e.g., facial expressions, voice intonation, body language, view of the surroundings) in the computer-mediated communication by utilizing video/audio conference systems. Participants recognized mutual understanding as indispensable for virtual collaboration and invested substantial amount of time getting to know each other and socializing virtually, which helped create a common ground.

To facilitate rewarding and meaningful computer-mediated teaching and learning experience (e.g., distance education, cross-border collaboration), it is no longer enough to rely on a single technological solution (e.g., discussion board). However, it might be a challenge for instructors to decide what technology is more appropriate for different tasks and to anticipate problems that learners might encounter in adopting and using new technology. This research provides not merely facts of what technology was used by virtual teams and for what purpose, but also contributes participants' in-depth explanations for the reasons behind their decisions as well as rewards and challenges associated with this experience. Based on the findings, the authors' previous research on collaborative learning (e.g., Correia et al., 2007, Correia and Karpova, 2007, Correia and Davis, 2007, Pershing et al., 2001), and an extensive literature review, a

working model for technology use in virtual collaboration was developed (Fig. 1). This model represents major stages of the virtual collaborative process and recommends associated technological solutions.
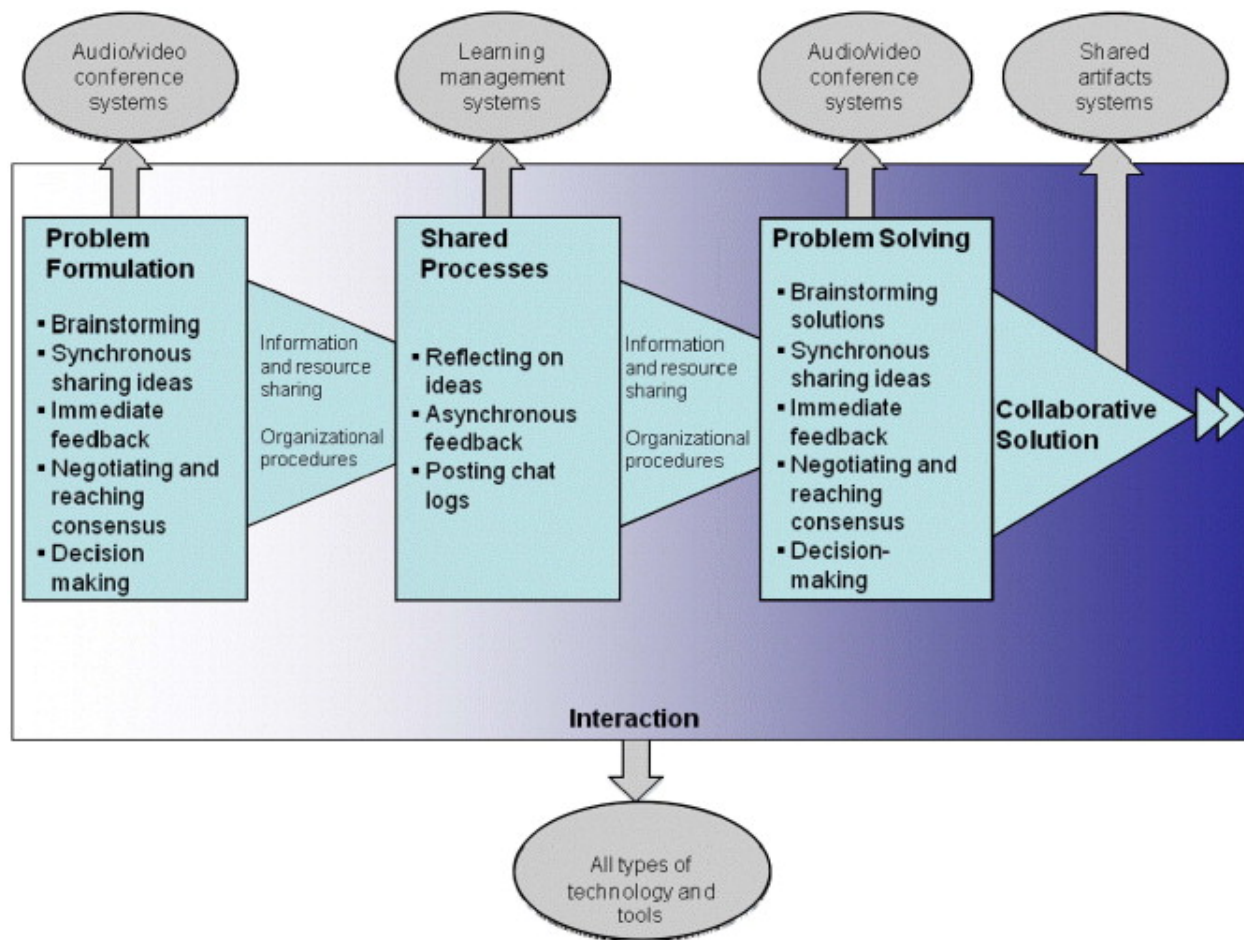

Fig. 1. Technology application at various stages of the virtual collaborative process.

The stages of the virtual collaborative process include: (1) problem formulation, (2) shared processes, (3) problem solving, and (4) collaborative solution (Fig. 1). At the beginning of collaboration, global teams work on brainstorming and formulating a problem to solve. Immediate feedback and real-time discussion, as well as nonverbal and contextual cues are critical at this stage for consensus reaching and decision making. Audio/video conference systems are proposed as the main mode of communication at this stage. In the next stage, *shared processes*, teams communicate asynchronously to exchange ideas, formulate strategies and to define a method of operation for the project at hand. Learning management systems (e.g., WebCT) are well suited to support these activities.

For *problem solving* stage, which includes complex tasks such as brainstorming, negotiating and reaching consensus, audio/video conference systems are recommended as a major technological support. When making key decisions, synchronous modes of communication are recommended to allow for the inclusion of additional cues (e.g., non-verbal and contextual cues); particularly, when team members have various communication styles (Correia, 2008a). At the last stage of the

virtual collaborative process, *collaborative solution*, global teams prepare to deliver project outcome(s). Shared artifacts systems, such as Google Docs or White Board in Acrobat Connect, are particularly useful. This stage creates a potential for continuing interactions among global team members beyond the project, as it was the case in this study. The network was created and participants leveraged on the established international connections.

One of the major issues that virtual teams face is the lack of clear team working processes (Leinonen et al., 2005). To address this problem and to help make these processes more effective and efficient, asynchronous modes of communication are recommended during all stages of the virtual collaboration to share information and resource, as well as for organizational purposes. Learning management systems can be organized with a focus on knowledge and resource sharing, while team asynchronous discussions can be utilized to address organizational issues that are less critical for the final project outcome (Correia & Davis, 2007). Several studies have demonstrated that for a successful virtual collaboration social relations are as important as the project content and team expertise (Leinonen et al., 2005, Leinonen et al., 2003). In this study, exchanges of personal and professional information among participants took place via various types of technology. Social knowledge construction and socially shared actions generate a constant flow of information during all stages of the virtual collaborative process. Interaction is at the heart of the proposed model. Organizational climate that supports social interaction is identified as an important factor conducive to high performance virtual teams (Correia & Karpova, 2007).

The proposed model of technology application at various stages of virtual collaborative process is recommended to maximize potential of global teams and facilitate further integration of virtual collaboration projects in university curricula. The purpose of the model is to support the process of virtual collaboration on a team level, a need expressed by many researchers who have voiced concerns on attaining shared understanding in distributed teamwork (e.g., Gutwin and Greenberg, 2004, Beers et al., 2005). This model might be useful for course designers and instructors who wish to incorporate virtual collaboration components into new or existing classes. The model may be particularly helpful in post-secondary education because assignments and projects in undergraduate courses are typically more structured and students may require more guidance in terms of what technology to use as well as expected communication patterns.

The proposed working model on the use of technology at various stages of virtual collaboration process is a first attempt to (a) formalize stages of virtual collaborative process global teams might engage in to solve a complex problem and (b) recommend appropriate technology for each stage of the collaboration. Further research is needed to validate and expand the model using a more diverse and larger sample of participants. Because participants in this study were dealing with an unstructured multidimensional task (solving a complex educational/instructional problem of their choice), they may require more types of technology than global teams that have a simpler assignment. The model was developed based on in-depth examination of global teams' computer-mediated communications in educational setting. While there is no evidence that virtual collaboration in industry settings might differ, it is important to confirm applicability and transferability of the model for non-student teams. Another promising research direction is to look at this same phenomenon and consider more deeply how technology can be used by global teams, investigating not only what technology is suitable for various stages of virtual

collaboration, but also examine strategies to use the technology that can facilitate faster adoption and more successful computer-mediated communication.

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