AEC Global Teamwork: Emergent Work Processes

Dr. Renate Fruchter, ASCE Member, Director of Project Based Learning Laboratory,
Department of Civil and Environmental Engineering, Stanford University
Stanford, CA94305-4020, fruchter@stanford.edu

Yunn-Chyi Chao, Graduate Student, Learning, Design and Technology Program,
School of Education, Stanford University, Stanford, CA94305
Senior Lecturer, Singapore Polytechnic, Singapore, chaoyc@sp.edu.sg

Summary

This ethnographic study reports on emerging work processes and practices observed in the AEC (Architecture/Engineering/Construction) Global Teamwork program, i.e., what people experience when interacting with and through collaboration technologies, why people practice in the way they do, how the practice fits into the environment and changes the work patterns. It presents the experience of two high-performance typical but extreme AEC teamwork cases adopting and adapting to collaboration technologies and how these technologies in practice impact their work processes. The findings illustrate the importance of collaboration technologies in cross-disciplinary, global teamwork. Observations indicate that high performance teams that use the collaboration technologies effectively exhibit collaboration readiness at an early stage and manage to define a "third way" to meet the demands of the cross-disciplinary, multi cultural and geographically distributed AEC workspace. The observations and implications represent the blueprint for yearly innovations and improvements to the design of the AEC Global Teamwork program.

1. Introduction

The AEC (Architecture/Engineering/Construction) Global Teamwork program (Fruchter 2003) was established in 1993 in response to the current poor coordination and communication among professionals in the AEC industry. By emulating a real-life geographically distributed working environment, it aims to prepare a new generation of AEC professionals who know how to team up with practitioners from other disciplines and take advantage of information technology to produce a better, faster and more economical constructed facility.

The technical improvements in computer hardware, software, and infrastructure have increasingly optimized conditions for the application of Internet-based tools to support collaborative work in the past decades. Many of the necessary networking components do not require high-end hardware or high-level technical support and are commercially available or free to download today. Collaboration technologies such as discussion databases, application sharing, desktop conferencing, instant messaging have emerged in many communities and workplaces. Researchers reported how context, peripheral awareness, incidental properties of artifacts, and informal conversations allow us to coordinate our activities with others, and how the collaborative technologies can help or hinder those patterns (Fussell et al 2000) (Grudin 1994) (Herbsleb et al 2002 a, b) (Nardi et al 2000) (Olson et al 2000) (Teasley 2001).

The challenge for the educators in AEC Global Teamwork program has been on how to integrate technology effectively into the program to support the collaboration work in this geographically distributed, highly networked, highly interactive, and media-intense learning environment.

This ethnographic study aims to understand what people experience when interacting the technologies into their work process, why people practice in the way they do, how the practice fits into the environment and changes the work patterns. The implications are used to improve the design of the learning experience in this AEC Global Teamwork program.

To establish the context of investigation, the first part of the paper gives a brief introduction to the AEC Global Teamwork program. In reporting the results of the study, the analysis is structured under the following research questions:

- How people make choices – the adoption and abandonment of collaborative technologies
- The roles of the technologies in a global team
- The impact of the technologies in practice and the emergent work practice

To narrow the scope of the study, this report concentrates mainly on the synchronous collaboration tools (desktop Video Conferencing (VC) and Instant Messaging (IM)) since these tools played a major role in replacing the face-to-face interaction in this setting. However, it is important to note that asynchronous systems such as email and threaded discussions, together with the hardware infrastructure, were used complementarily with the synchronous systems by the AEC teams.

2. The AEC Global Teamwork Program

The curriculum of this program is based on a Project-Based Learning Model that has evolved over the years through the course offering by Civil and Environmental Engineering Department at Stanford University in collaboration with partners worldwide (Fruchter 2003). The five-month course runs from January till May yearly. It engages M.Sc. students, faculty, and industry practitioners from the three AEC disciplines in a distributed learning environment including universities from Germany, Switzerland, Sweden, Slovenia, UK, Netherland, Japan, and USA.

The Learning Context
Students in the AEC Global Teamwork program are grouped into teams with an assigned project right at the beginning of the course. Each team consists of members from the three AEC disciplines from the M.Sc. program in different universities. A team may also have one undergraduate participates as apprentice.

Members of a team meet face-to-face only during the one week kickoff event at the beginning of January at Stanford. Thereafter, the members return to their respective Universities. Hence modes of interaction and content sharing of an AEC team are spread out both in time (synchronous and asynchronous) and in space (geographically distributed and collocated) mediated by collaboration technologies.

As shown in Figure 1, the core of this learning environment is a building project based on a real-world setting with a program, a budget, a site, a time for delivery, and a demanding client/owner. The project requires the expertise from the three AEC disciplines, which are intricately interdependent on each other (Fruchter 2003). During the five months period, each team needs to come up with two building designs with a complete proposal. They have to meet the tight deadlines, engage in design reviews, and negotiate modifications.

The learning activities are revolving around the building projects. They include structured lectures, professional practice sessions[1] and project presentations. Students spend most of their time working in teams on their project. Learning is situated and developed collectively through activities and practices in this program. Learners are challenged to cross four chasms – time, disciplines, culture, and technologies. A team relies heavily on technology to overcome the barriers of time and space. Participants are challenged to collaborate with people across different disciplines, languages, cultures, and many time zones. These ever changing challenges (change in technologies, people, conditions, etc.) train learners to be attuned to the constraints and affordances in a setting. And at the same time, allow the learners to practice the sophisticated social and information-processing skills that they will need in their future careers (Greeno et al 1996) (Lave and Wenger 1986).
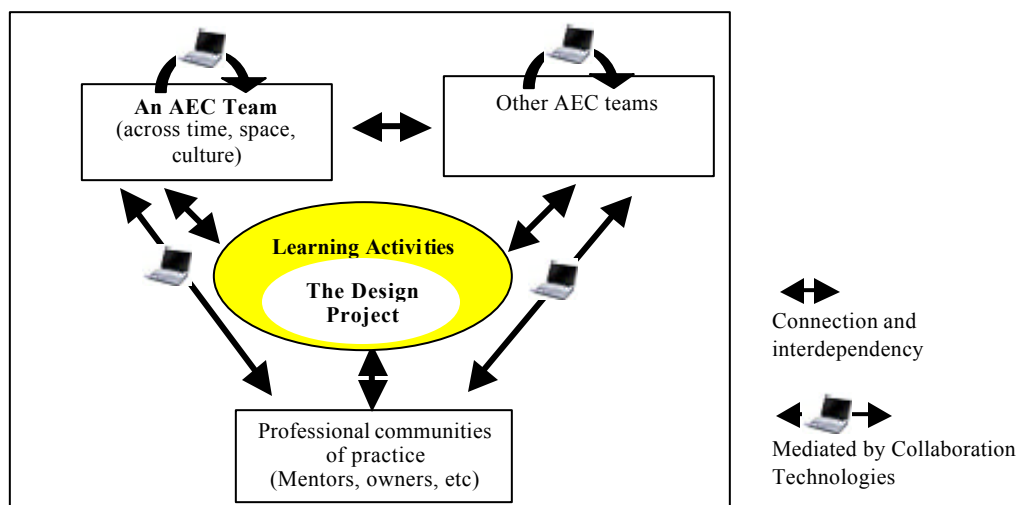

Figure 1. The learning structure of the AEC Program

The people and the teams, the activities, as well as the technology tools, are mutually dependent, impact and change each other continuously in this environment. The setting, the technologies, and the people together shape the problem and allow the teams to come up with different innovative designs. This explains why, in the past decade, every successive generation has produced drastically different designs for the same project requirements. (http://pbl.stanford.edu)

The Collaboration Technologies
The collaboration technologies made available to the students include:
- The software – Commercial systems that are explicitly designed for person-to-person communication and in-house developed system that are designed for specific collaboration functionality:
  - Synchronous systems – desktop video conferencing (VC) such as Netmeeting™; instant messaging (IM) such as MSN Messenger and ICQ; and telephone.
  - Asynchronous systems – emails; threaded Discussion Forum; shared WWW workspace for each team.

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[1] The professionals are gathered to solve design problems with students observing at the periphery their perfomance. These activities aim to make explicit the expert's best practice and knowledge (Fruchter 2003)

- The supporting hardware – Stylistic Fujitsu Lifebook with touch screen; and network (LAN and wireless), SmartBoards.

3. Ethnographic Approach

This paper reports on an ethnographic study of two geographically distributed high-performance typical but extreme AEC teams, with particular attention to the collaboration technologies in practice and the team's emergent work processes. The two teams are referred to in the paper as Medial Team and Isle Team (which differ from the real names of the teams).

Medial Team was randomly selected at the beginning of the program in January and Isle Team was singled out after their well-received Winter presentation in March as well as based on their outstanding high performance emergent work process.

- Medial Team had three members, where **A** (Architect) was located in Germany at Bauhaus University, **E** (Engineer) and **C** (Constructional manager) were stationed at Stanford, USA. The building they designed was located in San Francisco, USA.
- Isle Team had four members, **A** was at Kansas University in Kansas, USA, **E** was at KTH in Sweden, **C** and the **apprentice** were at Stanford, USA. Their building project was located in Florida, USA.

General background surveys indicated that all the members from these two teams were experienced users of email, PC and web applications. All rated themselves at least at level 7 on a scale from 1 to 10 on computer skills. The majority indicated that they have only some understanding of the other two disciplines. All members were high-achievers in their respective institutions. Both teams excelled and produced exciting building proposals at the end of the program.

Data was collected from interviews, observations, logs of IM, messages from the threaded discussion forum and a general background survey. We conducted altogether 11 interviews which spanned throughout the five-month period from January to May. 6 of the interviews were face-to-face and the rest were via IM. Each interview took about one to two hours on the average and took place either in the team members' workspaces, i.e., dorm or on campus. All face-to-face interviews were recorded and those conducted via IM were saved. During the interviews, we asked informants to comment on the technology provided; describe their work patterns; reflect on issues and challenges they encountered. Observations on the team dynamic were gathered from observing more than 30 sessions of team meetings, VC sessions, class meetings, dry runs and the spring and winter presentations. Most of the logs of IM sessions by Isle team were studied.

The units of analysis were individual team members, dyads, and the team as a whole.

4. The Findings and Discussions

During the study, we observed how the roles of collaboration technologies evolved and became idiosyncratic to a team in stages. We defined the following three stages:
Stage 1: *Preparation for collaboration* – The adoption and abandonment,
Stage 2: *Adaptation* – The transition from visible to invisible, and
Stage 3: *Idiosyncratic Usage* – The coupling of readiness-to-hand and present–at–hand[2].

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[2] Heidegger (Heidegger 1977) uses hammer and hammering to illustrate the concept that objects and properties are not inherent in the world, but arise only in events that lead to present-at-hand. The essence of this example is in the way in which the hammer moves from being ready-to-hand to present-at-hand, i.e. from being employed within the action of hammering as an almost "invisible" extension of my arm to becoming more immediately present and "visible"

However, a point to emphasize is that there was no clear distinction among the stages, it was a series of continual phenomena that progressed through the stages.

4.1 How People Make Choices

Stage 1: Preparation for collaboration – The adoption and abandonment of technologies

Setting up a common "collaboration workspace" is the first task for a geographically distributed team. Even though the same set of tools are introduced to all the participants at the beginning of the AEC program, it was observed that the decision which technology to adopt or abandon later was not pre-planned. Rather, it was the result of a series of evolving actions that emerged over a period of time and was idiosyncratic to each team. The process also revealed the extent to which the members were motivated to work with each other and willing to adapt to the common needs of a team. This "collaboration readiness" is a key factor that affects the success of a global team (Finholt).

Isle's Decision – The Instant Messaging Team

VC was abandoned by Isle after some members failed to setup the camera and audio within the first couple of weeks. Throughout the whole program, they used VC only while they were meeting (formally) with the instructor every other week for project review sessions. For meetings among the members, IM was adopted as the main (synchronous) communication tool. Email was used to compensate when a person was not available online. *"If the person is available [online], you use IM, if not, we use emails."* said the **apprentice**. Telephone has not been an option due to the expensive trunk calls expenses.

In explaining why Isle abandoned VC and adopted IM, **A** said,

> *"While we tried to set up VC, we would talk through IM half of the time, just trying to coordinate the logistics of getting a VC together and then sometimes, one of our cameras or microphones would be out.....so, we just went right to IM with no problem."*

However, we found that little effort was spent on troubleshooting the setup problem among the members, in other words, they gave up VC easily and adopted an alternative.

On the surface, one reason for Isle to abandon VC was attributed to the technical breakdowns. But using VC also meant that the team had to spend time to make prior arrangement and prepare the materials for discussion beforehand.

> *"We're really fast pace, a lot of quick meeting, so you don't really have the time to set something up [for VC],"* said the **apprentice**.

For Isle, being efficient and not "waste time" were their main objectives. The most important criteria for adopting or abandoning a tool was whether it enabled them to get things done most efficiently and effectively. Hence VC was reserved only for the meetings with the instructor or the client/owner.

On the other hand, we were not surprised to see that Isle chose IM as their main communicative tool. Majority, except **E**, were already very familiar with this tool. **A, E**, and the **apprentice**

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as an object of focus and attention. When the hammer is present-at-hand, it is separated from its user, while in the ready-to-hand situation, the hammerer's arm and the hammer feature as a single unit in the hammerer's activity (Dourish 2001) (Winograd and Flores 1987)

indicated that they chatted online daily before they joined the program. To them, IM was a tool that was "ready-to-hand" before attending the AEC Global Teamwork course.

In addition, the affordances of IM fit well with the team's *"no time wasted"* attitude. IM supports short and quick opportunistic conversations for questions and clarifications. It makes intermittent exchanges more straightforward, allowing participants to attend to other tasks and then return to an IM (Nardi et al 2000).

In sum, the choice of tools by Isle indicated that the team's actions were very much affected by: the team's prior experience (familiarity with IM), their needs (need a tool to communicate, need to complete the project, etc.), shared prejudice and values (efficient and *"no time wasted," "there was no need to have everybody there, people are there only when they are needed to be there," "video and audio in VC are not important"* even though they have either no experience or only little experience in using VC, their existing work pattern *"find a time that is common for everybody is almost impossible"* and their life-style - going online was part of the daily routine for **A, C** and the **apprentice**.

However, we also noticed that a choice for a team is not necessarily the choice of every member. In this situation**, E** from Isle had no prior experience in using either IM or VC, he simply followed the choice of his teammates, even though he indicated that *"sometimes it's hard to ask the right question and to understand the answer over IM,...."*, IM remained the main communicative tool for Isle throughout. This illustrates also how one was "thrown" into action, he needed to respond to the adopted technology and process and "flow with the situation." (Winograd and Flores 1987). Another key observation was the commitment of all team members in Isle to be almost all the time on line and on IM. This enabled all team members to be visible and available to each other on an as-needed-based.

Medial Team – Combining all!
Medial also encountered problems with the camera and audio setup for the VC (Netmeeting™). But instead of abandoning it, they worked around it and coupled it with another new product iVisit™, which was introduced by **A**. The team took the trouble to creative ways to combine the tools in order for all the members to meet together and be able to see and hear each other in real-time, i.e., using NetMeeting for application sharing and iVisit for audio and video. Besides the need to set up a platform to work and communicate, the driving force behind this effort was *"to build a strong team spirit."*

The team considered the way to produce the best product was to establish a good understanding and sense of belonging among its members.

> *"Just for [building] the team spirit it is worth the effort [to schedule meetings and prepare drawings before hand],"* said **C.**

They indicated that being able to see each other and to meet as a team was essential in building the team spirit and to communicate.

> *"The more cues you have about ones facial expression, tone of voice etc. the better empathy works, the better the communication is."* Said **A.**

On the other hand, Medial used IM only as a cue to check if their team members were online, a way to keep in touch and to create a sense of social connection to each other.

> *"We don't really chat over [IM]. Sometimes just drop a one liner like "hello, how are u there".* We won't discuss our project over [IM]."* said **E** of Medial before the winter presentation in March.

Even though the reason Medial team adopted the tools was very different from Isle, it was observed that their decision too was influenced by: their prior experience - **A** is familiar with VC and is considered technically savvy by his teammates; shared prejudices and values - *"Team meeting means everyone in the team meet together, " "There is a risk if only 2 meeting, the other may feel excluded from the team."* and the motivation for them to work as a team, to see and hear each other and make decision together.

The fact that there were no two teams among the cohort operating in the same manner and using the same set of tools suggests that the presence of technologies does not guarantee their successful adoption and ways of implementation. Rather, systems that are easily integrated into the team's existing working environment (e.g. IM for Isle) or systems that provide evidence that they will serve the common goal of the team (e.g. VC for Media) will be adopted. This indicates that people's action is social and situated within their community of practice (team). The community determined the shared systems of meaning and values, norms and rules of practice.

For Isle and Medial, the process of setting up the collaboration workspace revealed the personality and preference objectives of their members and at the same time, allowed them to discover their shared values and differences. E.g. Isle valued *"no time wasted"* and Medial valued *"team spirit"*. The process shaped the norms and rules of practice of the teams as well as their collaboration workspace.

Collaboration readiness exhibited by the two teams in this early stage set the ground for the teams to develop a "third way" (O'Hara-Deveraux and Johansen 1994) to work in this challenging environment.

4.2 The Roles of the Collaboration Technologies in a Global Team

Stage 2 and 3: From Adaptation to Idiosyncratic usage
The roles of technologies transcended from being visible "present-at-hand" to their users who were acting consciously in adopting and abandoning the tools, to becoming "ready-to-hand." For both teams, the technologies had integrated into their "world" and work practice in such a way that they turned IM or VC into their meeting room, socializing place, working area, and a "window" to "see" each other (Lave and Wenger 1986). The availability of information such as visual/audio alerts of active/inactive, online/offline, provided by IM allowed its users to track down people who were difficult to find by other means.

As **A** from Isle described the way he interacted with his teammates (via IM):

> *"Because we are often near our computer...I'm on it all the time...and usually my partners are on too...that way, we can just say "how is it going" everyday or answer specific questions...I feel like we always have a good idea about how the other is doing...[For*

*example] I was working last night and talked to [the **apprentice**] for 30 minutes. Off and on with different questions, then talked to [**E**] for 15 minutes. This morning...I mailed everybody and told them my progress.*"

IM created a virtual environment similar to a shared physical office for Isle. In this environment, members engaged in work related tasks, interspersing sporadic interchanges throughout their individual work (Nardi et al 2000).

Similarly Medial used VC creatively to respond to their needs. Most of the times, one laptop will be on iVisit™ for 3-way conference calls and the other on Netmeeting™ with application sharing. **C** summarizes how VC transcended from a "visible" to a "ready-to-hand" technology in their team:

> *"It works for us now. But for the first 3 weeks, it took us at least 30 minutes just to set up these things. To figure out what works, what doesn't, what program works and what not. But now it's fast to set-up the computers and focus on our meeting."*

The scenes in Figure 2 were captured during a VC meeting by Medial. They planned to discuss the feedback gathered from the industry mentors during the professional practice session held in Spring Quarter (Fruchter 2003). The pictures show the setup of the meeting and how **A, E** and **C** joked and discussed as if they were all present in a same "meeting room".

Location: E's dorm

Time: U.S. (PST)
       10pm;
       Germany, 7am

1. **E**'s laptop runs iVisit. **A** (on screen) from Germany saying *"Good Morning!"* and waving at his 2 partners at Stanford.

2. Both **E** and **C** smiled and said *"Good morning!"*

3. They went on to discuss the mentor's suggestion. *"ok. I'm going to draw the girder to you, it's going to be deep"* said **E**.

4. **E** drew the structure on **C**'s laptop which is running Netmeeting. (Note: the laptop affords touch screen stylus input)

5. *"Maybe we can change the roof design and ask the mentor."* **A** drew his concept on the shared whiteboard.

6. *"But this really doesn't reduce the cost much."* **C** commented. A heated discussion and exploration followed.

7. *"Yes!"* shouted both **E** and **C** when **A** proposed a great solution. They finally came to an agreement after 30 minutes of discussion.

Figure 2. Interaction Examples during a VC meeting of Medial
Location – E's dorm at Stanford, Time – 10:00PM PST USA, 7:00AM Germany

IM and VC were *appropriated* by Isle and Medial, respectively, were "invisible" to their users, and put to work within the specific emergent work processes by Isle and Medial (Dourish 2001).

Transcending from being "present-at-hand" (visible) to "readiness-to-hand" (invisible), the "appropriateness" and the "invisibility" of these tools was an important phenomenon in this learning environment.

Invisibility or "readiness-to-hand" of mediating technologies is necessary to allow the participants to focus on, and thus support (the visibility of) the learning tasks at hand, i.e. the invisibility of the technology allows the members to concentrate on their building project and coordinate their tasks with their partners. The sooner these tools become "ready-to-hand" for the learners, the sooner they are able to concentrate on their learning activities.

On the other hand, "present-at-hand" or visibility of the significance of the technology is necessary to allow the team to use the tools effectively as a medium for communication. For instance, members of Isle had to be consciously aware that going online (login to IM) and being available for their partners through IM are crucial to their team dynamic. Whereas for Medial, they needed to realize that setting up a VC meeting and ensuring that audio, video work properly during the meeting is essential for them to focus on the discussion.

The effective use of the tools is thus a matter of providing a good balance between these two interacting requirements – synergy and conflicts between invisibility and visibility (Lave and Wenger 1986), the tools fade in and out from the background to the foreground and vice versa as and when they are needed during the practice.

4.3 Emergent Work Processes:
How the technologies in practice affected the team's work patterns

As shown in Figure 3a, Medial worked as one "solid" unit. The team considered the work process and practice for them to produce the best product was to establish a good understanding and sense of belonging among its members. They made an explicit effort to set-up and prepare for their team meetings. All three members gathered, discussed and made decisions over VC. All information was sent to all three members and decisions were made by consensus. There were a couple of times when **A** failed to attend a meeting. **E** and **C** simply waited and chatting about other subjects instead of carrying out the meeting without **A**, they eventually cancelled the meeting and re-scheduled another one.

Whereas Isle was a team of networked dyads. Most of the meetings among the members were carried out in dyads (Figure 3b) engaging third or all members only on an as needed basis. Meetings were on a needs basis. Information circulated only to those who were deemed "needed".

Despite the very different work patterns exhibited by Isle and Medial, both teams excelled and produced high quality building proposals at the end of the program. Both Isle and Medial developed a "third way" (O'Hara Deveraux and Johanson 1994), which is idiosyncratic to each team, to meet the demands of work in the diverse physical, cultural, cross-disciplinary and electronic workspaces.
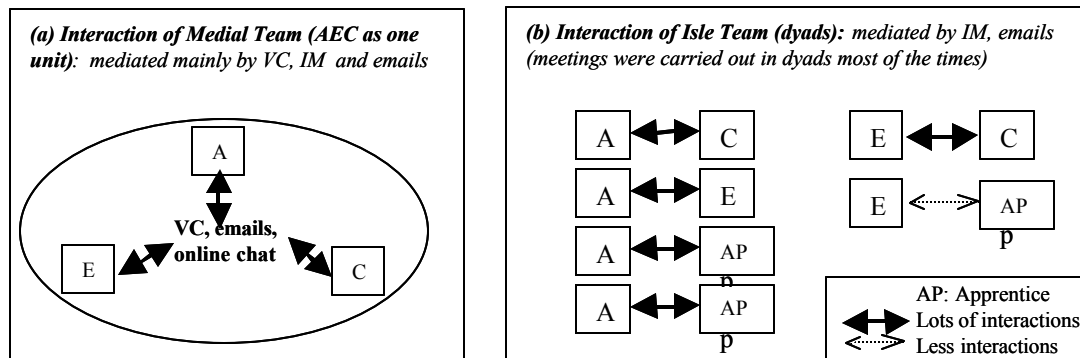
Figure 3: Patterns of interactions of Medial and Isle Teams

As O'Hara-Devereaux (O'Hara-Devereaux and Johansen 1994) states, *"there is no "best way" of team management.....If there is a best way, it is usually a new "third way" that has to be invented anew for each team."* The work processes and patterns that emerged in these two teams showed that on one hand, the practice is the process of continual response from the people as well as the tasks to the circumstances within which it was being produced. On the other hand, it was also the consequence of the technologies they adopted in their practice.

For example, Isle's style of working in dyads and constantly engaging in quick and short questions and problem solving sessions were the response *from* its members, whose top priorities were *"Efficient and no time wasted",* as well as the tasks emerging in these circumstances, i.e. the short and direct questions such as *"how long should the beam be?" "What is the cost of the materials?"* etc. Nevertheless, this work pattern was also the response to the functionality of the tool adopted by the team. A comparison shows that the work pattern of Isle arose from the affordances of IM. IM is a tool that supports dyads (Nardi et al 2000). It encourages instant and quick exchange of information. The iconic display and the alerts about the status of the user's contacts (online or offline, available or busy, etc) allowed the members to know the availability of each other and thus encourage impromptu contacts.

Consequently, team practices and work processes were directly affected by the way each team adopted the technologies. Depending on the communication technologies adopted by the team, the affordances and constraints of the tools influence and shape how the messages can be produced and received, how the members interact and negotiate meaning, and the construction of thoughts. But on the other hand, it was also the team's decision, their heritage and their pre-set goals that drove them to adopt the technologies. This observation showed the intricate and dynamic embodied relationship between the people, technologies, activities and the setting. Consequently, technology should not be treated as a given. Its affordances play a key part in affecting the work practice and process of a team.

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