Sensemaking and Design Practices in Large-scale Group-to-Group Distance Collaboration

Gloria Mark
Department of Informatics
University of California, Irvine
gmark@ics.uci.edu

Steve Abrams
Department of Informatics
University of California, Irvine
sabrams@ics.uci.edu

A new paradigm in collaborative interaction is arising. Large-scale collaborations across distance are becoming more common enabled by technological development such as the Access Grid and the need to bring together not just individuals, but entire groups of experts to solve complex problems. Despite this growing trend, this form of collaboration have not received much attention. In this paper we describe how this new kind of interaction order affects collaboration in the domain of space mission design.

Intersubjectivity, sensemaking, and group interaction

In group-to-group distance collaboration, entire groups, each working in a common space, are connected together through some combination of technologies. People are interacting in multiple social worlds simultaneously: their collocated team, and the larger, distributed team. Interaction in these different social worlds is characterized by different types of sensemaking, where people interpret cues, negotiate, apply expectations, and commit to decisions [4]. In any collaborative context, through the experience of interacting with another, and making sense of the environment, a sense of common meaning, or *intersubjectivity* is developed. Intersubjectivity refers to a state of interaction where perspectives can be mutually or reciprocally understood [3]. Especially sharing a common environment or "community of space", where people directly experience each other, creates favorable conditions where intersubjectivity can emerge. People are constantly modifying their understandings of the other, and consequently are continually constructing shared meanings. In the case of social relationships that are not face-to-face, one understands the other through an "ideal type". Schutz [3] describes that people rely on assumptions to construct a "shared interpretive scheme" (pg. 229). In distant interaction, one receives little or no feedback as to whether one's assumptions about the partner type were accurate. Compared to the full spectrum of possible experiences that can be shared in face-to-face settings, this is meager information. Without information to contradict or update it, distant partners generally continue to rely upon the ideal type.

Interaction does not always remain at the same "level" according to Wiley [5] who frames interaction from the individual to the societal and cultural level. Through interaction, individual meanings can merge into intersubjective meanings, which in turn can emerge into a *generic subjectivity*, which constitutes social structure[1]. Intersubjective interaction over time evolves into "interlocking routines and habituated action patterns" (Wiley, pg. 74) between individuals that can be taken for granted and which affords a degree of predictability to the interacting individuals.

When actors are distributed across distance with technology-mediated interaction, intersubjectivity can emerge differently than in a face-to-face environment. In a collocated setting, it is easier to understand when intersubjectivity is slipping away due to the rich availability of feedback. When generic subjectivity emerges, this is also easier to maintain in a collocated setting as the extent to which people follow (or don't follow) scripts is highly visible. In a distributed setting, with limited feedback through distinct channels (i.e. audio, video, images, text) the "ideal type" perception must be overcome for intersubjectivity to emerge. Experiencing distant behavior through limited social bandwidth makes it difficult to predict routines and patterns, which also can inhibit the development of generic subjectivity. Interaction may also vascillate between levels, e.g. between intersubjective and generic subjective states. No interaction is purely one form of (inter)subjectivity or the other.

The study setting

We performed an ethnographic investigation, guided by our research question of examining different types of sensemaking in group-to-group collaborative settings. We studied a large distributed technology organization, who

[1] Wiley describes four levels, the individual, the intersubjective, the generic subjective, and cultural, but only the middle two levels are treated here as they are relevant for the current study.

researches, designs, and develops space-based scientific technologies and missions. We observed a design team from this organization, comprised of four engineering groups (teams 1–4) distributed around the U.S. Team 1 had 24 team members at Site 1 on the west coast, team 2 had 12 members at Site 2 in the Midwest, team 3 had 9 members at Site 3 in the south, and there was a single person at Site 4 in the southwest. Most of the people on teams 1, 2, and 3 had previously worked together within their teams but had never worked with the other teams in the past. The purpose of collaborating together was to combine different specializations to work on a conceptual design for an actual space mission.

The design team relied on a number of technologies to share design data, audio, and video streams. *NetMeeting* shared applications across sites projecting document views from Microsoft *Excel* and *PowerPoint*. *ICEMaker* [2] linked workstations and shared data, thus enabling the members of the design team to publish design specifications and parameters relevant to a particular subsystem as either numeric data in the spreadsheets. A dedicated person managed the updating of spreadsheets and the projection of spreadsheets both locally and remotely. A *video-teleconferencing* (VTC) service shared the audio of all four sites, and switched the video such that it displayed the view of the recent most vocally active site to the other sites. Multiple large public displays (12 x 6 feet at Site 1 and 6 x 5 feet at Sites 2 and 3) showed the video and the shared applications. *MeetingPlace* managed distributed small group discussions, or sidebars, by sharing multiple voice streams by telephone. E-mail and fax, were also available.

The design team collaborated for a total of nine hours, spanning three days within a week. Three researchers traveled to Sites 1–3 and observed the teams' interactions for the whole duration. We videotaped the teams at Sites 1–3 and interviewed the team members at Sites 2–3. We also received individual audio recordings of each of Site 1 participants, and audio recordings of all distributed sidebars.

The task of space mission design involves constant problem-solving. The design involves choosing a number of different parameters, e.g. trip time, weight, power type, as well as graphically designing the spacecraft configuration. Parameters begin with initial estimates and are constantly refined. The work is highly interdependent, e.g. the power engineer needs information from the mission design and instruments expert before she can calculate her values. The interdependencies in the design decisions leads to the high degree of interaction to negotiate values or discuss design tradeoffs.

Different levels of sensemaking in the team process: Reciprocity of perspectives

At Site 1, for the most part, all team members were familiar with each others' identities and were aware of their areas of expertise. More commonly, collocated team members shared perspectives in the design process. They were all concerned with keeping costs down, minimizing mass in the design, and assessing "technology readiness levels" to estimate the amount of research and development needed between that design session and the commencement of mission operations. Shared perspectives emerged in individual interaction for example when team members made guesses about the meanings and implications of numeric values in a spreadsheet, which were confirmed by another member indicating a shared understanding.

An essential aspect of design is the capacity to explore various scenarios for benefits and risks. When, in the course of such exploration, a feature is identified and its implications are immediately grasped by another, it indicates a reciprocal understanding of the situation. For example, a telecommunications hardware expert expressed concern about the effects of cold temperatures found in space on an instrument to penetrate the surface of a spatial body. The Science and Instrumentation experts immediately grasped that cold-induced brittleness was a risk that had not yet been identified in this design.

Other reciprocal perspectives reflect local norms and attitudes. One engineer at Site 1 told another that he was going to "pick on him," reflecting a local norm encouraging informed peer critique. In another situation, two team members at Site 1 sought advice from a non-Team member, also at Site 1, rather than seek assistance from a team member at a remote site.

Finally, shared perspectives were reflected in the common practice of conveying design information in a "shorthand" manner by referencing similar information from prior designs. For example, when one CDS engineer referred to a data system design as "Seeker," the other CDS expert immediately understood. Similarly, a shorthand reference to the "Cassini" mission for the schedule was then used by another person.

In contrast, the full, distributed design team experienced difficulty in establishing shared perspectives for the design process. Discrepancies, in both understanding and in the actual design parameters, occurred. Design decisions made at each site were often reported on the third day, and there was insufficient time to track down subsequent design decisions that had already been made with the discrepant values.

Thus, sensemaking was conducted differently within sites compared to across sites. The collocated team members exhibited behaviors that indicated that they shared common perspectives, especially with respect to the design process. In contrast, in the entire design team, many incidents occurred that pointed to a lack of common perspectives. These differences led to three consequences for the team, discussed next.

Sidebars as scripts: the "heart" of design work

In space mission design, much of the "heart" of design work occurs in smaller groups, or sidebars, where clarifications or design tradeoffs are discussed. A characteristic of the sidebars at Site 1 was their spontaneity. At any time, from one to five sidebars usually occurred at the Site. People continually monitored the environment, listening for keywords in the surrounding discussions that had relevance for them. When such a keyword was detected, the team member would spring up from their seat and join the sidebar. Importantly, nearly all sidebars were self-organized. Thus, it was expected that the patterned interaction of sidebars was the standard type of encounter in this collocated setting. Rarely did the facilitator organize a sidebar. Sidebars could range from a simple and quick question, such as for clarification or to seek specific information ("what is the temperature of Mars?") to a lengthy and complex design tradeoff discussion, such as how to reduce weight on the spacecraft.

In contrast, sidebars did not exist as standard types of encounters for the larger distributed design team. Sidebars were always delegated by facilitators who announced publicly over the VTC who would join them. All sidebars were held via teleconferencing. It was perfectly possible for any team member to initiate a sidebar across distance by asking the coordinator for a phone line and dialing the other site. Yet of the 24 distributed sidebars that occurred, only three were self-organized. The distributed sidebar interactions generally involved complex discussions of longer duration, generally around a single topic. The distributed team never used sidebar interaction to spontaneously clarify, seek information, or challenge a design value or assumption. This would have been advantageous for the design team, e.g. if the Power engineer in Team 1 clarified a value with the Power engineer in Team 2.

Thus, a pattern of behavior never emerged where distributed team members would spontaneously contact their colleagues across distance as the need arose. The coordination overhead may have prevented people from spontaneously engaging in distributed sidebars; it took an average of three minutes, 17 seconds to set up a distributed sidebar. In fact, no other generalized forms of distributed interaction, or scripts across sites, were detected.

Discrepant methodologies and assumptions

When intersubjective meaning is achieved in a group, it follows that all group members understand terms and processes in the same way. During the design session, the different sites not only used different concepts and terms, but also unique methodologies and design processes. In three cases, the different sites used different methodologies for concepts that are standard in mission design, e.g. in computing contingent mass. They also used different terms for standard concepts, e.g. "trajectory". These cases revealed two things. First, though each site had developed a common understanding of its own terms, a lack of shared understanding existed across sites. Second, intersubjectivity depends on actors performing the work to maintain and develop shared perspectives. When attempts at establishing shared meanings were made by proposing hybrid terms, these were not adopted by the design team. The sites did not make the requisite effort to allow intersubjectivity to emerge in the entire team by committing to the decision. Though the design team was able to intellectually negotiate the common terms and methodologies, the design team did not have congruent perspectives established that would enable them to adopt the solutions.

Blind trust in technology

A third consequence that we observed is that misattributions occurred during the distributed design team interaction. Participants at the different sites developed a blind trust that the collaborative tools that they used to interact and share data across distance were "delivering" the information they intended. The actors behaved as though their distributed partners would perceive their behaviors and work practices in the same way that their local team members would.

Examples included "what I say is what you hear". There were 24 instances, spread approximately equally over Sites 1–3, where team members did not put in the requisite effort in public conversations to make themselves heard at the other sites. Team members at remote sites complained that the site who spoke recently could not be heard. The speaker either forgot to unmute the microphone, or spoke too far away from the VTC microphone to be heard remotely. Another example of blind trust is "what I see is what you see" when people at one site expected other sites to see the same displayed value on the networked spreadsheet. Still another example is falsely believing "what data I can access is what you can access" across sites. They expected that once values were entered into the spreadsheets, they were immediately propagated and accessible to the other remote sites which was not always the case.

While interaction is easy within a site, it was not clear to participants that they needed to invest extra effort to understand how the remote members' perceived their behaviors and work practices conveyed by technology. Also, for most people, they were using new and unfamiliar technologies and did not have the opportunity to develop appropriate expectations of the capabilities of the technology [1].

Discussion

In this paper we have investigated a new interaction order of large-scale group-to-group collaboration. We discovered that in the collocated sites, sensemaking tended to be mostly intersubjective, i.e. that people's perspectives were congruent and reciprocal. In the larger distributed design team, sensemaking was far less intersubjective. Sensemaking has different facets and we can interpret the differences between collocated and distributed groups by examining these facets. Table 1 shows more specifically how different components of sensemaking relate to the three consequences that we observed.

Communication breakdowns in the design team were triggers for developing intersubjectivity, i.e. for the team to move to a different level of sensemaking. An example of such a breakdown was when discrepant methodologies were discovered, as for contingent mass. The breakdown had the potential of being a catalyst for the design team to develop shared meanings. The team succeeded partially as new emergent terms did develop as a result of conversations, and were unique to the design team. Yet intersubjectivity was not actually constructed across distance, as the design team did not adopt the new terms. Each site reverted back to the use of their own terms, knowing that it was not accepted by the other sites. The compromise agreement for contingent mass that each site would apply their methodology for that part of the design they were responsible for is not a viable longterm solution. This agreement was also not adopted. Design is an iterative process and the use of discrepant methodologies may lead to incongruencies downstream in later stages of mission design. This poses a risk to the design (and mission).

Observed consequences	Components of sensemaking	Distributed design team	Collocated teams
Sidebars	Sensemaking as expected patterns of behavior	Only three self-organized sidebars; the rest are delegated and not spontaneous, but formal; coordination intensive; identities of partners not always known	Spontaneous joining of sidebars; monitoring sidebars; articulation as well as design sidebars; identities of partners mostly known
Adoption of terms	Sensemaking as commitment	Though common terms were negotiated and agreed upon, they were only temporarily used; not permanently adopted	Common language and guidelines were developed and used
Misattributions or "blind trust" in technology use	Sensemaking as expectation	Have not developed appropriate set of expected behaviors for technology use across distance; not aware when human use of technology breaks down	Breakdowns in human use of technology are usually visible

Table 1. Different components of sensemaking in the distributed design and collocated teams.

Intersubjectivity does not remain constant but vascillates between the intrasubjective and generic subjective states and must be maintained. The team process is a cycle of alignment and breakdown. Breakdowns can lead to the identification of points where common meanings can be established. When alignment occurs, intersubjectivity has the opportunity to emerge. The nonadoption of the common terms by the entire design team and misattributions were examples of how the design team transitioned away from intersubjectivity. If communication repair occurs, then it is a step towards intersubjectivity.

A major risk for large-scale scientific collaborations is when perspectives are not questioned. At local sites we observed many instances of spontaneous challenges to e.g., a design parameter or assumption. These occurred mostly in sidebar discussions, but also in large public discussions within the site. Debate and negotiation were the norm. In contrast, we rarely observed spontaneous challenges made by team members across distance. The facilitators sometimes questioned a perspective or a value, but the mission design would benefit more by having nonfacilitators, or experts in multiple specialties, introduce challenges. Distributed sidebars, where design tradeoffs were discussed, were mostly limited to formal discussions of predefined topics by team members assigned by the facilitators.

It was not our expectation that intersubjectivity or generic subjectivity would be achieved by the design team as it did not have much experience meeting together. Our goal in this paper was rather to examine the consequences of what happens when groups in large-scale collaborations experience *different levels* of intersubjectivity and practice different types of sensemaking. Such short-term interaction is not uncommon in large-scale ad-hoc collaborations such as when scientific teams discuss a problem using the Access Grid.

REFERENCES

[1] Olson, G. M. and Olson, J. S. Distance Matters, *Human-Computer Interaction*, *15,* 2/3, 2000, 139–178.

[2] Parkin, K. L., Sercel, J. C., Liu, M., and Thunnissen, D. P., ICEMakerT: An Excel-Based Environment for Collaborative Design, *IEEE Aerospace Conference,* (Big Sky, MT, March 8-15, 2003). IEEEAC Paper #1564. Updated Jan 25, 2003. http://monolith.caltech.edu/Papers/Parkin%20IEEE%20Paper%201564.pdf

[3] Schutz, A. *On Phenomenology and Social Relations: Selected Writings,* H R. Wagner (ed). University of Chicago Press, Chicago, IL, 1970.

[4] Weick, K. E. *Sensemaking in Organizations,m Sage Publications.* Thousand Oaks, CA, 1995.

[5] Wiley, N. (1988). The Micro-macro problem in social theory. *Sociological Theory*, vol. 6, 254-261.