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Boundary Negotiating Artifacts: Unbinding the Routine of Boundary Objects and Embracing Chaos in Collaborative Work

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Abstract. Empirical studies of material artifacts in practice continue to be a rich source of theoretical concepts for CSCW. This paper explores the foundational concept of boundary objects and questions the conception that all objects that move between communities of practice are boundary objects. This research presents the results of a year-long ethnographic study of collaborative work, specifically the multidisciplinary collaborative design of a museum exhibition. I suggest that artifacts can serve to *establish and destabilize* protocols themselves and that artifacts can be used to push boundaries rather than merely sailing across them. Artifacts used for collaboration do not necessarily exist within a web of standardized processes and disorderly processes should not be treated as ''special cases''.

Key words: articulation work, artifacts, artefacts, boundary negotiating artifacts, boundary objects, collaborative work, communities of practice, Computer Supported Cooperative Work, design, ethnography, museums, theory

1. Introduction

Much CSCW research has been devoted to the role of inscription and material artifacts in cooperative work. Myriad ethnographic studies have documented the importance of inscriptions and material artifacts to the creation of shared understanding (Star and Griesemer, 1989; Tang, 1989; Bucciarelli, 1994; Heath and Luff, 1996; Pycock and Bowers, 1996; Mambrey and Robinson, 1997; Harper, 1998; Perry and Sanderson, 1998; Bechky, 1999; Henderson, 1999; Hertzum, 1999; Brereton and McGarry, 2000; Eckert, 2001; Lutters and Ackerman, 2002; Schmidt and Wagner, 2002; Subrahmanian et al., 2003). In particular, the relationship of material artifacts to coordinative practices has rightfully attracted a great deal of interest.

Empirical studies of material artifacts in practice continue to be a rich source of theoretical concepts for CSCW. Concepts such as boundary objects

* An earlier draft of the work was published in the Proceedings of the 9th European Conference on Computer Supported Cooperative Work (ECSCW 2005). Several pages longer, this work adds substantial clarification of the theoretical critique and also includes photographs of actual case study artifacts.

(Star, 1987–1989; Star and Griesemer, 1989), coordination mechanisms (Schmidt and Simone, 1996), prototypes (Subrahmanian et al., 2003), ordering systems (Schmidt and Wagner, 2005), and intermediary objects (Boujut and Blanco, 2003) have been proposed as ways to theorize the role of material artifacts vis-à-vis coordinative practices, and by extension, to theorize collaborative work in general. These concepts overlap to form a patchwork quilt of frameworks that are moving us towards an increasingly sophisticated theoretical understanding of collaborative work.

The concept of boundary objects, in particular, has attracted a great deal of attention as a useful theoretical construct with which to understand the coordinative role of artifacts in practice. I will discuss how the concept of boundary objects came about and how the concept has been used as a catch-all for artifacts that fit uncomfortably within the definition. After an exploration of the foundational concept of boundary objects and presentation of the findings of a year-long ethnographic study of collaborative work, I suggest that artifacts can serve to *establish and destabilize* protocols themselves and that artifacts can be used to push boundaries rather than merely sailing across them. I also question the assumption that artifacts necessarily exist within a web of standardized processes and that disorderly processes are to be treated as "special cases".

2. Boundary objects

The concept of boundary objects is an important innovation in the study of collaboration and information practices and systems. Many have suggested that the creation of boundary objects is key for collaboration between communities of practice (Star and Griesemer, 1989; Wenger, 1998; Bowker and Star, 1999; Henderson, 1999) and I agree. However, I believe there is some danger in taking the concept as a given when theorizing collaborative work.

Since Star and Griesemer (1989) initiated the concept of *boundary objects*, it has been used in a wide variety of research areas including research on collaborative information systems, organization science, and information science (Krasner et al., 1987; Mambrey and Robinson, 1997; Albrechtsen and Jacob, 1998; Van House et al., 1998; Bechky, 1999; Henderson, 1999; Garrety and Badham, 2000; Pawlowski et al., 2000; Karsten et al., 2001; Lutters and Ackerman, 2002; Diggins and Tolmie, 2003; Larsson, 2003). Research employed the concept of boundary objects to show that a single object can be used for different purposes by different people (Larsson, 2003), to theorize information systems as boundary objects between communities of practice (Pawlowski et al., 2000), and to explore activities surrounding boundary objects within information or work flow (Mambrey and Robinson, 1997; Lutters and Ackerman, 2002).

Boundary objects are described as objects that coordinate the perspectives of various communities of practice (Wenger, 1998; Henderson, 1999). The

concept of boundary objects relies heavily on the concept of standardization and examples of boundary objects are typically things with a standardized structure such as forms, maps, and grades – or things with a naturally predetermined structure such as a bird. The question then arises as to how groups of people who lack standardized structures begin to collaborate.

When Star and Griesemer (1989) first introduced the term *boundary objects*, they introduced boundary objects as one of two major factors that contributed to the successful cooperation between biologists and amateur naturalists. The other major factor, *methods standardization* was the less glamorous and less innovative of the two concepts and the title of the article reflects the favored status of the boundary objects concept; the title refers to boundary objects but not to methods standardization. Despite this, the concept of standardization is important to the boundary objects itself. Star and Griesemer discuss Joseph Grinnell, the museum's first director, and Annie Alexander, the museum's founder and amateur naturalist:

> Grinnell and Alexander were able to mobilize a network of collectors, cooperating scientists and administrators to ensure the integrity of the information they collected for archiving and research purposes. The precise set of standardized methods for labeling and collecting played a critical part in their success. These methods were both stringent and simple—they could be learned by amateurs who might have little understanding of taxonomic, ecological or evolution theory. They thus did not require an education in professional biology to understand or to execute. At the same time, they rendered the information collected by amateurs amenable to analysis by professionals. The professional biologists convinced the amateur collectors, for the most part, to adhere to these conventions—for example, to clearly specify the habitat and time of capture of a specimen in a standard format notebook (Star and Griesemer, 1989).

The director and founder of the museum, two people in managerial positions, engineered methods standardization. While Star and Griesemer found methods standardization to be necessary, they did not find it to be sufficient for cooperation across diverse social worlds. Other means for cooperation, namely boundary objects, were found to be necessary. Boundary objects are created when groups from different worlds work together. Shared work creates objects which inhabit multiple worlds simultaneously. In *Sorting Things Out*, Bowker and Star (1999) describe the concept of boundary objects.

> Boundary objects are those objects that both inhabit several communities of practice and satisfy the informational requirements of each of them. Boundary objects are thus both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in

> common use and become strongly structured in individual-site use. These objects may be abstract or concrete. Star and Griesemer (1989) first noticed the phenomenon in studying a museum, where the specimens of dead birds had very different meaning to amateur bird watchers and professional biologists, but "the same" bird was used by each group. Such objects have different meaning in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting communities (Bowker and Star,1999).

Boundary objects arise over time from durable cooperation among communities of practice. Star lists four types of boundary objects (Star, 1987–1989; Star and Griesemer, 1989):

- *Repositories* which are piles of objects that are indexed in a standardized fashion such as a library or museum.
- *Ideal Type* which does not accurately describe the details of any one locality or thing but is abstract and vague and therefore adaptable, such as a diagram or atlas.
- *Coincident Boundaries* which are common objects which have the same boundaries but different internal contents, such as the political boundary of the state of California.
- *Standardized Forms* which are standardized indices that serve as methods of common communication, such as forms.

While Star notes that this list is by no means exhaustive, it is interesting to note that two of the four types of boundary objects listed have standardization as a key component. Repositories are indexed in a *standardized fashion* and standardized forms are *standardized indexes*. Furthermore, it could be argued that political boundaries or atlases also relay on standardized forms of both measurement and representation. This is particularly interesting given that methods control and boundary objects were said to be two different strategies for cooperation across social worlds. Standardization is integral to the definition of boundary objects.

2.1. BUILDING ON THE CONCEPT OF BOUNDARY OBJECTS

Since the introduction of boundary objects, ethnographic research has expanded on the theory. Departing from the original concept of boundary objects as satisfying informational requirements, studies have revealed the importance of providing contextual information about boundary objects in order for the objects to be useful. For example, understanding the context of a boundary object's inception, including its history and surrounding negotiations, is a necessary precursor for boundary objects to be intelligible to

those in the receiving community of practice (Mambrey and Robinson, 1997; Bechky, 1999; Henderson, 1999; Lutters and Ackerman, 2002; Diggins and Tolmie, 2003; Subrahmanian et al., 2003). Boundary objects may need to be augmented with additional contextual information in order to be effective in other words.

Research has also documented cases where so-called boundary objects failed to satisfy informational requirements for various reasons (Henderson, 1999). Bechky's (1999) ethnographic work of engineers, technicians and assemblers involved in the production of semiconductor equipment manufacturer found that boundary objects were not always enough to negotiate shared understanding:

> The occupational communities negotiated a shared understanding through the use of boundary objects, but they were not always enough. Boundary objects can fail to serve as a translation tool when they are not plastic or flexible enough to be used by all groups. Because these groups had different experiences with the objects and spoke different languages, misunderstanding resulted, particularly between engineers and assemblers. These misunderstandings were resolved through verbal translation into the language of drawings or by the offer of a tangible definition, which provided the context needed for shared understanding (Bechky, 1999).

The assemblers found the engineers' drawings to be too abstract and ambiguous. The drawings were clear to the designers who created them because they were familiar with the context in which they were created, but the assemblers needed additional context in order to understand the drawing. While Bechky does not go so far as to suggest that these drawings are not boundary objects, one may conclude that they are not. By definition boundary objects are supposed to satisfy the informational requirements of different communities of practice.

In her ethnographic work on design engineers, Henderson (Henderson, 1999) found that the boundary object concept required amendment in order to describe the way that designers actually use artifacts. Consequently, she coined the term *conscription devices* to mean a type of boundary object that enlists group participation, are receptacles of created knowledge, and that are adjusted through group interaction.

> The focus of conscription devices is the process, while the focus of boundary objects is product. During the design process conscription devices exert a powerful influence. Participants find it difficult to communicate about the design without them (2003).

Unfortunately, Henderson does not elaborate on the concept and ultimately posits conscription devices as a type of boundary object. I would argue that objects that are used and adjusted through simultaneous group interaction

are not a new type of boundary object, rather, while similar and related, they are not actually boundary objects at all.

Other work has stated more directly that the boundary object concept requires amendment (Boujut and Blanco 2003; Subrahmanian et al., 2003). Subrahmanian et al. (2003) propose the broad concept of *prototypes* based on their observations of artifacts and activities that support systematic updating of boundary objects and their observations of organizational changes that rendered boundary objects unable to support activity. Prototypes are described as verbal, gestural, and virtual representations and models, protocols, process graphs, and physical artifacts that serve as partial or complete representations of the product or process that is being produced. Prototypes are described as boundary objects but also as representations that are necessary to support the understanding of boundary objects.

The first case study found that even in a stable organizational environment, boundary objects may require a fair amount of updating in order to continue to satisfy the information needs of the collaborating parties. The second case study highlighted that boundary objects can be somewhat brittle. In the face of organizational instability, existing boundary objects failed and new prototypes and boundary objects needed to be created to support work. Subrahmanian et al. (2003) raise important points: Boundary objects may fail due to changes in the organization context or structure; There is a broad class of representations and activities that dynamically change their representational status in the achievement and breakdown of shared understanding that are not boundary objects.

Another concept that amends boundary objects is that of Intermediary Objects (Boujut and Blanco, 2003). Intermediary objects are intermediate states of a product. Intermediary objects are representations, but they are also the traces as well as the outputs of a collaborative transformational process. A sketch, for example, is a conjecture that is evaluated and confronted by collaborators who have other constraints.

> More precisely we think that co-operation can be considered as a process of ''disambiguation'' if it is properly framed. Negotiation and compromise setting are particular ways for creating specific shared knowledge. The concept of intermediary objects can provide a tool that allows the production of a conceptual frame that formalizes and represent this shared knowledge through objects and various representations (Boujut and Blanco, 2003).

While Boujut and Blanco (2003) note, in passing, that intermediary objects act as boundary objects. I suggest that they may be something other than boundary objects.

Examples of boundary objects such as birds, political borders, or repositories are described as passing from one community of practice to another

with little or no explanation. Boundary objects are supposed to ''satisfy the informational requirements of each community of practice.'' Yet some of the things we call boundary objects do not actually do so. Throughout the literature described above, the following themes recur:

(1) So-called boundary objects may require considerable additional explanation and discussion to be intelligible;
(2) Artifacts sometimes play a role in the *active negotiation* of shared understanding amongst communities of practice (and thus are can be used to enlist participation and can be adjusted through group interaction);
(3) Unstandardized artifacts that are partial, incomplete, or are intermediary representations are ubiquitous in collaborative work;
(4) So-called boundary objects can ''fail'' to satisfy the informational needs of collaborating parties (Henderson, 1999; Subrahmanian et al., 2003).

The boundary objects concept is not incorrect, rather it is incomplete. In their original work on boundary objects, Star and Griesemer (1989) introduce their work by proposing a theoretical framework, derived from Latour, Callon, and Law (Callon, 1985; Latour, 1987; Law, 1987) that presupposes divergent viewpoints and political maneuvering; This model of collaborative work is hardly reductionist. Despite this theoretical underpinning, the vagaries of research intervened: The authors had difficulty finding records of the amateurs and non-managers in the centralized repositories of the Museum. The authors themselves bemoan the managerial bias of their study. Limited by the scope of available historical records, the picture of network participants was lopsided. We can then infer that the story of the *process of participating* and the clash of divergent viewpoints was, out of necessity, given limited attention. Star and Grisemer caution readers: ''Nevertheless, it is important not to mistake the search heuristic of starting with the centralized records for a theoretical model of the structure of the network itself.'' The incomplete theoretical model that began with the necessary limitations of the search heuristic resulted in a managerial bias that may contributed to a conception of boundary objects as standardized objects that pass cleanly and unproblematically between communities of practice and satisfying the needs of all. As the theoretical model of the structure of the network of participants may have been incomplete, so may have been the articulation of boundary objects.

Despite the intention of the original authors, boundary objects are often discussed as if they exist apart from the process of methods standardization. A crack opened between methods standardization and boundary objects starting with the original work because limitations of the ''search heuristic'' disallowed an in-depth treatment of standardization as a process that is negotiated and enacted by many, but also because boundary objects received much more attention than methods standardization. As seen, by the many

examples of boundary objects that depended on established standards, while the importance of process was acknowledged, ultimately boundary objects was posited as a creature based on established standards. Over time, followers have allowed that crack to widen into a canyon with boundary objects standing uncomfortably apart from process. We are beginning to realize our mistake, hence studies showing the failure of boundary objects, although none have traced the failure back to inherent limitations in how the concept was conceived.

The most pressing problem with the concept of boundary objects, however, is not that the concept is under-specified, rather it is the manner in which the concept is taken as rote. A virtual box has been drawn around every thing that moves between communities of practice. The tendency of researchers to label every artifact that "lives" in that space a boundary object is troubling because it forces us to deny what we observe, to ignore the finer points of the boundary object definition, or to awkwardly wrap new theories around the box. It's time to stop these gymnastics. The role of material artifacts in practice is incredibly important to collaborative work and is far too complex to be defined by a single concept, however compelling. I'm not calling for throwing away the concept of boundary objects, I have found it to be useful and inspiring, rather I suggest that we begin to unpack the assumptions that lie therein.

The dependence of boundary objects on the premise of established standards is inherently problematic for theorizing incipient, non-routine, and novel collaborations. Theories are needed to explain how collaborators from different communities of practice, that lack pre-existing standards, use material artifacts to collaborate. The empirical research undertaken for this study follows a newly formed, interdisciplinary design group. Lacking standardized processes and objects for collaboration, the collaborators created what I will call *boundary negotiating artifacts*. My point is not that there is a strict dichotomy between standardized and non-standardized processes and work. Rather I am seeking to increase the profile of the role of material artifacts in the non-routine work commonly found in incipient interdisciplinary design. As I will discuss later, boundary negotiating artifacts and boundary objects are likely to be related and to vary in prevalence along a continuum from routine to non-routine work.

The concept of boundary objects retains its popularity partially because it has a powerful intuitive appeal but also because it has been a useful placeholder for explaining that artifacts "live" in the space between collaborating communities of practice. I would argue, given the points above and the case study that follows, that artifacts other than boundary objects live in that considerable space. Rather than pushing the limits of the concept of boundary objects, it would be fruitful to consider that the concept of boundary objects may not be up to the conceptual heavy lifting that many of

us have been trying to assign it. Others in CSCW have noted this before, not only critiquing boundary objects but also common information spaces, workflow systems and coordination mechanisms, as forming a picture that is ''rather patchy and incoherent'' and as collectively forming a defective foundation for CSCW (Schmidt and Wagner, 2005). While I don't presume to singlehandedly lay that foundation. I may be able to identify weaknesses in the existing foundation.

3. Case study: museum exhibition designers

This research used ethnographic methods to understand how a team of designers used physical artifacts and social practices to collaborate. I wanted to find out what communities of practice were involved, what sorts of practices they used, and how they used artifacts.

The site for the fieldwork was a project to design a traveling exhibition about wild and domestic dogs. The project was sponsored by a large natural history museum, hereafter referred to as the Natural History Museum. An interdisciplinary team of designers, most of them located on-site, was charged with the responsibility to design the exhibition.

At any given time there was a core group that worked intensively on the project and a peripheral group of participants who made occasional contributions through participation in meetings and provision of information or artifacts. The core design team was comprised of educators/writers, exhibit designers (an industrial designer and graphic artist by training), a builder, and off-site scientific advisors/curators.

I used ethnographic methods such as participant-observation and interviewing and also used documentary analysis. Data was collected at the Natural History Museum for over a year between December 2001 and March 2003. I spent well over two hundred hours in the field with members of the exhibition design team and collected over a thousand pages of field notes, documents, and photographs. I have used pseudonyms for the names of people and places to protect the privacy of individuals who have participated in this research.

3.1. COMMUNITIES OF PRACTICE IN THE DOGS GROUP

Communities of practice (Wenger, 1998) are social configurations where people engage in practices, negotiate meaning, and create their identities. A community of practice is identifiable through participation in mutual engagement. People may belong to many communities of practices. Communities of practice do not necessarily map to organizational divisions. A community of practice may not be formally identified as an organizational entity, such as a recreational club that meets during lunch hours. Yet through

mutual engagement over time, the people from these disparate departments develop shared memories and practices and over time become a community of practice.

As a precursor to exploring how the exhibition designers used artifacts to negotiate the boundaries between them, it is important to mention the communities of practice that comprise the larger landscape of the Dogs group as a whole. Designers come to design situations with pre-existing individual and group patterns of personal beliefs, social groups, and work activities. Differences between participant's unique "life-worlds" lead to misunderstandings, conflict, and uncertainty and participants appear to contest, or challenge, each other's contributions; The design process of the Dogs group could certainly be described as "contested collaboration (Sonnenwald, 1995)".

Interviews revealed that each team member had multiple self-identified affiliations to communities of practice such as departments, functional units within departments, previous occupations, education, training, other museum genres, and professional associations. These multiple, sometimes cross-cutting, communities are described in more detail in previous work (Lee, 2004). Although each member identified with a multiple communities of practice that were relevant to their work lives, communities of practiced based on functional units were by far the most salient ones for this study. Therefore when we speak of communities of practice in the discussion of empirical findings, we are referring to functional units.

The functional units to which Dogs group members belonged each comprised their own community of practice. The education department was its own community of practice. The department had its own floor that was physically separate from the rest of the museum; Members of the department frequently socialized in the common areas of the hallway and lunchroom. The department had regular meetings, and staff members with different functions became well-acquainted with each other because over time they inevitably participated in common projects. The exhibits department was an umbrella for different functional units that also mapped to communities of practice. Within the exhibits department were special exhibits, traveling exhibits, production/fabrication, and art. Only the exhibits designers from traveling and special exhibits, production/fabrication, and art actively participated in the design of the Dogs exhibition. The exhibit designers shared an office. The fabricators all had their desks in the same cavernous room – except for their manager who had his own office down the hall. The artists and graphic designers shared offices with each other whenever possible, although they were coping with offices that were scattered around the building, and contractors used whatever space was available. The managers of the art department and fabrications held weekly meetings with their respective groups for status updates and to discuss any difficulties. The manager of the

art department maintained a whiteboard in the hallway that listed each artist or graphic designer and the part(s) of each exhibition for which he or she was responsible. The coordinator of the fabricators, not the manager, maintained a calendar on a white board in the hallway listing salient dates and deadlines such as the dates for installing, opening, closing, and taking down exhibitions. Individuals from the Dogs group occasionally had lunch with those from their functional unit and, much more rarely, socialized on the weekends or after hours with those same co-workers. Functional units, more so than department, reflected the actual communities of practice at NHM. Managers played a key role in shaping practices, and the physical proximity, shared responsibilities, common professional and personal interests tended to promote participation and the creation of reifications (e.g. whiteboards, the organization of space).

The existence of different communities of practice, and the boundaries between them, are highlighted when members of the Dogs group talk about themselves and others. Boundaries between educators, designers, fabricators, and curators surfaced quickly.

> Angela (Exhibit Designer): Education writes more like curators in a deductive manner. But we've impacted how they've done it.
>
> Hannah (Educator): I mean I communicate with Martin (Exhibit Designer) too about the fact that y'know sometimes we're speaking different languages, and I don't mean to be frustrated, and we've both said these things, and we both have the best interests of the exhibit at heart. It's just learning how to interpret each other's language.
>
> Emma (Educator): She (Contractor) came in and she said—part of what she had to do what we needed her to do—was to teach the curators the realities of an exhibit as an educating tool. Visitors will spend an average of 30 seconds at a component. Visitors will spend—a good diligent visitor—will spend 20 minutes in the entire exhibit. If you divide that out among the components it comes to like a fraction of time and you can't write a tome of copy. 'Cause we had already started trying to drill them about limited label copy, limited stuff you can communicate in an exhibit. It's not a book. It's not a college course and all these types of things.
>
> Brent (Fabricator): Emma and Nikki and Hannah (Educators) all come from the point of view that they would like to intrigue kids in very much the way of a science center. And they're educators. And I respect them as educators and I know that they are trying to get a point across, but sometimes I feel like what they're trying to accomplish is quite possibly a neat little thing for the sake of a neat little thing. "Oh the kids are going to

like that'' and the point that I think then gets—misses sometimes—is what do they specifically learn from this.

Martin (Exhibit Designer): Brent (Fabricator) had an agenda and he'd come up with another design. Production would come up with a new design and they'd just do it.

Members of the functional units within the museum were acutely aware of each other as individuals but also as members of communities of practice that had their own unique practices, languages, and values. The notions of the Dogs group as an interdepartmental, inter-disciplinary group and notions of the curators as belonging to an academic community of practice were never far from the consciousness of the NHM Dogs staff (Lee, 2004). My goal is not to suggest a reductionist model of collaboration as conflict predestined by participation in one or more communities of practice. Because someone is an educator or a designer does not mean that he or she acts in exactly the same way as any other educator or designer. However, by definition, those in a community of practice share practices and reifications, and altering and combining ways of working is rarely a trivial matter. Differences between communities of practices – as reflected by functional units – represented active ''fault lines'' where disagreements and misunderstandings often occurred.

3.2. BOUNDARY NEGOTIATING ARTIFACTS

This research found designers using artifacts and surrounding practices to iteratively coordinate perspectives and to bring disparate communities of practice into alignment, often temporarily, to solve specific design problems that are part of a larger design project.

Before proceeding, it should be emphasized that because artifacts are defined by their use, the status of a given artifact can change over time (e.g. from being an inclusion artifact at one point in time to later becoming part of a structuring artifact). The fluid, changing status of boundary negotiating artifacts over time and contexts is consistent with previous studies of cooperative work that found ''chains of mediation where the same object is mediated by many artefacts and many users, where outcomes become artefacts for further mediation of the total activity, and where artefacts modify artefacts (Bertelsen and Bødker, 2002)''.

The discussion that follows will describe five types of boundary negotiating artifacts that do not fit the definition of boundary objects: (1) self-explanation, (2) inclusion, (3) compilation, (4) structuring, and (5) borrowing. Self-explanation *artifacts* were created by and for either a single individual or two to three members of the same community of practice working in tight

collaboration. Four types of artifacts were created for crossing and negotiating boundaries between communities of practice: *inclusion*, *compilation*, *structuring*, and *borrowing*. Each artifact was created for specific purposes and was used differently by members of the Dogs group.

3.2.1. *Self-explanation artifacts*

Self-explanation artifacts (e.g. notes, tables, concept sketches) were the most difficult to study as they were rarely presented directly to others and were typically created while Dogs group members worked in the privacy of their offices. The designers used self-explanation artifacts for learning, recording, organizing, remembering, and reflecting. While created and used privately, self-explanation artifacts were sometimes indirectly presented to others through the creation of inclusion artifacts or compilation artifacts.

Self-explanation artifact example 1: Hannah's table for section 4. Hannah, an educator, was responsible for generating the label copy for a section of the exhibition about what people do to help dogs, Section 4. While working on her own, Hannah created a table (Figure 1) to organize elements of Section 4.

Hannah's table was an innovation because up to that point she, and also Emma, had relied primarily on the narratives, which were essentially scripts for the exhibition, and her meeting notes.

Hannah used her table to organize the information that she was getting from various sources, to remind herself of the artifacts associated with each exhibit and the personal stories and a scientific issues to cover in the label copy. Eventually, Hannah used her self-explanation artifact to develop and refine her label copy, a structuring artifact. Self-explanation artifacts are surrounded by a web of practices such as recording, remembering, collecting, and organizing.

Self-explanation artifact example 2: Martin's journals. For over twenty years Martin has been keeping journals relating to his work as an exhibit designer. His journals included illustrated notes on science and technology topics and sketches of ideas for interactive electrical-mechanical museum exhibits. Martin also used his journal as a place to collect ideas and images (Figure 2). Sometimes he would visit a museum and would see a quote that he particularly liked and record it in his journal. When his work took him to foreign countries he made rough sketches of things he had seen and he pasted local postage stamps in his journal. When I asked him about the quotes and postage stamps, he said that they were things that he liked that were potential material for future exhibitions.

In his role as a designer at NHM many of Martin's exhibit concepts were brand new, but his ideas were also very much influenced by what he had seen and created in the past and had recorded in his journal. On one occasion,

Exhibit Draft
Section IV

Component #	Personal Story	Scientific Issue	Rank
4.0 Introduction	Many people are working to help canines, wild and domestic.	Science is used to help canines, wild and domestic.	
4.1 Urban Coyote	Hilltop resident who has learned to coexist by covering garbage cans, keeping cats in, etc.	Coyotes are highly successful at adapting to various living conditions. This has led to their presence in urban environments. This presence sometimes results in difficulties both for humans and coyotes.	
4.2 Yellowstone Wolves	[redacted] formerly of the [redacted] was instrumental in the reintroduction at Yellowstone. He tells us some important things for humans to consider in order to make reintroduction successful.	Predators are important to a healthy ecosystem. When the wolves were removed from Yellowstone their were ecological problems. In order to restore this balance, wolves are being reintroduced to the area. There are challenges associated with this.	
4.3 **African Wild Dogs and Disease**	[redacted] is a biologist who is working to control disease in the domestic dog populations as well as spay/neuter to decrease their numbers. She hopes this will result in less transmission of disease to the African Wild Dog.	One reason the African Wild Dogs are endangered is because they are catching diseases such as distemper and rabies from uncared for domestic dogs that are causing their populations to decline rapidly. Biologists are trying to find ways to stop this and save their populations.	
4.4 Rabies and Foxes	[redacted] is a biologist who has learned some successful techniques for vaccinated wild red foxes for rabies without having to handle them all. He uses a food bait laced with the vaccine- the foxes don't even know they've been vaccinated.	Rabies has always been a problem with wild canines. As human populations have come closer to red fox populations in Europe, rabies came closer to. This created fear that led to people killing large numbers of red foxes. To keep numbers of foxes steady but still protect humans from the threat of rabies, vaccination programs were started. Now, rabies has been eradicated from Europe.	

Figure 1. Subsection of Hannah's Table for Section 4

Martin used a concept from an old journal for a new exhibit idea. He then created a new sketch that was used as an inclusion artifact (discussed below). Martin used his journals to record pleasing, useful, and potentially useful information and images, to remind himself of personal stories and feelings,

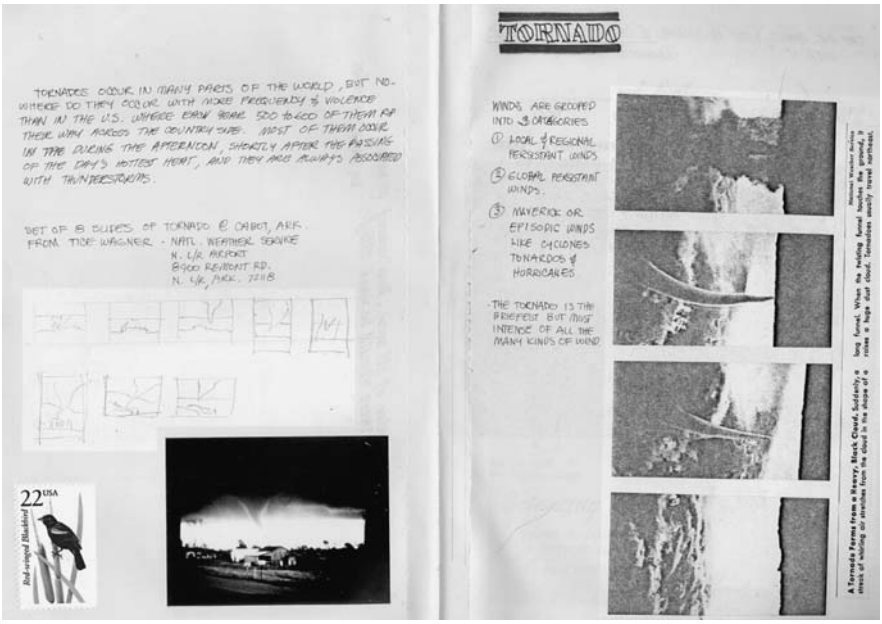


Figure 2. Sample from Martin's Journals—1977

and to explore scientific issues and exhibit ideas. His journals were a tool for learning, remembering, and reflecting.

3.2.2. *Inclusion artifacts*
These were used to propose new concepts and forms. These artifacts were created from self-explanation artifacts and went through an informal screening process of group discussion whereby an idea embodying different concepts and forms (e.g. sketches or text) originating from one community of practice would be proposed to others. This screening process entailed communal gatekeeping whereby the group would use the inclusion artifact as a reference or symbol for the new idea.

Inclusion artifact example: object theater. Inclusion artifacts can be used to create alliances with sympathetic communities of practice to exert pressure on still other communities of practice. Martin tried to include an inclusion artifact on his own behalf, but also on behalf of the curators, when he designed an exhibit he called object theater (Figure 3). Object theater was a theater that displayed artifacts depicting dogs from different cultures and eras and related those artifacts to dog myths and legends using audio or video recordings. The theater was important to Martin because he wished to emphasize that dogs are part of human culture – a theme that had been

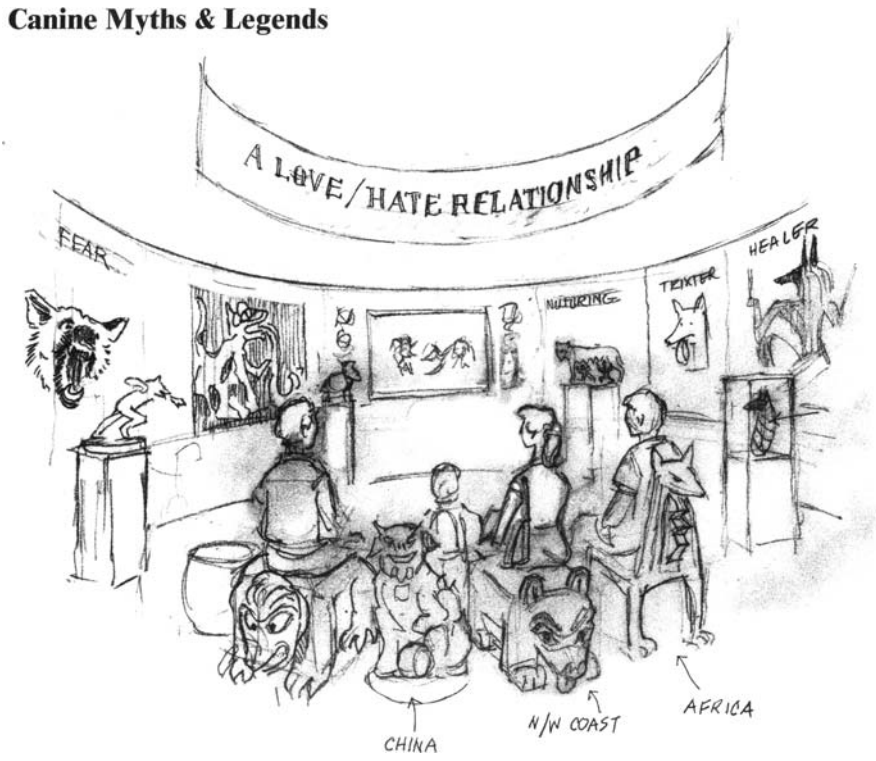


Figure 3. Sketch of Object Theater

strongly encouraged by the curators. In fact, the curators had expressed disappointment that the exhibition did not have more content about dogs and culture.

The educators were initially very reluctant to include the theater for practical reasons – the exhibition was already well behind schedule and the object theater required a large amount of additional work including researching and choosing specific myths and legends, identifying, locating, and borrowing appropriate artifacts, writing and recording a script, or filming a storyteller, and editing the audio or video. Many of these tasks would need to be undertaken by the already over-burdened educators themselves. While the educators liked the concept and visual impact of the theater, they were wary of the amount of work it would entail. The educators actually discouraged Martin from presenting his drawing of the object theater, an inclusion artifact, to the curators because they feared that the curators would then insist upon its inclusion. Eventually, this is exactly what happened. During the next meeting the curators again complained about the lack of culture in the exhibition and Martin took advantage of the

opportunity to engage in including practices, specifically presenting a sketch of the object theater.

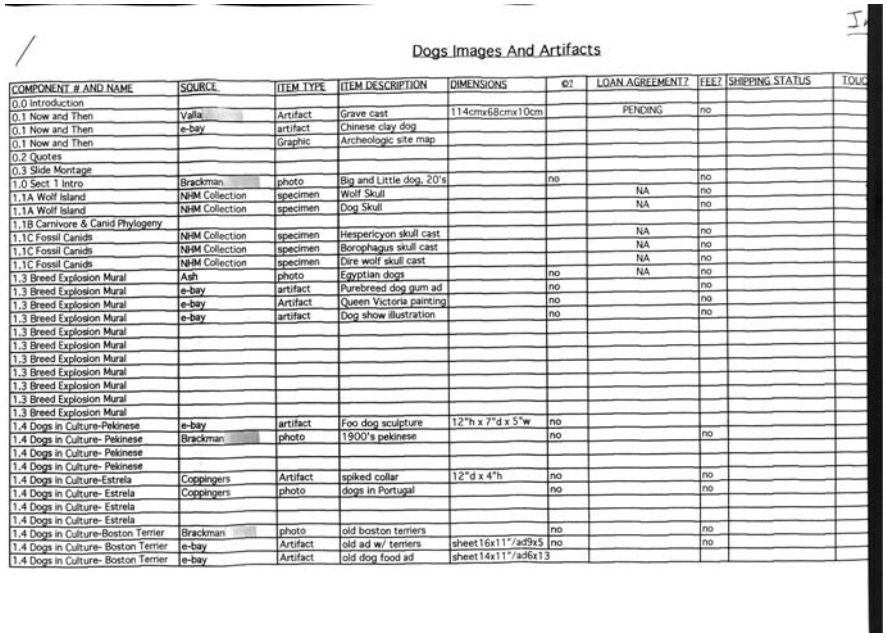
When the curators saw Martin's drawing they recognized a chance to include more culture in the exhibition and they then persuaded the rest of the group to accept the theater as part of the exhibition. Martin belonged to a community of practice of traditional exhibition design whereby exhibit designers would translate curator's ideas into exhibits and Martin used the object theater to create an alliance with the curators who held views similar to his own.

Martin successfully used including practices to have his including artifact incorporated into the exhibition, but it is important to note that engaging in including practices does not necessarily entail the successful acceptance of an inclusion artifact. One can engage in including, yet fail to gain acceptance of one's inclusion artifact. Inclusion artifacts are embedded in a web of practices that can be considered including practices – presenting, accepting, rejecting, and reserving judgment.

3.2.3. *Compilation artifacts*

Compilation artifacts (e.g. tables, technical sketches) were used to coordinate both media and the designers themselves. The designers used compilation artifacts to bring two or more communities of practice into alignment just long enough to develop a shared and mutually agreeable understanding of a problem and to pass crucial information from one community of practice to another. This process of alignment and sharing of information facilitated the creation of shared understanding about each exhibit and the exhibition as a whole. This process of alignment was continually necessary as knowledge was distributed across functional specialties (e.g. sculpture, taxidermy, education, etc.) and elements of each exhibit were constantly evolving. While inclusion and compilation artifacts often fully or partially incorporated self-explanation artifacts, structuring artifacts often fully or partially incorporated inclusion and compilation artifacts.

Compilation artifact example: Angela's table for the graphic designers. One day I observed Angela (Exhibit Designer) and Emma (Educator) cooperating to turn Emma's images and artifacts table (a self-explanation artifact) into a compilation artifact that was to be given to the graphic designers. Angela explained to me that she was trying to help the graphic artists by putting together a new table. Emma's document, Dogs Images and Artifacts (Figure 4), listed the images and artifacts for each exhibit, but within each exhibit were several discrete labels. Emma's document did not relate each image and artifact to its corresponding label. The graphic artists didn't know which images went with which labels.



Dogs Images And Artifacts

COMPONENT # AND NAME	SOURCE	ITEM TYPE	ITEM DESCRIPTION	DIMENSIONS	©?	LOAN AGREEMENT?	FEE?	SHIPPING STATUS	TOUC
0.0 Introduction									
0.1 Now and Then	Valla	Artifact	Grave cast	114cmx68cmx10cm		PENDING	no		
0.1 Now and Then	e-bay	artifact	Chinese clay dog						
0.1 Now and Then		Graphic	Archeologic site map						
0.2 Quotes									
0.3 Slide Montage									
1.0 Sect 1 Intro	Brackman	photo	Big and Little dog, 20's		no		no		
1.1A Wolf Island	NHM Collection	specimen	Wolf Skull			NA	no		
1.1A Wolf Island	NHM Collection	specimen	Dog Skull			NA	no		
1.1B Carnivore & Canid Phylogeny									
1.1C Fossil Canids	NHM Collection	specimen	Hespericyon skull cast			NA	no		
1.1C Fossil Canids	NHM Collection	specimen	Borophagus skull cast			NA	no		
1.1C Fossil Canids	NHM Collection	specimen	Dire wolf skull cast			NA	no		
1.3 Breed Explosion Mural	Ash	photo	Egyptian dogs		no	NA	no		
1.3 Breed Explosion Mural	e-bay	artifact	Purebreed dog gum ad		no		no		
1.3 Breed Explosion Mural	e-bay	Artifact	Queen Victoria painting		no		no		
1.3 Breed Explosion Mural	e-bay	artifact	Dog show illustration		no		no		
1.3 Breed Explosion Mural									
1.3 Breed Explosion Mural									
1.3 Breed Explosion Mural									
1.3 Breed Explosion Mural									
1.3 Breed Explosion Mural									
1.3 Breed Explosion Mural									
1.4 Dogs in Culture- Pekinese	e-bay	artifact	Foo dog sculpture	12"h x 7"d x 5"w	no				
1.4 Dogs in Culture- Pekinese	Brackman	photo	1900's pekinese		no		no		
1.4 Dogs in Culture- Pekinese									
1.4 Dogs in Culture- Pekinese									
1.4 Dogs in Culture- Estrela	Coppingers	Artifact	spiked collar	12"d x 4"h	no		no		
1.4 Dogs in Culture- Estrela	Coppingers	photo	dogs in Portugal		no		no		
1.4 Dogs in Culture- Estrela									
1.4 Dogs in Culture- Estrela									
1.4 Dogs in Culture-Boston Terrier	Brackman	photo	old boston terriers		no		no		
1.4 Dogs in Culture- Boston Terrier	e-bay	Artifact	old ad w/ terriers	sheet16x11"/ad9x5	no		no		
1.4 Dogs in Culture- Boston Terrier	e-bay	Artifact	old dog food ad	sheet14x11"/ad6x13					

Figure 4. Sample from Dogs Images and Artifacts Table—Early Version

Angela, with help from Emma, created a compilation artifact by collecting information from various sources. The information necessary to create Angela's table came from Emma's table, label copy, folders, and from Emma herself. By going through the act of compiling, all this information was funneled into one table that was formatted specifically for the graphic designers; Angela created a bridge between Emma and the graphic designers. As they filled in the table, they innovated with terminology and with the information structure of the table. For example, they had to figure out how to represent single labels that contained multiple images, they also had to figure out how to indicate that the graphic designers may choose amongst several images, or if they had to include all the images listed. Additionally, they created shorthand for: the state of an image, how to code the component type, and how to indicate repeating items. While Angela's table came very close to being a boundary object, it was not a boundary object because Angela developed names for the fields on the fly and needed to decide how to communicate instructions to the graphic designers as she went along. Additionally, when it came time to give the tables to the graphic designers, Angela found it necessary to explain how to read the tables.

While Emma's and Angela's respective tables look fairly similar, it is only in the context of their use that the difference between the documents becomes clear. While this work is structured around the description of artifacts

themselves, it cannot be emphasize strongly enough that it is the context of artifacts-in-use, the practices which the artifacts support, that give the artifacts meaning.

Compilation artifacts are involved in a web of compiling practices: remembering, gathering, organizing, discussing, anticipating needs, presenting, and explaining. Angela and Emma used the table to coordinate both media and themselves. The table provided a focus for finding and organizing media. Lacking a boundary object, Angela was able to use her tacit knowledge of graphic design to create a compilation artifact that augmented her brokering role. Ultimately Angela used her table to bring two communities of practice into alignment just long enough for the communities to pass crucial information from one to another.

3.2.4. *Structuring artifacts*

Structuring artifacts (e.g. exhibition narrative, exhibition concept map) were plentiful throughout the design of the Dogs exhibition. The structuring artifacts created by different members of the Dogs team often competed with each other for primacy. The curators, the educators, and one of the exhibit designers each had a vision for the exhibition and their vision was made manifest in their structuring documents and their expectations for how their structuring documents would be used. Like compilation artifacts, structuring artifacts are used to coordinate media and understanding but, unlike compilation artifacts, structuring artifacts are also used to establish ordering principles, establish tenor in narrative forms, and to direct and coordinate the activity of others.

Structuring artifacts were often at the center of heated struggles between communities of practices and were sometimes used to push and negotiate boundaries themselves – quite different from boundary objects which move across boundaries from one community of practice to another with relative ease.

Structuring artifact example 1: the curator's narrative. The curators, Brad and Elaine, wrote a large text that I'll call the *curator's narrative* (Figure 5 shows a sample page). The curator's narrative contained chapters for each of the topic sections that the NHM Dogs staff had agreed upon. Within each chapter, the curators had isolated sub-topics and written one to four paragraphs about each.

Additionally, the curators included detailed suggestions for illustrations or photos, indicated what should be wall panels or kiosks, and suggested what exhibits might look like. The curators believed that their narrative provided the framework for which topics and sub-topics would be included in the exhibition and how they would be organized. One of the curators was

SECTION 1
Q: WHAT IS IT ABOUT DOGS?
A: THEY COME IN SO MANY SHAPES AND SIZES

1. INTRODUCTORY PANEL: They come in so many shapes and sizes
Variety is the spice of life, and dogs and their wild cousins provide this in abundance. Domestic dogs are wildly diverse, ranging in size from a one pound Chihuahua to a 200-lb giant mastiff. Nowhere else in the animal kingdom does so much diversity exist within a single species. The causes of this diversity have to do with 1) the nature of natural selection in human environments 2) deliberate artificial selection for work and whimsy by humans and 3) biological (developmental) features unique to the domestic dog. In this section we explore these three issues in an attempt to explain the spectacular diversity of dogs and to educate the public about basic concepts of evolution. We also contrast the diversity in domestic dogs to that among wild canines, because, in many ways, domestic dogs' evolution parallels trends of canid evolution established over millions of years. However, in wild canids, diversity reflects differences among species in the natural environments in which they live and contrasts with the range of artificial selection practiced on dogs by humans. These similarities and differences also will be a focus of the first section.

2. BREED EXPLOSION MURAL : Divide this into three phases of domestic breed development – early, middle, late. Add text at bottom of each phase that briefly describes in very general terms what the dogs were being selected for (function, sport, fashion), and perhaps add some images (dog paintings, photos of hunter-gatherers with dogs, shepherds). The narrative below provides some background for what is to be conveyed.

> **The first Domesticated dogs.** As dogs were incorporated into human society, their roles and the selective pressures on them became more diversified. These first dogs likely were used in defense, warning, herding, transport, on the hunt, as food, and for warmth and companionship. As such, specific traits were selected by human handlers that would enhance the function of dogs in specific roles, and thusthe diversification of breeds in form and function began. Indirect selection, by the human environment, changed as well with the continuing diversification of civilization.
>
> Illustrations demonstrating a more mutualistic and closer association between dog and human, an association in which both species benefit. This illustration could be of hunter-gathers with early dogs such as exemplified by Papua New Guinea,

Figure 5. Sample from Curator's Exhibition Narrative

stunned to discover that the museum staff seemed to be removing and changing whole concepts.

In fact, the educators *were* using the curator's narrative, but they were using it as a source of material, rather than as a plan, for the whole exhi-

bition. Because of their affiliation with the visitor studies community, Emma and a few other members of the staff believed that it was their professional responsibility to remove, shorten, and simplify the text of the exhibition. The educators did not accept the curator's narrative as the primary structuring artifact for the exhibition – a fact that the curators fought throughout the duration of the project.

The curator's narrative was a structuring artifact. Like all structuring artifacts, the curator's narrative showed the structure of the final design product. As a structuring artifact, it was concerned mostly with the organization of concepts, however it also dealt with how those concepts would be expressed in text, graphics, and physical forms. The curators had introduced one structuring artifact, but Dogs group members introduced structuring artifacts of their own. Sometimes structuring artifacts were compatible and sometimes they competed.

Structuring artifact example 2: educator's narratives and label copy. The curators produced a narrative, a structuring artifact, but the educators Hannah and Emma, created their own narrative, which was later renamed ''narrative summary'', for the exhibition which quickly supplanted the curator's narrative as the structuring artifact for the exhibition. The educator's narrative (Figure 6) was derived from the curator's narrative and was intended to facilitate the organization of the exhibition as a whole. The educator's narrative, like the curator's, was divided into agreed-upon sections and corresponding topics. From there the educators began to impose their own structure on the narrative. Topics were moved, combined, and finally given exhibit titles and component and label numbers. The resulting educator's narrative also provided a concise summary of topics and any preliminary ideas for the physical design of exhibits. Early narratives dating from late 2001 covered the first three sections of the exhibition and were quite similar in structure to the curators' narrative. Changes from that point on were incremental with some topics being rethought, added, or eliminated based on discussions amongst the NHM Dogs staff and, to a lesser extent, also the curators. The narrative was redistributed every few months to keep people apprised of changes in the order of exhibits, additions of sub-topics, or the assignation of different numbers for existing exhibits. The narrative became the dominant structuring artifact.

From December of 2001 through early February 2002 Emma and Hannah gradually began to spend less time deciding and elaborating on what should be listed in the narrative and more time conveying and explaining listed items to Martin, Angela, Evan, and Brent. Hannah and Emma began to spend more time on several other exhibition-related activities. One of these activities was writing the label copy for the exhibition. The educator's narrative had distilled the curator's narrative to its simplest form, essentially an outline

Dogs Exhibit Narrative

Introduction

This section of the exhibit prepares visitors for what they will see and introduces key concepts.

0.0 Introduction
Visitors will be introduced to the exhibit and its main theme(s) using photographs, illustrations, and text. Advance organizer for exhibit.

0.1 Now and Then: Dogs and People
12,000 year old burial of woman w/ puppy; linked to imagery of current human-dog relationships. Map showing archaeological sites worldwide w/ dog remains

Section I: Dogs Come in so Many Shapes and Sizes

This section explores the sheer diversity of canines, wild and domestic, in particular the physical structure of dogs and how they have changed naturally and with human intervention.

1.0 Domestication Subsection Intro
How and when did wolves become domesticated?

1.1.a Wolves and the Origin of Dogs
Taxidermied wolf mounts and accompanying copy and artifacts will illustrate that all domestic breeds have descended from the wolf. Compare skulls of wolf and dog

1.1.b Carnivore and Canid Phylogenies
Canid and carnivore phylogenies will be displayed and explained simply and concretely.

1.1.c Fossil Canids
Information panels exploring early canid relatives, potentially with a touchable cast of the dire wolf or a fully articulated skeleton, and some fossil hesperocyon bones.

1.2 Introduction- Shapes and Sizes
Visitors will be introduced to the theme of Dogs coming in many shapes and sizes using photographs, illustrations, and text. This panel will serve as an advanced organizer for the section.

1.3 Breed Explosion Mural
This painted mural will portray many different breeds of domestic dogs and will illustrate the recent breed explosion, when the number of breeds increased dramatically and in short time. It will begin with the wolf, move to a smaller group of early breeds, and then lead to the explosive growth.

1.4 ~~Breed World Map~~ Dogs In Culture (touch screen)
This map will highlight 8-10 breeds that have been developed in various locations around the globe. Focus will be on the cultural stories behind the breeds' development and will show historic images, and images in art. Artifacts for each breed will be presented. This display will allow for interactivity.

1.5 Domestic Dog Models

Draft 12/12/01

Figure 6. Sample from Educator's Exhibition Narrative

form that could be easily scanned and reorganized. The label copy then took the educator's narrative and constructed new text based on a combination of the curator's narrative, conversations with the curators and other dog experts, the educators own investigations, and encounters with artifacts created by other members of the Dogs group such as Evan's Dog Component List

and Martin's concept maps. Gradually the label copy supplanted the educator's narrative as the dominant structuring artifact – the master artifact.

The educator's narrative, and later the label copy, was used to coordinate the activity of the entire Dogs group. Like compilation artifacts, structuring artifacts are used to coordinate media and understanding, but unlike compilation artifacts, structuring artifacts are also used to establish ordering principles and tenor of narratives.

Structuring artifact example 3: concept maps and the notion of hierarchy. Martin's concept maps were bubble diagrams that showed the structure of sections of the exhibition. Early drafts of the concept maps were hand drawn and were created by Martin, Elaine, and Brad and were comprised of a large bubble with the main idea for the section and smaller bubbles containing sub-topics that were linked to the main idea with simple lines. Each sub-topic could be linked to a set of lesser sub-topics that were in bubbles that were smaller yet. Later versions of the concept maps were drafted by Martin on his computer and printed out for meetings (Figure 7). The maps also included section numbers from the educator's narrative and replaced the singular bubble shape with three or four different shapes to indicate hierarchic level.

Martin intended for the concept maps to fulfill two functions: re-organize sub-topics into related clusters within the exhibition sections, and establish a hierarchy of ideas so that more important topics could be visually emphasized in the exhibition. While Elaine, a curator, was familiar with the purpose

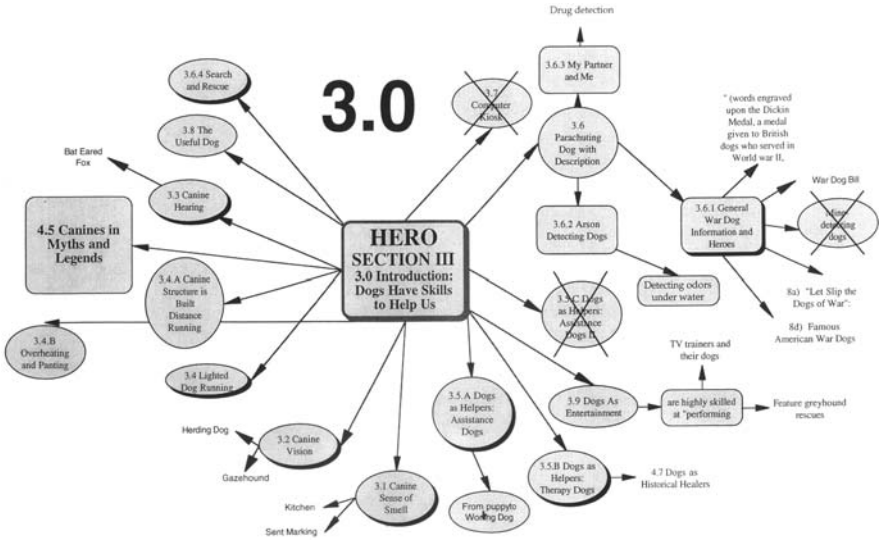


Figure 7. Concept Map—Intermediate Version

of concept reorganization, unlike the educators, she was unaware of the role of the concept map as a tool for establishing a visual hierarchy. In contrast the educators, Hannah and Emma, believed that the concept map was purely for helping the exhibit designers with the three and two-dimensional design of the exhibition. It was no wonder then, that they expressed some frustration when Martin presented later versions of the concept map to the Dogs group and Brad and Elaine began to rearrange concept bubbles. With their understanding of the role of the concept map, Emma and Hannah saw Brad and Elaine's second round revisions of the concept maps as an unfortunate side effect: changes on the concept map generated a lot of additional work. The act of the curators rearranging the concept map meant that the educator's narrative would also have to be rearranged and the label copy that had already been written would have to be revised.

Martin believed that his role as a designer went beyond the design of the two and three dimensional elements of the exhibition. He believed that his role should include designing the structure of the concepts within the exhibition. He also thought that the concept map was a way that he could directly engage the curators in the conceptual design of the exhibition. Martin's structuring artifact was produced partially to help his own community of practice, but he also used it indirectly to help that of the curators because he believed that the message of an exhibition should come from the curators.

Hannah and Emma sat patiently through a couple iterations of Martin's concept maps with the understanding that they were helping Martin to put concepts in a hierarchy of importance for the purpose of emphasizing concepts visually. But ultimately, the concept map was hardly used for that purpose. Most of the exhibition was comprised of kiosks and the size and shape of the kiosks were limited to two basic styles. The decision to use only two basic styles was a business decision to make fabrication easier and faster. The exhibit designers had control over placement of kiosks, wall panels, and islands within the space of each section; However, these decisions were largely determined by practical (e.g. safety and flow) and aesthetic concerns (e.g. making the view of the next section attractive from the point of view of the section in which one is standing). Ultimately the exhibit designers themselves actually had fairly little to work with in order to visually emphasize concepts deemed particularly important. Furthermore, the graphic designers never saw the concept map. Despite Martin's intentions, the concept map was hardly used to influence the visual prominence of the various exhibits. However, it was very much used to promote an alternative to the structuring artifact of the educator's narrative.

The concept map structuring artifact was also used to direct the activity of others and, less successfully, to create shared understanding. Structuring artifacts are used to coordinate media and understanding but, unlike compilation artifacts, structuring artifacts are also used to establish ordering

principles, establish tenor of narratives, and to direct the activity of others. Structuring artifacts can be used to promote alternative ordering principles and alternative protocols that shake the status quo.

3.2.5. *Borrowed artifacts*
Borrowed artifacts artifacts that are taken from its creator in one community of practice and used in unanticipated ways by those in another community of practice. Designers use borrowed artifacts to augment their understanding of design problems. The practice of borrowing occurs when communities of practice are in close proximity.

Borrowed artifact example: Brent's physical design collages. In January of 2002, the fabrications coordinator, Brent, spoke to the NHM Dogs staff to ask for more specifics about the exhibits that were to comprise the final exhibition. He was concerned that he did not have enough information to allocate human resources in the upcoming months. Brent needed to know what sorts of exhibits were going to be built and how many of each type. He was not getting the type of information he needed in order to begin building the exhibition. The rest of the Dogs groups replied to his request with pleas for patience – they would get to it soon.

Consequently, Brent decided to create a series of self-explanation artifacts from several artifacts: two versions of the educator's narrative, the exhibition floor plan, and the concept sketches. He incorporated these three different types of documents into a self-explanation artifact without the knowledge of the producers. Using scissors and glue, he cut pieces from the documents he had gathered and pasted them to blank sheets of paper. Each fully assembled sheet represented one exhibit (Figure 8).

Brent created a self-explanation artifact in much the same way that Emma created her Images and Artifacts table. However, in this case we have a borrower from one community of practice borrowing artifacts from two other communities of practice: exhibit design and education. The concept of borrowed artifacts is focused on the procurement of an artifact and not its creation. Therefore borrowed artifacts are can be used as another type of boundary negotiating artifact, sometimes being physically transformed in the process. In our example, Brent takes objects that he finds useful and adopts them for his own purposes: creating a self-explanation artifact.

The importance of borrowed artifacts is that they imply a special kind of relationship between communities of practice. The communities of practice must be in close enough proximity that they are aware of the artifacts created by other communities of practice, and while not having dual membership, is in a trusted position whereby he or she has access to those artifacts and can appropriate them for his or her own community of practice to further the goals of the project. Furthermore the community of practice that produces

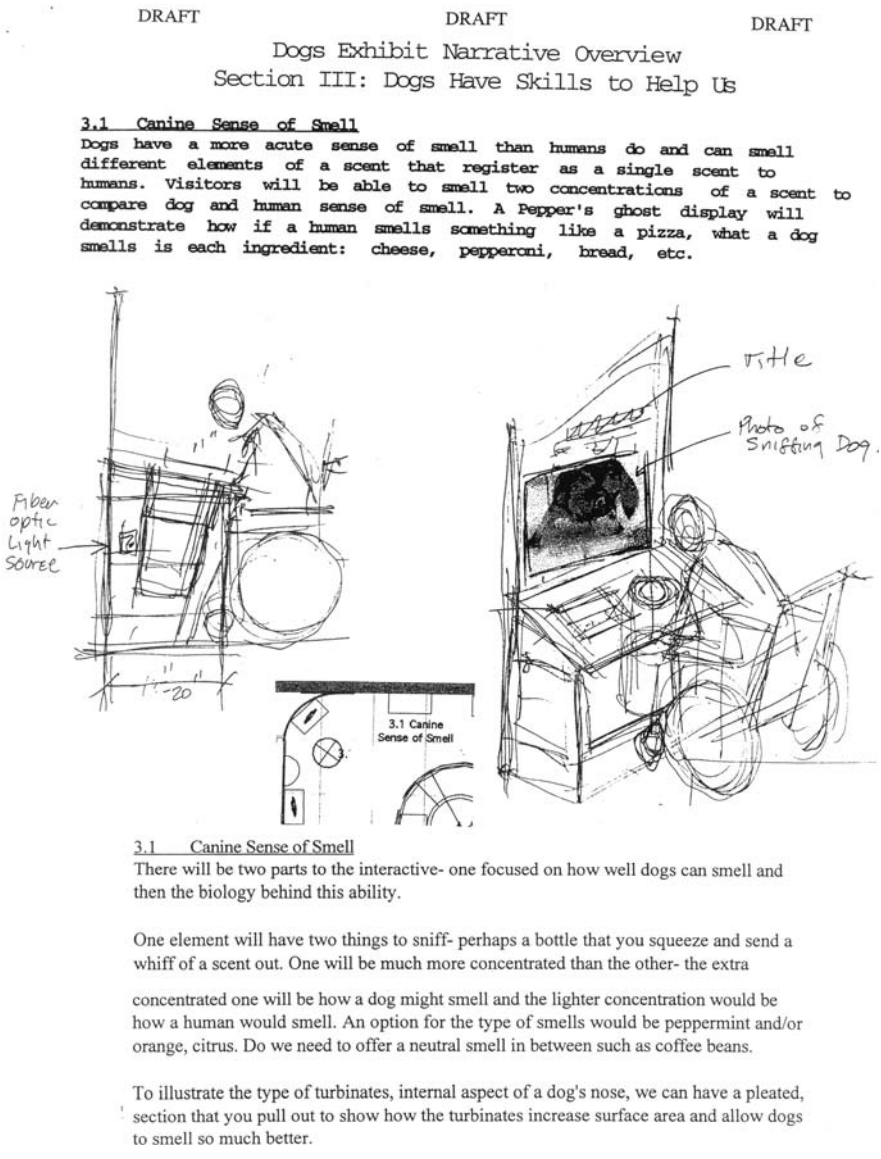


Figure 8. Self-Explanation Artifact Created from Clippings from Borrowed Artifacts

the artifact bears no burden for making their product intelligible or useable for the borrower's community.

3.3. DISCUSSION OF BOUNDARY NEGOTIATING ARTIFACTS

Each type of artifact is entangled in a mesh of practices. The Dogs group was relatively unaccustomed to working together and was also unaccustomed to

working on a project of this size and complexity so some practices were more evolved than others.

The practices surrounding self-explanation were fairly evolved because each team member had years of specialized experience with artifacts in their own field. Each team member had years of specialized training and experience that helped them create self-explanation artifacts for recording and analyzing ideas in ways that were understandable and helpful to themselves and to those from similar backgrounds.

The practices surrounding inclusion artifacts were fairly simple: involving creating and proposing on the part of the artifact's creator; and accepting, rejecting, or reserving judgment on the part of the receivers (the other communities of practice). Including, and the related practices of accepting and rejecting, took up a great deal of time during the meetings of the Dogs group. These practices were stable and occasionally including practices would take place without the actual creation of an inclusion artifact.

Unlike with self-explanation and inclusion artifacts, the practices surrounding compilation artifacts and structuring artifacts were not well-developed and required the development of new practices. This resulted in confusion and conflict. The curators, educators, and the exhibit designer each produced their own structuring artifacts and they each had their own expectations for how their own artifacts and those of others would be used.

Boundary negotiating artifacts are used to: record, organize, explore and share ideas; introduce concepts and techniques; create alliances; create a venue for the exchange of information; augment brokering activities; and create shared understanding about specific design problems. Boundary negotiating artifacts may be considered to be an extension of previous work on coordinative artifacts such as ordering systems, intermediary objects, and prototypes. The concepts of structuring and compilation artifacts resonate with the concepts of ordering systems (Schmidt and Wagner, 2005) and intermediary objects (Boujut and Blanco, 2003) – and to a lesser extent to the concept of prototypes (Subrahmanian et al., 2003). Simultaneously, the notion of boundary negotiating artifacts and its sub-concepts provides a lens through which we can view how artifacts are used in the space that exists between communities of practice, artifact uses that are frequently inconsistent with the concept of boundary objects.

In summary, boundary negotiating artifacts:

- Are surrounded by sets of practices that may or may not be agreed upon by participants;
- Facilitate the crossing of boundaries (transmitting information);
- Facilitate the pushing and establishing of boundaries (dividing labor);
- May seem "effortful" in use as opposed to effortless;
- Are fluid: (1) a boundary negotiating artifact can change from one type to another when the context of use changes; and (2) a boundary

negotiating artifact can sometimes also simultaneously be physically incorporated or transformed into another artifact;
- Can be largely sufficient for collaboration;
- Are possible predecessors of boundary objects.

The implications of boundary negotiating artifacts for CSCW extend beyond a simple critique of boundary objects, or how the term is used, to a more generalized critique about how we conceptualize collaborative work itself.

4. Implications for CSCW

4.1. POTENTIAL FOR ARTIFACT CONSTELLATIONS

Strauss (1988) noted that projects could be mapped according to two axes: from routine to non-routine and from simple to complex. On these axes projects fall along a continuum. Routine projects have project paths that have been traversed frequently, with clear and anticipatable steps, experienced workers, an established division of labor, stable resources, and strategies for managing expected contingencies. Non-routine projects would have projects paths that have been traversed infrequently, with unclear steps, inexperienced workers, an unclear division of labor, etc. Complex work includes that which has many workers and many types of and levels of workers, a complicated division of labor, variable worker's commitments, possibly more than one explicit project goal, and a complex organization context for the projects. A simple project would have few workers, few types and levels of workers, a simple division of labor, similar levels of commitments from workers, an explicit project goal and a simple organizational context. If we apply Strauss' definition, Star and Griesemer's prototypical boundary objects (1989) were part of a somewhat routine and fairly simple project because Grinell and Alexander were in the position of having stable resources, had the authority to dictate clear and anticipatable steps, had experienced workers, an established division of labor, an explicit project goal and a simple organizational context. Perhaps boundary objects are found primarily in fairly routine or fairly simple work projects. Boundary negotiating artifacts on the other hand might be more prevalent in projects that are fairly non-routine and fairly complex.

We might consider that not only do projects fall along the two dimensions Strauss described, but particular constellations of artifact types may also correspond with project location on those two axes. At each point in space, perhaps a whole taxonomy of artifacts including, but not limited to, boundary negotiating artifacts and boundary objects, may be prevalent.

4.2. OPENING THE BOX AROUND BOUNDARY OBJECTS

In recent years a disturbing trend has emerged: the concept of boundary objects has become a catch-all for several theoretical constructs. When we pay careful attention to collaborative work, especially novel or multi-discipline collaborations, we quickly discover artifacts that do not quite fit the definition of a boundary object. The creation of the concept of boundary objects gave us a name for artifacts that move between communities of practice, but rather than considering this as a box into which everything else fits, we would do well to think of boundary objects as a pioneering concept: the first data point on a graph or the first settler in an uninhabited place. The black boxing of boundary objects has entailed an uncomfortable separation between artifacts and the socially negotiated processes that give them meaning. Researchers have intuited that what is interesting about boundary objects is not merely that they exist, but rather the means by which they are created and break down and, as per this research, when they may not be necessary. By avoiding the temptation to treat the boundary object as a black box, we open ourselves to models of collaborative work that go beyond simple exchange to more comprehensive and richly specified models of negotiation and enactment.

4.3. TOWARDS A NEW MODEL OF INTERDISCIPLINARY COLLABORATIVE WORK

A great deal of boundary work is concerned with discovering, testing, and pushing of boundaries (e.g. attempting to modify division of labor). By extension collaborative work can involve discovering, making, testing, developing, and arguing over practices and how to instantiate those practices into intermediary artifacts and end products. Collaborative work can be highly contested and practices and artifacts are not always well understood. Alignments can be partial, shared understanding between groups can be spotty, and these breaks in alignment extend to understanding and use of representational and coordinative artifacts. Boundary negotiating artifacts may be considered a first step towards a theory of boundary negotiating which is a model of collaboration that, while centered upon artifacts-in-use: (1) does not presuppose fairly high levels of coordination, (2) does not focus on coordinative aspects of artifacts at the expense of disruptive aspects, and (3) involves artifacts that are not ''standardized inscribed artifacts'' such as those found in boundary objects or ordering systems (Schmidt and Wagner 2005).

Further research might pursue comparative case studies to explore more fully the relationship, or lack thereof, between boundary objects and boundary negotiating artifacts. The concept of boundary objects is important and is deserving of more research, but we must also push past assumptions of

standardization and stable boundaries between communities on which the concept lies. Perhaps boundary negotiating is part of a process by which methods are developed and become standardized. Or perhaps, even more intriguingly, future work may find that boundary negotiating is an alternative form of collaborative work that is advantageous for certain types of circumstances (e.g. short term or highly innovative projects).

5. Conclusion

Since beginning this work, I was asked by someone in the CSCW community, ''Isn't this just a story about people behaving badly?'' The answer is no. This is a story of perfectly nice people with a common goal behaving rationally on a project that was highly complex and non-routine. Could the assumption of well-ordered and deliberate progression in the design process be clouding our vision? Might we be dismissing complex and non-routine collaborations as ''people behaving badly'' so that we can return to the safety of standardized artifacts and stable organizational contexts? Perhaps the artifacts and protocols found in these situations can be most easily codified into our computational systems, but for the purposes of creating a theoretical foundation for CSCW we should try to do more.

In his work on the articulation process and project work, Strauss (1988) noted that articulation work is but a constituent element of the articulation process. Articulation work refers to the putting together of tasks and aligning lines of work in the service of work flow. The articulation process includes articulation work, but also includes *interactional processes* such as negotiating, persuading, educating, manipulating, and coercing. Furthermore, he noted that these interactional processes occur at different levels of organizations and require continual alignment. Articulation work, as Strauss conceived it, occurred within an organization and within a project group that was subject to manipulation and coercion. It's not a pretty picture of collaboration, perhaps, but indeed this is much closer to the picture formed by this research.

I have attempted to document a movement within CSCW that branches out from the concept of boundary objects and forms a new constellation of theoretical constructs that lie in the considerable space between chaos and routine. Conducting additional studies of how incipient collaborations create and use artifacts to negotiate and establish boundaries, and that explore the relationship between boundary negotiating artifacts and boundary objects may prove to be fruitful for developing increasingly sophisticated theories of collaborative work.

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