ENGINEERING OBJECTS FOR COLLABORATION: STRATEGIES OF AMBIGUITY AND CLARITY AT KNOWLEDGE BOUNDARIES

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INTRODUCTION

Studies have shown that objects – such as sketches, photographs, or tables of data - can play an important role in supporting collaboration among individuals with differing knowledge (e.g. Henderson, 1999; Carlile, 2002). These objects often serve as “boundary objects” that simultaneously permit multiple meanings for individuals across knowledge boundaries, while supporting unequivocal meanings to individuals within them (Bowker & Star, 1999; Star & Griesemer, 1989). According to most past research, the meanings that individuals attach to boundary objects emerge through cross-boundary collaboration as members engage with one another and the object (e.g. Fujimura, 1992, Bechky 2003). By focusing on the point of such interactions, existing research highlights how distinct knowledge communities can use the diverse meanings engendered by boundary objects to work together.

Treating meaning as emerging through interaction, however, ignores that objects may enter cross-boundary settings via individuals who created them with the intent to guide others toward a particular set of meanings. Acknowledging individual agency and strategic action in the production of the object’s form would portray boundary objects not as ‘tabulae rasae’ whose meanings develop in an unplanned and emergent way, but as objects that enter interaction with a planned form aimed at engendering particular meanings. Understanding the how the ultimate meanings associated with an object develop, therefore, would require us to attend to the object not as it enters cross-boundary collaboration, but as it is created. In this paper, we expand the research lens to include the preparation that individuals undertake before bringing objects into group interactions.

Ambiguous Objects and Strategic Individuals

Supporting multiple meanings requires plasticity, which research on boundary objects suggests is achieved when an object’s meaning is ambiguous (Marsh & Jackson, 2008). By ambiguity, we mean an uncertainty or inexactness of meaning. In their original formulation of the boundary object concept, Star and Griesemer (1989) argued that the state of California, as an object, was sufficiently ambiguous to support multiple meanings attributed to it by the actors who took part in the creation of a museum of vertebrate zoology (i.e. evolutionary biologists, amateur bird collectors and conservationists, and Joseph Grinnell, the museum’s first director). As Star and Griesemer observed, even though these experts from different knowledge domains did not agree about why California's border was important, all agreed that it was and were thus able to build a common focus for their efforts.

Fujimura (1992) observed that individuals can co-opt a boundary object to promote their own agendas - if they are careful not to over-specify its meaning, thereby removing its ambiguity. Exemplifying this, Joseph Grinnell had a specific goal: to build a vertebrate zoology museum. To achieve that goal, he had to enlist the support of various experts who were not necessarily interested in creating a museum. Star and Griesemer (1989: 409-410) suggest that while California's ambiguous multiple meanings emerged naturally, Grinnell exploited this ambiguity to achieve his own goals by never attempting to reconcile the differing interpretations he knew his team members held.

Although boundary object scholars view ambiguity as emergent, organizational research has shown that individuals can foster it purposively. Eisenberg (1984: 229-230) wrote that individuals employ "strategic ambiguity" when, in pursuit of their goals, they shun communication clarity by purposefully refraining from narrowing the range of possible interpretations of their message. At the group level, strategic ambiguity fosters relationship development by allowing groups to perceive greater similarity amongst their members than may actually exist, which can help them to work together long enough to achieve some actor's goal (Eisenberg 2007; Gioia & Chettipeddi, 1991).

One problem with strategic ambiguity, however, is that it relinquishes control of the interpretation of meaning to others. In so doing, a strategy of ambiguity can lead a group to take a path other than the one the strategist intended (Davenport & Leitch, 2005). To avoid the risks of losing control over meaning, individuals may opt for an approach that aims for clarity. The goal of clear communication is to create shared meaning, such that everyone agrees on the implication of the message and its purpose (Weick & Browning, 1986). Although a strategy of clarity may help to ensure that everyone understands a message in the way the sender intended, research suggests that overt attempts at clarity are often seen as pushy and self-serving in situations where people have little formal authority (Pruitt, 1971; Rubin, Perse, & Barbato, 1988).

If we recognize that individuals may be strategic in their use of ambiguity (or clarity) and that ambiguity is a key feature of boundary objects, we arrive at the premise that individuals may have choice in the degree of ambiguity that they allow in the objects they strategically engineer for cross-boundary collaboration. If we wish to understand individuals' processes and motivations in making that choice, we would do well to examine their strategies when creating objects for use in communication across knowledge boundaries. In what follows, we use this approach to answer three research questions: (1) Why would individuals act to foster ambiguity versus clarity at a knowledge boundary? (2) How would they configure objects to enact one strategy versus the other? (3) When are they likely to use one strategy over another?

METHODS

We studied design engineering at International Automobile Corporation (IAC), a large US based automobile manufacturer. We studied three engineering specialties at IAC's engineering center in Michigan: Frame and Body (F&B), Noise and Vibration (N&V), and Safety and Crashworthiness (S&C). Each specialty had its own directives, resulting in different desired characteristics in vehicle design. Among F&B engineers, a major concern was vehicle formability, or the ability to shape steel or aluminum alloys into the necessary parts. Economic imperatives typically drove F&B engineers to look for formability solutions that were low in mass, thereby reducing materials cost. N&V engineers aimed to make the quietest, smoothest riding vehicles possible. They achieved their goal by minimizing airborne noise traveling from the engine to the cabin as well as structure-borne noise transmitted via vibrations in vehicle parts. The goal of S&C engineers was to develop the safest possible vehicle for the occupants. S&C engineers attained safety by designing the vehicle to absorb the bulk of the energy generated in an accident so it would not be passed on to the occupants; diverting energy from the occupants was referred to as achieving a 'good crush' of the vehicle. As these descriptions suggest, the three engineering groups worked interdependently and collaboratively, often in pursuit of conflicting goals, as they developed vehicle design solutions.

We conducted detailed ethnographic observations of engineers at work in these three groups between July 2003 and September 2005. We observed most engineers in the study on four occasions, for a total of 128 observations across 12 F&B engineers, 12 N&V engineers, and 10 S&C engineers. We employed a grounded theory approach to analyze our data (Glaser, 1978; Strauss & Corbin, 1998). First, we isolated specific episodes of activity involving either cross-boundary collaboration among engineers or preparation for such collaboration. Following this, we examined engineers' practices when producing objects for collaboration. Ultimately, we identified a set of strategies and motives guiding engineers' object production. We also identified design activities that reflected engineers' motives and spoke to the strategic use of ambiguity and clarity in the object's design.

FINDINGS

Engineers frequently collaborated outside their specialties with others who were concurrently working on different aspects of vehicle development. During collaboration, engineers often used objects to help communicate problems and proposed solutions (e.g., a computer model of a part, graphs and tables of test results, audio recordings, computer models of parts, crash test videos, etc.) Interaction was not always cooperative. Formal meetings, for example, frequently included debates among engineers from different specialties about the proper design direction for the vehicle. As one S&C engineer remarked: "Doing design work is sort of like being in a contest. In theory, everyone's supposed to work together. ..but the way things are organized, the N&V guys have their own objectives and we [in S&C] have our own goals and most of the times they're competing."

Within specialties, engineers often prepared for the contests of future cross-boundary interactions by producing objects. In total, we observed 31 engineers produce 92 such objects. Engineers used their perceptions of other specialties' values to predict the environment in which their objects would be interpreted to choose which data and format of presentation would best suit their motives. A deeper look at work practices surrounding object creation reveals that engineers used two distinct strategies for object production. We use the term "strategy" to describe a combination of the engineers' motives driving the objects' production and design activities that engineers undertook to shape objects in ways that would help to accomplish their goals. Engineers used a *strategy of ambiguity* to produce objects (33 total) intended to be meaningful and desirable to all parties. Engineers designed these objects to foster ambiguity and promote multiple meanings in cross-boundary collaboration. At other times, engineers used a *strategy of clarity* to produce objects (26 total)[1] meant to force collaborators to accept a specific outcome regardless of its effects on competing specialties. Engineers designed these objects to minimize ambiguity, reducing the potential for collaborators to interpret them in a way that would be oppositional to the creator's intended meaning.

Strategy of Ambiguity

The most common strategy engineers used when creating data objects was a *strategy of ambiguity*. When using this, engineers produced objects intended to be meaningful to outsiders' perspectives and encourage a common group decision about the design. The desired outcome was a situation where the object creator would meet their goals, while other groups would perceive mutual benefit through agreement upon potential changes. Accordingly, the engineers' motives driving this strategy were (1) to establish common understanding and future direction, (2) to promote compromise, and (3) to avoid potential conflict. Engineers believed that ambiguity was only achievable by creating objects that were simple enough to embody multiple meanings. Thus, they pursued these three motives via two design activities: simplifying data and eliminating unnecessary data.

The following example shows two S&C engineers (E1 & E2) producing an object that demonstrates two of the major motives (1 & 3) and shows design activities that eliminates unnecessary data. E2 had developed a computer analysis assessing the crash benefit gained by adding 'end caps'[2] to a car seat. To estimate the benefit, she had created a simulated vehicle based upon data gathered from a real-world test crash. After simulating the vehicle without the end caps, she added the end caps to her model and ran the simulation a second time. The difference in performance between the first and second simulations allowed her to predict the safety benefit the end caps would provide. Although her analysis was incomplete, management asked her and E1 to make recommendations that afternoon:

E1: Do you have anything we can show?

E2: I've got a little bit of stuff. It's basically this. [Pulls up a graph] But I'm not too happy with the model right now. This blue is the [real-world crash] test, and all these curves are my [computer] analysis and they're way different. But it shows the trend of end cap benefit.

E1: So *maybe we can take the test off of there and just show an A to B* [a comparison of only simulated data].

E2: We could do that. It's basically if you have [both] end caps you're [to the] left [on the plot]. And if you only have the outboard end cap, then you're in the middle, and then the baseline you're far to the right. So you can do an A to B.

E1: That would be good just to show really quick.

E2: The only problem with this is we're poor for pretty much everything because my model's so soft. *So I'll take off the poor lines so maybe they won't catch it. We don't want to confuse them.* [Emphasis added]

Although E2 was unhappy with the poor quality of her computer models in comparison to the physical crash test data, she believed they could still use her analysis to support a general understanding of the design recommendations without engendering conflict. To prepare the object for presentation, E1 suggested they remove the evidence of the poor model quality (the blue line showing the physical crash test results) and only show the information about the benefit of the proposed design change. By removing the physical crash results, these engineers underplayed the incomplete nature of their analysis in an effort to make the object ambiguous enough to prevent unnecessary conflict.

Strategy of Clarity

When engineers predicted that group interaction would result in a design solution that was not amenable to their specialty, they shifted to a more forceful strategy of object production that focused on clarity, not ambiguity. In the face of opposition from other groups, engineers opted not to enable multiple meanings, but focused instead on creating objects that would force others to concede to their point of view. Two major motives guided object creation under a strategy of clarity: (1) justification against criticism and (2) blocking opposing proposals. In accordance with these motives, engineers created objects intended to reduce the potential for other engineers to interpret the objects in an oppositional manner. Two design activities – adding data sources and using robust data – aided them in carrying out their motives.

Exemplifying a blocking motivation and both design activities, the following example was prompted by a management proposal to standardize parts across several vehicle platforms. Although this step would save money, it would also result in very steep half-shaft angles[3] that E3, an N&V engineer, thought would increase interior noise. In an effort to block the proposal, E3 performed extra analyses to convince management to change their mind, as he explained here:

> *"[To convince management] we are going to run a test* on a chassis dyno by just taking [one of our cars] and putting weaker suspension springs in it… it will artificially increase these angles so we can find out what the noise and vibration effects are… *The other thing we are going to do is get a bunch of competitor vehicles,* any other all wheel drive premium vehicles. Then we are going to measure what their angles are to *show that, in general, the industry is running the small angles rather than high angles."* [Emphasis added]

E3 described two analyses that would serve as the foundation for objects he would later present to management. The first analysis would produce data using a real vehicle to approximate the effects that the increased half-shaft angle would have for N&V. Additionally, E3 planned to measure the half-shaft angles on competitor cars to show that the design change was not only detrimental, but beyond the limits of industry standards - a measure he thought would be particularly meaningful to management. E3 intended the objects produced from the extra analyses to carry a specific meaning: to show management that the change would be detrimental to the vehicle.

Varying Strategy Use by Design Phase

A strategy of ambiguity seems most useful early in product development, when the details of the vehicle are still open to modification and there is less likelihood of conflict. As a vehicle design solidifies and changes become more costly, a strategy of clarity becomes more necessary to affect change because engineers are more likely to encounter resistance. We can empirically explore when engineers used each strategy by mapping the 92 objects we identified to the phase of the vehicle development process (early, middle, late) when they were produced. Figure 1 plots data showing that early in vehicle development, engineers employed a strategy of ambiguity more often than they employed a strategy of clarity. As the process progressed, engineers began to use a strategy of ambiguity less frequently. By the end of the development process, when changes to the vehicle were much more difficult to make, a strategy of clarity eclipsed a strategy of ambiguity. Overall, these data suggest that engineers were more inclined to employ a strategy of ambiguity when creating objects for cross-boundary collaboration than they were to use a strategy of clarity. However, when push came to shove, engineers transitioned to a strategy of clarity to assure that the group approved their design.

Figure 1 about here

DISCUSSION

The central finding of this study is that individuals are strategic in the creation of objects they plan to use for communication at knowledge boundaries. Potential boundary objects in our study did not enter cross-boundary collaborations as 'tabulae rasae;' rather, they entered as objects purposefully shaped by their creators to achieve particular goals. Thus, we found that our first research and third research questions were closely interconnected. We suggest that the choice of which strategy individuals employ is tied tightly to their assessment of whether there is sufficient leeway in the collaboration process to foster goodwill with others or whether it is imperative that their own individual needs be met. A direct consequence of this finding is that individuals do not intend for all objects that they create for use at knowledge boundaries to become "boundary objects" in Star and Griesemer's (1989) sense of the term. Although individuals strategically create some objects to foster ambiguity in meaning and, thus, to have the potential to become boundary objects, they strategically create others to clearly convey a specific, single meaning. This finding cautions researchers against the common tendency to treat all objects used for communication at a knowledge boundary as boundary objects.

In response to our second research question, we found that engineers at IAC designed objects in very different ways depending upon their goals. At the highest level, our findings showed that engineers who employed a strategy of ambiguity worked to simplify their objects to promote broad understanding and interpretability. By contrast, when engineers employed a strategy of clarity, they made their objects more detailed and complex to demonstrate to people from other knowledge communities that there was but one way to interpret the object's meaning. This finding points out a potential paradox between an object's form and its meaning: Those objects that have the simplest forms may produce the most complex meanings (opening the object to multiple interpretations), while those objects with the most complex forms may produce the simplest meanings (reducing the possibility of multiple interpretations). These findings suggest that when people interact with objects whose meaning appear simple and straightforward, they might be wise to probe whether the object's apparent simplicity reflects strategic intent on the part of its creator to provoke a complex set of meanings, while possibly masking a specific interpretation that will, at least initially, go unrecognized.

ENDNOTES

1. Due to the cross-sectional nature of our data, we could not discern a strategy for the remaining 33 objects and thus did not associate them into either group.
2. The 'end cap' is a support for the frame of a car seat. It attaches to the inboard (closer to the middle of the car) and outboard (closest to the door) sides to add stiffness during a crash.
3. A half-shaft connects the wheel to the differential of the car. These shafts provide energy from the motor to each of the driving wheels. The half-shaft angle is the angle of the shaft coming from the wheel up to the differential of the car.

REFERENCES AVAILABLE FROM THE AUTHORS

Figure 1: Percentage of Objects Reflecting Strategies of Ambiguity vs. Clarity by Design Phase