BOUNDARY NEGOTIATING ARTIFACTS FOR DESIGN COMMUNICATION: A THEORETICAL AND EMPIRICAL EXPLORATION

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INTRODUCTION

Interdisciplinary teams must figure out ways to navigate team members' differing disciplinary backgrounds and successfully communicate with one another. This can prove challenging because disciplines comprise unique cultures, goals, perspectives, epistemologies, methodologies, and languages.[1] Consequently, communication is among the most frequently cited challenges to interdisciplinary collaboration, and developing communication skills is widely recognized as an important facet of teamwork.[2] Yet, "Newcomers often underestimate the challenges of interdisciplinary work and, as a rule, do not spend sufficient time to allow them to overcome difference and create common ground, which in turn leads to frustration, unresolved conflicts, and…discontinued work."[3] Thus, it is important that teams establish common ground in terms of shared language, concepts, and goals.[4]

Boundary negotiating artifacts (BNAs) are one way in which interdisciplinary teams can establish common ground and facilitate communication between team members. BNAs are artifacts and inscriptions that coordinate perspectives and align different communities of practice so that they can collaboratively solve design problems.[5] They facilitate transmission of information across disciplinary boundaries, allow team members to learn from other disciplines, create shared understanding of a design problem, and communicate important information. The concept of BNAs emerged out of boundary object traditions in the field of Science and Technology Studies, and is an attempt to overcome limitations of the original concept. More specifically, BNAs add nuance and depth to studies of the complex, non-routine projects which designers increasingly face as they work to address societal challenges. Focusing on the daily micro-level practices of designers reveals communication processes and facets of design work that otherwise remain unseen and are not revealed through either normative descriptions of design work or through interviews alone. Boundary negotiating artifacts provide a framework to study just such daily micropractices and inscriptions.

We suggest that boundary negotiating artifacts are a timely and essential concept for multiple stakeholders in academia and the workplace. This paper presents a theoretical exploration of BNAs and their roles in design teams, supported by an empirical example from a long-term ethnographic study. The three-fold aim of this paper is to present BNAs as: 1) a theoretical and methodological tool for other researchers, 2) a pedagogical tool for faculty members, and 3) a conceptual tool for team members themselves.

FROM BOUNDARY OBJECTS TO BOUNDARY NEGOTIATING ARTIFACTS

The concept of boundary objects was introduced by Star and Griesemer in their study of diverse groups (amateurs, professionals, and administrators) from different "social worlds" working together to create a science museum during the early decades of the 20th Century.[6] They found that two factors in particular helped enable successful collaboration among diverse individuals and groups, namely

standardized methods and *boundary objects*. Boundary objects can be abstract or concrete objects that are:

> ...both plastic enough to adapt to local needs and the constraints of 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. ... They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation.[7]

Examples of boundary objects in Star and Griesemer's study included diagrams, maps, and repositories of items catalogued in a standardized manner.

Since their introduction, boundary objects have been taken up enthusiastically by scholars in multiple fields, and many modifications and additions to the original concept have been proposed.[8] For example, conscription devices, prototypes, intermediary objects, and standardized packages have all been proposed as necessary modifications or alternatives to the original concept.[9] Despite the fact many of these modifications retain the label of boundary objects, the modifications do not always meet the requirements of boundary objects.[10] Therefore, Lee argues that the concept is incomplete, and we should resist the temptation to treat boundary objects as a "catch-all for several theoretical constructs."[11] She elaborates:

> The black boxing of boundary objects has entailed an uncomfortable separation between artifacts and the socially negotiated processes that give them meaning. ... 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.[12]

In other words, by developing a better ontology for the objects involved in collaborations, we gain nuance and deeper understanding of the distinctions between different types of objects, as well as insights about how their different uses affect collaboration. Other recent work makes a similar case for refining the ontologies of intermediary objects because doing so reveals how design work actually unfolds.[13]

From routine and simple to nonroutine and complex projects

In part, the limitations of the concept of boundary objects stem from the fact that there are many different kinds of projects, problems, and collaborative work, and the original concept may not be sufficient to describe and understand all kinds.[14] One way to delineate different kinds of collaborative work is to draw on Strauss' distinctions. Strauss developed a categorization schema that locates projects along two axes.[15] The first axis ranges from *routine* to *nonroutine*, where routine projects have "a project path that has been traversed frequently, clear anticipatable steps, experienced workers, an established division of labor, stable resources, and strategies for managing expected contingencies."[16] Nonroutine projects are not as stable and predictable. The second axis ranges from *simple* to *complex*, where complex projects have "many types of work, many workers and many types and levels of workers, a complicated division of labor, variable workers' commitments, possibly more than one explicit project goal, and a complex organizational context for the project."[17] Simple projects are characterized by fewer people and kinds of work, minimal divisions of labor, singular goals, etc.

The original concept of boundary objects was developed during a study that involved "a somewhat routine and fairly simple" project.[18] It is therefore possible that boundary objects are most appropriate for studying these kinds of projects, while for complex, nonroutine projects, on the other hand, a different concept may be needed to develop more nuanced, in-depth understandings of the work and

objects involved. To this end, Lee introduces the concept of boundary negotiating artifacts, which are more appropriate for nonroutine and complex projects.[19]

A TYPOLOGY OF BOUNDARY NEGOTIATING ARTIFACTS

BNAs are "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."[20] They include inscriptions such as sketches and concept maps. BNAs have a variety of different functions and affordances. They transmit information, facilitate collaboration across disciplines, create shared understanding of a design problem, and communicate concepts and techniques, among other functions. The original BNA typology, summarized in Table 1, emerged from a study of the creation of a museum exhibit.

Table 1. The original BNA typology[21]

Type	Purpose	Examples
Self-explanation	Record, collect, remember and organize information for oneself	Concept sketch, Notes, Journals
Inclusion	Propose new ideas, concepts, or forms to team members: a reference or symbol for the new idea	Sketches or drawings, Text summarizing a new idea
Compilation	Create alignment and coordination between the team members to bring them together long enough to produce a shared understanding of a problem and/or to communicate important information	Tables, Technical sketches
Structuring	Communicate a vision and compete with other structuring artifacts to make that vision dominant: push and negotiate boundaries between communities: establish ordering principles: direct and coordinate the activity of others	Narratives, Concept map
Borrowed	Taken from one community of practice and used unexpectedly in another, suggesting close relationship between communities of practice	Design collage

CASE STUDY

The empirical content of this paper comes from a year-long ethnographic study conducted at a public university in the United States in 2016 and 2017. In-depth observations, as well as interviews, were conducted with an interdisciplinary student design team. Data came from those observations, sixteen semi-structured interviews, and material sources that were created or used by the participants during group meetings or class activities to communicate and collaborate. These materials included diagrams and sketches, PowerPoint presentations, technical documents, design renderings, and prototypes. The design project was part of a national collegiate competition to create green, sustainable living communities. The team was complex and nonroutine, comprised of multiple and overlapping sub-teams. Our primary observations were of architecture, computer science, and engineering undergraduate students and faculty members. Additional details about the methods are reported in greater detail elsewhere.[22]

We observed that the team largely focused on one *structuring artifact* in the form of what they called the "project narrative." Over-reliance on this one structuring artifact to produce shared understandings introduced challenges and tensions. In particular, one sub-team did not utilize enough *inclusion* and *compilation* artifacts, which have been found in prior studies to be highly important for successful interdisciplinary collaboration.[23]

DISCUSSION: BNAS AS THEORETICAL, METHODOLOGICAL, AND CONCEPTUAL TOOL

Studying BNAs in this project allows us to ask and answer questions such as: Which artifacts facilitate a shared understanding of a design problem? Which do not? Which most successfully lead to alignment between team members? Which artifacts get saved and are easily accessible, under what circumstances, and to what effect? How do artifacts shape team members' actions? How do team members communicate new ideas from their home disciplines to team members from other disciplines? Are some artifacts more successful at communicating certain ideas than others? What artifacts do designers create for themselves to make sense of assimilating, studying, or engaging material from other disciplines? Answering such questions provides new insights into interdisciplinary collaboration that have not been captured by other approaches. Furthermore, BNAs can have a longevity that conversations do not, allowing researchers to capture aspects of interdisciplinary communication and design that might otherwise escape notice or be lost.

Answers to these questions can then be translated into professional development materials for educators. Faculty members can proactively utilize BNAs to more effectively teach interdisciplinary teamwork and communication skills and facilitate their student teams. By examining BNAs, specific artifacts involved in communication processes can be identified, in turn revealing where problems in communication occur and how successful communication can be replicated and taught. For instance, if team members are producing different structuring artifacts, team leaders should be aware of that because it means that team members have different visions or understandings of the project and, consequently, of what members' actions should or will be. With the language and concepts from BNAs translated into faculty development materials, educators can teach students about BNAs to help students manage and negotiate their interactions with team members. Ultimately, creating such materials will be one outcome of this project. Furthermore, the conceptual tools provided by BNAs could also be translated into materials designed for student team members to help them navigate their interactions with teammates directly.

In sum, research suggests that studying BNAs can:

- Empirically advance the research landscape beyond normative assertions that interdisciplinarity and communication are important.
- Help designers, faculty members, and students navigate the challenges of interdisciplinary collaboration.
- Contribute to important learning outcomes for students, such as communication skills and multidisciplinary teamwork skills.
- Provide insights otherwise lost to memory and not capturable through other data collection methods because they are inscriptions.

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