KNOWLEDGE BOUNDARIES AND SPANNING PRACTICES IN CONFIGURING PACKAGED SYSTEMS

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ABSTRACT
The implementation of organizational information systems (IS) typically involves collaborative work among business area personnel, IS professionals and information technology (IT) vendors or consultants. Knowledge boundaries exist between these domains of expertise, presenting problematic barriers in knowledge-intensive IS work. Our understanding of how IS project teams overcome knowledge barriers in practice remains limited. To investigate these issues we conducted an intensive field study of business user and IT consultant teamwork in a multi-site enterprise resource planning (ERP) configuration project. We assessed three types of knowledge boundaries (syntactic, semantic, and pragmatic) discussed by Carlile (2002; 2004) and identified a fourth boundary (authority-related). Each presented barriers to effective knowledge sharing in the user-consultant teams' collaborative work. We identified four situated practices (translating, illustrating, probing, and escalating) that project analysts, the designated boundary spanners, enacted to overcome barriers and assessed the implications of the practices for knowledge sharing outcomes (communication, integration, transformation, negotiation). Boundary-spanning competence entailed a variety of abilities, which project analysts developed and deepened through their enactment of spanning practices. Our study extends understanding of knowledge-intensive IS project work by integrating consideration of knowledge barriers, spanning practices, and knowledge sharing outcomes. Our study also provides practical insights for nurturing boundary-spanning competence.

Keywords: *Boundary Spanning; Boundary Spanner; Knowledge; Collaboration; User-Consultant Communication; Configurable Technology; Enterprise Resource Planning (ERP)*

INTRODUCTION

The implementation of organizational information systems (IS) typically involves collaborative work among business area personnel, IS professionals and information technology (IT) vendors or consultants. Each type of participant brings essential expertise to an IS project, but, as Carlile and Rebentisch (2003:1182) note, "the unique terminology, tools, practices, or incentives that define each domain also establish knowledge boundaries across domains." Knowledge boundaries are discontinuities in shared knowledge *across* domains of expertise, which can become problematic in multi-party collaborations among experts from different domains (Bechky 2003; Carlile 2002, 2004). The IS field has long recognized knowledge boundaries that exist between project participants with technical knowledge and those with business or organizational knowledge (e.g., Curtis et al. 1988; Volkoff et al. 2004). In a globally-distributed or outsourced

IS project, boundaries arise as well from cultural, geographic, language, organizational, or status differences (c.f. Levina and Vaast 2008). Each of these types of boundary has implications for knowledge sharing and communication. However, in this study we focus on knowledge boundaries that arise from specialization and expertise in knowledge domains, as the knowledge-related barriers that may arise due to these boundaries can hinder the integration of business-area, technical, and consultant knowledge that is essential in collaborative IS work.

Knowledge boundaries arising from domain expertise are particularly problematic in one category of IS projects, the configuration of packaged software. These IS projects typically require IT consultants' expertise related to the software package as well as business users' in-depth knowledge of organizational policies and procedures to assess how to configure the software (Balint 2011; Ko et al. 2005). (We use the term "business user" to refer to organization members who manage or carry out business processes, using information systems.) Sharing knowledge between consultants and business users is critical for determining requirements and specifying ERP configurations successfully (Volkoff et al. 2004) and ensuring client organizations gain sufficient knowledge to be independent from consultants after implementation (Ko et al. 2005; Robey et al. 2002). Knowledge-related risks in collaborative IS projects are well-documented (Balint 2011; Pozzebon and Pinsonneault 2005). For example, researchers have investigated the interplay of knowledge and power between IT consultants and client organizations (Pozzebon and Pinsonneault 2012) and the complexity of organizational processes for their knowledge transfer (Robey et al. 2002; Van Fenema et al. 2007).

If knowledge boundaries present intrinsic and problematic barriers in this type of knowledge-intensive collaborations, how can IS project teams overcome knowledge barriers in practice to develop shared knowledge and to accomplish their collaborative work effectively? IS researchers have theorized IS boundary spanning generally (Levina and Vaast 2005; 2006; Sawyer et al. 2010) but have not developed an integrated perspective of knowledge boundaries, spanning practices and knowledge sharing outcomes. To investigate these issues, we conducted an intensive field study of business user and IT consultant teamwork in a multi-site enterprise resource planning (ERP) implementation project. ERP systems are commercial "off-the-shelf" software packages with generic, embedded business rules (often termed "best practices") and are composed of multiple modules with thousands of parameters that can be modified to meet the specific requirements of a particular organization or business function (Davenport 1998).

The organization that served as our research site utilized project teams composed of business functional area users, analysts, and IT consultants in software configuration activities. We collected in-depth data on team member interactions through onsite observations, interviews, and close examination of written communication documents. We assessed three types of knowledge boundaries (*syntactic, semantic,* and *pragmatic*) discussed by Carlile (2002) and identified a fourth boundary (*authority-related*) during the user-consultant collaborations. Each boundary presented barriers to effective knowledge sharing in the teams' work. From the empirical study we identified four situated practices (*translating, illustrating, probing,* and *escalating*) that analysts on the teams enacted to address these barriers and assessed the implications of the practices on knowledge sharing outcomes (*communication, integration, transformation,*

negotiation). In this interpretive study, we developed a holistic perspective on knowledge boundaries, knowledge sharing outcomes, and spanning practices to suggest how competence in spanning the boundaries may develop and be fostered in IS projects.

In the next section, we review key concepts in the knowledge management and boundary spanning literature that informed our study. We then describe our research site, data collection and analysis methods. We organize findings around four types of knowledge boundaries and illustrate how spanning practices were enacted and resulted in various knowledge outcomes. We discuss patterns in the interrelation of knowledge boundary spanning practices and boundary spanning competence and highlight implications for practice as well as areas for further research.

THEORETICAL BACKGROUND

The research literature on knowledge management, knowledge boundary, and boundary spanning informed our study of multi-party collaborations in enterprise software configuration. Consistent with Alavi and Leidner's (2001) framework, we adopt the perspective of knowledge as "a state or fact of knowing" and "knowing" as a condition of *understanding*, gained through experience or learning. Further, we apply this perspective consistently with the "knowing in practice" perspective advocated by Orlikowski (2002), in which she argues for the "mutual constitution of knowing and practice" (2002: 251) and maintains that "people's ongoing engagement in social practices, and thus their reproduction of the knowing generated in those practices, is how they reconstitute knowledgeability over time and across contexts" (2002: 253).

Developing Shared Knowledge in Knowledge-Intensive Collaborative Work

In multi-party IS projects, participants with different practices, interests, and competencies draw from their diverse knowledge domains in their joint work (Levina and Vaast 2006; Sawyer et al. 2010), but they must also develop a degree of shared knowledge that crosses their specialized domains (Bechky 2003; Carlile 2002; 2004). This suggests that knowledge exchange must occur among project participants for shared knowledge to develop. Prior research suggests different possible outcomes for knowledge sharing among individuals and in project teams, which are relevant to our study. We categorize these as (i) *knowledge is communicated* (Shannon and Weaver 1949), (ii) *integrated* (Faraj and Sproull 2000), (iii) *transformed* (Bechky 2003; Carlile 2002), or (iv) *negotiated* (Marshall and Brady 2001; Pozzebon and Pinsonneault 2005).

Communication theory (Shannon and Weaver 1949) has viewed knowledge exchange as a dyadic process during which a knowledge source transfers knowledge to a recipient. In this theoretical perspective, knowledge can be separated from context so that knowledge from the source can remain intact when it reaches the recipient (Joshi et al. 2007; Ko et al. 2005). Establishing a shared and constant syntax is critical to ensuring that knowledge is received and decoded accurately by the recipient. If the recipient decodes the knowledge consistently as the knowledge source encodes it using a shared syntax, *knowledge is communicated* (Shannon and Weaver 1949) and shared understanding is enabled through interactions. For instance, if an employee sends a phone text to a colleague, "*lunch in 15*," the receiver must decode the sender's message using a common syntax (e.g., "lunch" is a meeting event, and "in 15" is the time).

Other theoretical perspectives argue that knowledge is context-specific and thus knowledge per se cannot easily be passed from source to recipient (Bechky 2003; Carlile 2002). The concept of knowledge "stickiness," for instance, suggests that knowledge cannot easily be separated from the context from which it was developed (Szulanski 1996). Instead, knowledge can have different meanings in different contexts. Thus, the potential lunch companion must not only decode "in 15" as a time but must also determine when the text message was sent to deduce the actual lunch date time. A possible outcome for knowledge sharing is that *knowledge is integrated* if the recipient interprets the knowledge in a similar context and consistently with the source (Faraj and Sproull 2000) and thus comes to understand the intended communication. Importantly for knowledge-intensive professional work, individuals build specialized knowledge through years of professional training and apply knowledge within specific contexts (Brown and Duguid 1991). If team members have strong interpersonal ties (Hansen 1999) or common learning experiences (Tucker et al. 2007) communication barriers can be reduced. However, developing the contextual understanding that supports knowledge integration across different contexts or knowledge domains can be problematic for ad-hoc teams composed of individuals from different organizations, functional areas, or professions.

Another context-specific outcome of sharing knowledge across boundaries may be that *knowledge is transformed* (Bechky 2003; Carlile 2002). Nonaka (1994) stressed the transformation of knowledge from tacit to explicit and the socialization processes required to do so across boundaries. However, Carlile (2002: 445) argues that Nonaka's knowledge creation processes do not consider adequately how "knowing in practice" is entwined with a community's goals and purposes for developing or applying knowledge. Rather than a straightforward articulation of tacit knowledge to make it explicit, knowledge transformation thus requires "altering current knowledge, creating new knowledge, and validating it within each function and collectively across functions" (Carlile 2002: 446) to achieve specific purposes and goals. Thus, an employee receiving the "*lunch in 15*" text may need to interact with the sender to determine their joint expectations about and consequences of the lunch date (where it is, what type of food, how long to plan, whether there is sufficient time given other appointments, and so on). This implies that both the source and recipient acknowledge the novelty as well as the consequence of applying knowledge to produce new knowledge in a new context. Ideally the source and recipient adjust their understanding of the novelty and consequence in similar ways.

Finally, a possible outcome of knowledge sharing across boundaries is that *knowledge is negotiated*, which acknowledges that individuals or groups bring different goals and incentives for the application of their domain knowledge to their joint decision making. *Negotiation* suggests that power and political processes influence what emerges as "accepted knowledge." To complete our analogy, if the boss texts "*lunch in 15*," the employee might interpret it as an imperative, not a suggestion. In multiparty IS projects, the need to negotiate existing knowledge and to co-create new knowledge can trigger the exercise of power relations between consultants and clients in ERP implementations (Pozzebon and Pinsonneault 2012), as various participants apply their domain expertise to bring about their own desired ends. Diverse or conflicting goals and incentives among stakeholders can create barriers to effective development of shared knowledge and lead to collaboration failures.

Knowledge Boundaries in Knowledge-Intensive Collaborative Work

In everyday usage, a boundary is simply a border or perimeter. In sociological usage, the concept of a boundary suggests that different social systems such as cultures or organizations exist and that "socio-cultural differences … give rise to discontinuities in interaction and action" (Akkerman and Bakker 2011: 139). A common theoretical assumption is that knowledge boundaries arise around specialized domains of knowledge and expertise and give rise to discontinuities in knowledge sharing and integration across domains (Bechky 2003; Carlile 2002; 2004). The discontinuities can become problematic in a multi-party collaboration, creating barriers that hinder the utilization of diverse knowledge in collaborative work.

Based on the investigation of cross-functional collaborations in new product development Carlile (2002) discusses three progressively complex knowledge boundaries: *syntactic*, *semantic*, and *pragmatic*. A *syntactic* boundary develops around different syntax. For instance, Carlile observed that, in the design process for a new type of valve (a high-volume 3-in-1 valve), design engineers assumed "assembly" of the new valve as the existing, single assembly process whereas manufacturing engineers perceived that "assembly" entailed a new sub-assembly method. Carlile noted that a shared and stable syntax (the new requirement of a sub-assembly method) facilitated sharing knowledge between these domain experts.

A s*emantic* boundary arises when meaning is context-dependent and contextual differences in how expertise is brought to bear in a joint project are significant between knowledge domains. In the example of the new valve design, a semantic boundary was apparent as manufacturing engineers evaluated design choices in relation to the expected 3,000,000-a-year manufacturing whereas design engineers assessed designs in relation to the number of critical sealing surfaces in a very small space. To apply both sources of expertise in the joint design required each expert group to understand these contextual differences. Carlile (2002) highlights the importance of surfacing dependencies in how knowledge is interpreted within a context and differences among contexts in order to overcome semantic barriers to sharing knowledge.

However, *syntactic* and *semantic* boundaries do not account fully for the ways in which knowledge-intensive collaboration depends on how participants interpret the consequences of applying diverse knowledge in a novel context. Building upon the literature of communities of practice (Brown and Duguid 1991; Lave and Wenger 1991), Carlile (2002) defines a *pragmatic* knowledge boundary to suggest that individuals within a community not only share syntax and semantics but also share expectations for (or approaches to assess) the consequences of applying knowledge to a novel situation. For instance, in the new product development project that Carlile (2002) studied, engineers from design and manufacturing recognized differences in their knowledge (functional design vs. assembly) as well as its interdependence to address the novelty in developing the new complex product. They not only relied on each other's domain knowledge but also acknowledged the organizational consequence of applying the knowledge (i.e., the original functional specs by design engineers would lead to failures in manufacturing assembly, causing the organization a nightmare in their new product release).

Boundary Spanning in Knowledge-Intensive Collaborative Work

Organizational theorists have long been interested in how managing boundaries influences organizational performance in relation to an organization's external environment. Boundary-spanning strategy refers to the patterns of activities a group or organization demonstrates to manage boundaries with its environment, while the term boundary spanner refers to the roles played by individuals (Ancona and Caldwell 1992). In contrast to research focusing on spanning environmental boundaries, theorists such as Wenger (1998), drawing from the literature on communities of practice (Brown and Duguid 1991; Lave and Wenger 1991), have considered boundary spanners as brokers situated *between* communities and engaged in coordination activities to connect communities of practice.

This approach to boundary spanning has been of particular interest to IS researchers. Pawlowski and Robey (2004) address knowledge boundaries in IS activities as they portray IS professionals as boundary spanners who have accumulated knowledge about both information technology and business domains and are able to share one business group's best practices of IS use with other groups. That is, the IS personnel can potentially serve as the knowledge brokers (Wenger 1998) for IT use practices between business units. Similarly, IT consultants are often expected to bring knowledge gained in multiple client engagements, as well as domain knowledge of software "best practices" to IS projects (Ko et al. 2005; Pozzebon and Pinsonneault 2012). Levina and Vaast (2008) investigated the multiple social and structural boundaries that can create barriers to effective IS development work among technical developers, such as geographic dispersion, organization, status, language, and culture, and the ways in which IT use may transform boundary-spanning relationships from community-oriented and personal practices to objectified, market-based practices (Levina and Vaast 2006). Adopting a practice theory approach (rather than role-based), Levina and Vaast (2005) suggest that boundary spanners may emerge in practice, that *designated* boundary spanners may not function as expected, and that boundary-spanning practices develop as a specialized field of practice.

These studies of IS boundary spanning adopt the practice theoretical perspective of knowledge work as "emerging from the ongoing and situated actions of organizational members as they engage the world. It is an explanation grounded in what it is people do every day to get their work done" (Orlikowski 2002: 249). Practices are understood as the "situated recurrent activities of human agents" (2002: 253) and competence as the skillful enactment of "useful practices," where "useful" is necessarily contextual and provisional (2002: 253). In organizational and IS research, practice theory approaches generally adopt "an empirical focus on how people act in organizational contexts, a theoretical focus on understanding relations between the actions people take and the structures of organizational life, and a philosophical focus on the constitutive role of practices in producing organizational reality" (Feldman and Orlikowski 2011: 1240).

In this study we adopt this practice theory perspective to investigate knowledge boundary spanning. We define a *knowledge boundary spanner* as an individual who connects various individuals from diverse knowledge domains in their knowledge-intensive work, *knowledge boundary spanning* as the situated actions and practices used to facilitate the collaborations through knowledge sharing, and *knowledge boundary-spanning competence* as the skillful

enactment of useful practices for this purpose (Orlikowski 2002; Walker and Nocon 2007). Building from the theoretical foundations, we investigated how boundary spanners addressed knowledge boundaries that are intrinsic to knowledge-intensive collaborations in IS projects, focusing on barriers between business and technical domains of expertise and spanning practices.

RESEARCH METHOD

We conducted an in-depth, interpretive field study to investigate how knowledge boundaries were manifested and how boundary-spanning practices were enacted in a multiparty collaborative IS project. Consistent with the interpretive approaches to IS research outlined by Orlikowski and Barouli (1991), our research objectives were to investigate how human actors made sense of knowledge boundaries and acted to address them in this context, rather than to hypothesize or test cause-and-effect relationships. Informed by earlier theorizing and by our empirical study, our goals were to develop an analytical generalization regarding knowledge boundary spanning in collaborative IS project work, which might be usefully applied in other research. This is consistent with Klein and Myers' (1999) principle of abstraction and generalization for interpretive field studies and Lee and Baskerville's (2003) framework for generalizability (empirical to theoretical generalization).

The site selected for this research provided us the opportunity to collect rich case study data in a setting where the phenomena we hoped to observe were likely to be widespread (Yin 1994) and allowed us to observe first-hand the knowledge boundaries and spanning practices that arose in team interactions. The case study focused on the early stages of an ERP software configuration project, when teams of business users and software consultants worked closely together to specify the configuration, that is, in activities well suited to our research goals of studying knowledge boundaries among domain experts. Our field study data collection (observations, interviews, document review) and qualitative data analysis methods were based on well-accepted qualitative research methods articulated by Miles and Huberman (1994). The following sections describe the research site to provide an overview of the project context and then detail our data collection, coding and analysis methods.

Research Site and Configuration Project Description

GiantOrg (a pseudonym) is a large private enterprise of 40,000 employees located in the northeastern region of the United States. GiantOrg includes one educational institution (University) and one health system with two hospitals and one college of medicine. The four institutions at GiantOrg operated independently, not only in their primary functions (patient care, education and research) but also in their administrative functions such as human resources and accounting. In an effort to integrate and streamline many of its administrative functions, GiantOrg decided to implement an enterprise system across the four institutions and chose to configure four modules from the SAP/R3 ERP package: human resources/payroll processing, finance management, supply chain, and special project management. This project was GiantOrg's first ERP endeavor as well as its first attempt to integrate business processes across the four operating units. Management hired a consulting firm, SmartCorp (a pseudonym), as its implementation partner for the 3-year, $200 million project starting in January 2004.

GiantOrg established a steering committee made up of chief executive officers from the four institutions to oversee the enterprise-wide project and to make high-level decisions regarding organizational policies. Reporting to the steering committee and managing the project operations was a project management office (PMO) with one executive director and three project directors. The implementation process followed the standard method commonly seen in consultant-aided SAP/R3 implementations: requirements analysis ("AS-IS"), design ("TO-BE"), specification of configuration ("blueprinting"), conversion, testing and training, and rollout. The study reported here focused on the 12-month period between March 2004 and February 2005, the stages of requirements analysis, design, and configuration of the ERP project. During these stages, consultants and users interacted frequently to develop requirements and design models.

GiantOrg recognized the need for knowledge sharing in the configuration process and took several key steps to address anticipated issues. First, managers established configuration teams of external consultants and business users from the four operating units to work on each module's configuration. GiantOrg emphasized the importance of transferring consultants' knowledge of SAP "best practices" to its employees and included a knowledge transfer plan in its service contract with SmartCorp. GiantOrg also created full-time "analyst" positions on each configuration team to facilitate users' learning of SAP capabilities from consultants and recruited experienced business managers as analysts. Upon hiring, GiantOrg assigned analysts to document current business processes. To familiarize analysts with the SAP package, analysts attended three levels of SAP training provided by the vendor. Finally, each analyst was assigned a consultant mentor when the consultants arrived on site in April 2004. By establishing the teams and by selecting and training analysts as designated boundary spanners, GiantOrg established its boundary-spanning strategy for the joint configuration by business users and consultants.

Data Collection

At the onset of the SAP/R3 configuration activities, we interviewed the project executive director and a functional team manager for an overview of the project and project leadership's expectations about the user-consultant collaboration. We negotiated access to observe team meetings at the research site during the requirements and design stages. We observed the requirements and design meetings of five teams: three HR/Payroll teams (Benefits, Organization Management, and Payroll), and two finance teams (Cost Allocation and Debt). The PMO recommended these five teams, which were staffed similarly to all other teams with business users from each of the four units, analysts, and consultants from SmartCorp. These teams allowed us to focus on a subset of functional areas and the configuration issues that developed, and the teams were actively engaged in configuration activities involving users and consultants. The requirement and design meetings were scheduled in three consecutive weeks in June and July, 2004, for requirements analysis, and in October for functional design (Blueprinting).

In total we observed 11 day-long requirements and design meetings (8 hours for each meeting, and 88 hours in total). The research site did not permit recording at the meetings. Instead, the first author took detailed field notes during the observations and supplemented the notes after the meeting on the same day to improve accuracy and completeness. We compared field notes with the meeting notes and other documentation produced by the teams after each meeting, to ensure

we had compiled a complete record and to assess how issues raised in a meeting were carried forward between meetings. In addition to design meetings, the first author observed a team project meeting, a design review meeting, and an executive management meeting. These meetings (on average 1.5 hours each) provided additional insights on organizational policies and project goals, the project team's assessment of configuration activities, and the progress of design issues raised in working sessions.

The first author interviewed team members in December 2004 at the completion of blueprinting for configurations. Our main objective in conducting the interviews was to understand participants' perceptions of knowledge boundaries and their experience with the designated boundary spanners, the analysts. We could then compare our interpretations of boundary-spanning practices, as we observed at the configuration meetings, with those of the participants. Due to the ERP project's intense schedule, two teams (Benefits and Organization Management) were available for interviews and allowed researchers access to individuals in each of the three roles (consultant, user, and analyst), which was important and sufficient for our research goals. Ten interviews were conducted, with each interview lasting forty-five to seventy-five minutes. Using a semi-structured protocol we asked interviewees open-ended questions such as, "How important is consultants' business domain knowledge for the SAP configuration?" "How important is users' SAP knowledge for the configuration project?" and "How important is an analyst's role on the team?" The interviewees' responses were written down verbatim and transcribed on the same day after the interviews. Interviewees reviewed the interview notes to check for missing points.

Finally, we obtained presentation materials and meeting minutes distributed among team members. This allowed us to cross check the accuracy and completeness of key discussion points recorded during observations. We also obtained documentation of the finalized requirements and design models. These documents (20 for high-level requirements decisions and 20 for functional designs) summarized the project's requirements and configuration specifications. Together with observation field notes and interviews, these documents allowed us to assess how configuration issues that we observed in team meetings evolved in subsequent meetings and were resolved (or not) in the final design documents.

Data Coding and Analysis

Our objective was to assess whether knowledge boundaries presented barriers to knowledge sharing and if spanning practices emerged in interactions among analysts, users and consultants to help overcome those barriers. We collected, coded and analyzed data iteratively, initially using open coding as well as codes suggested by the literature, then revised codes as we refined and clarified our theoretical interpretation. To analyze the interactions of users, analysts and consultants during the SAP overviews and requirements discussions, we reviewed the completed field notes of observations immediately following each day's observation. Margin notes were added to reflect the key themes and issues observed during the initial review of data. For example, we recorded the types of knowledge (i.e., ERP knowledge, business domain knowledge, configuration-specific knowledge), types of knowledge barriers (syntactic, semantic, or pragmatic), and analysts' practices (i.e., using an example). Analytic codes were further refined

between the observations of requirements and design meetings, and again at the conclusion of the study during the last stages of analysis and write-up. Table 1 summarizes the major analytic categories that resulted from this iterative analytic process.

Table 1. Summary of Coding Categories

Category	***Code***	***Definition***
Knowledge Barrier	Syntactic	Difference exists in syntax of knowledge, impeding the communication across two domains. (Carlile 2002)
	Semantic	Difference exists in interpretation of meanings of knowledge, impeding the common understanding of knowledge (Carlile 2002).
	Pragmatic	Difference exists in the consequence of applying knowledge, impeding the co-creation of new knowledge (Carlile 2002).
	Authority-related	Difference exists in the decision power of stakeholders, impeding the application of knowledge (Derived from the study).
Spanning Practice	Translating	Defining elements of one community's worldview in terms of the worldview of another community. (Pawlowski and Robey 2004).
	Illustrating	Representing differences and depicting potential consequences by using examples, scenarios, or concrete objects. (Derived from the study).
	Probing	Seeking further details to examine the underlying issues. (Derived from the study).
	Escalating	Recognizing limitations in decision-making authority to resolve a configuration issues (Derived from the study).
Knowledge Sharing Implication	Knowledge communicated	Knowledge recipient decodes the knowledge consistently as knowledge source encodes it; knowledge remains intact during its flow from source to recipient (Shannon and Weaver 1949).
	Knowledge integrated	Knowledge recipient interprets the knowledge within the relevant context, consistently with knowledge source; knowledge is evaluated for recipient's context. (Faraj and Sproull 2000)
	Knowledge transformed	Knowledge source and recipient acknowledge the novelty of knowledge for recipients' context, and agree to adapt knowledge to the context; knowledge is modified to fit recipient context. (Bechky 2003; Carlile 2000)
	Knowledge negotiated	Both knowledge source and recipient acknowledge diverse goals in applying knowledge, and make comprises in applying knowledge for a common goal; knowledge may empower the stakeholders. (Marshall and Brady 2001; Pozzebon and Pinsonneault 2005)

The first three knowledge barriers (syntactic, semantic, and pragmatic) are consistent with the categories by Carlile (2002). The categories of knowledge implications and the translating practice category were empirically derived by draw generally from the literature reviewed (as noted in Table 1). The authority-related barrier category and the three categories of boundary spanning practices (illustrating, probing, and escalating) were empirically induced in the data analysis process.

Associations among categories were evaluated based on empirical data as we finalized the case study analysis and write-up in the following steps. First, we assessed the emerging interpretation in relation to prior literature to help clarify patterns of relationships among categories. For example, examining analysts, users and consultants' discussions of Job Family and Job-Position hierarchy for the HR/payroll module (reported below), our coding indicated a barrier due to a semantic knowledge boundary. Second, we assessed spanning practices that were evident or not when identifying different types of knowledge barriers, and identified related data on outcomes in the documents of requirements or functional design. Third, we used case data display matrices, as recommended by Miles and Huberman (1994) to organize data on the patterns and themes. *Appendix A* contains a sample of one such data matrix for illustration of the analytical method. Fourth, to assess boundary spanning outcomes and boundary spanner competency, all data sources were examined for incidents in which an issue was resolved in a team meeting, was not resolved but was recorded for later action, or reappeared in later meetings or in configuration documentation. The latter case suggested that initial attempts to reconcile the incident were inefficient. *Appendix B* provides a sample matrix to illustrate this step in the qualitative data analysis process.

In the next sections, we present the findings and analysis of the case study. To illustrate how boundary spanning practices were enacted during configuration activities, we organize and present findings around the four types of knowledge boundaries and analyze the ways in which these practices were effective or not in assisting team members to develop shared knowledge.

WORKING COLLABORATIVELY TO CONFIGURE ENTERPRISE SOFTWARE: FINDINGS AND ANALYSIS

In the following sections we examine in details how the EPR configuration teams encountered barriers in sharing domain-specific knowledge due to four types of knowledge boundaries (*syntactic, semantic, pragmatic,* and *authority-related*) and how analysts, the designated boundary spanner, enacted practices that often enabled the teams to overcome the barriers.

Overcoming Barriers Due to Syntactic Knowledge Boundaries

To determine ERP configuration recommendations, consultants and users had to overcome differences in their understanding of the terminology, jargon, and concepts that members from each knowledge domain used to discuss requirements. GiantOrg management had recognized the importance of addressing these knowledge boundaries by staffing the analyst positions with those experienced functional managers, assigning them to document (and thus learn more about) current business processes, and providing them with SAP training. A project manager explained the depth of training that GiantOrg provided to these designated boundary spanners:

> *"There are three levels of SAP training (part of our contract with SAP). Level I training focused on the overall features and overviews. Level II training is tailored to each function, such as finance, HR etc. Level III will be tailored to the special areas within functions*."[Interview, Finance manager, 12/2004]

Analysts understood their boundary-spanning role in the configuration activities was to facilitate knowledge exchange and collaboration between consultants and users, as this analyst explained:

> *"I want to make sure that they [users] know what the consultants are saying. For example, "infotype" is the SAP terminology, but users may interpret it differently from consultants. … My job is to make sure that consultants use common terms in explaining the SAP system and for me to interpret the organizational business processes to the consultants."* [Interview, Benefits analyst, 12/2004]

Syntactic barriers due to differences in users' and consultants' lexicon and jargon were most pronounced at the beginning of the configuration activities during the requirements analysis meetings, as consultants attempted to share their knowledge of the ERP package with business users. For example, during the early discussions about the SAP Human Resource (HR) module, users were confused by two SAP security rules, "general authorization" and "structural authorization," and raised questions during consultants' presentation. An analyst at the session explained to users that the "general authorization" rule focused on the type of data a user could access, and "structural authorization" rule referred to the group of employees a user was allowed to access under the organizational structure. The analyst offered an explanation by *translating* the SAP terminology into the language that the users were able to understand, allowing this piece of knowledge about SAP functions to be *communicated* to the users.

Syntactic barriers also impeded the transfer of knowledge from business users to consultants, who lacked knowledge of the idiosyncratic processes at GiantOrg. At one design meeting for the SAP HR module for employee benefit plan offerings and eligibility, consultants presented their standard SAP matrix of benefit types and eligibility, assuming that only full-time employees were eligible for full-time benefits. However, a temporary position at GiantOrg's hospitals, "Option Nurse," did not fit into any of the five generic employee types in the consultants' template. The analyst on the team identified the consultants' confusion and translated the organizational jargon into the SAP terminology that the consultants could understand, as shown in the following exchange,

> *User: They (option nurses) only work 20 hours/week on weekends, Friday, Saturday, and Sunday nights. They are temporary in nature, but they enjoy the full-time benefits rates.*
> *Consultant: (regarding option nurse) OK, in the matrix, we can put "Full-time Option Nurse," and eligible for full-time benefits rate. Is that correct?*
> *User: It is correct. But I don't know. They are actually temporary employees; (they) should be moved from the full-time category to the temporary category.*

> *Analyst: [to consultant] I think what the user is trying to say is, the type of employment and the type of benefits are two distinct categories, but there is an established linkage between them, such as temporary employment [i.e., an option nurse] is linked to full-time benefits.*
> [Observation – HR/Payroll – Benefits Team, 10/2004]

In this case, the analyst *translated* the term "Option Nurse" used by GiantOrg's employees into the terms meaningful to the consultants, i.e., "distinct categories," "type of employment," "type of benefit," and "linkage." Users' knowledge of local practices was *communicated* effectively to the consultants. This allowed both groups to more clearly understand employment status and benefit eligibility. The team then modified the SAP configuration to add a new eligibility category to accommodate the unique position.

Translating was not always sufficient to overcome the syntactic barrier between technical and business knowledge domains. When translating became insufficient, the analysts were found shifting to *illustrating* to help users and consultants understand each other's knowledge. In the following incident, which occurred in a financial costing session, consultants explained to users the three cost allocation methods built into SAP -- distribution, assessment, and manual allocation -- and provided a definition and simple calculation formula, which users understood during the initial review. However, as the discussion continued, users asked for clarification of the assessment allocation method:

> *User: I have a question about transfer of primary (costs) to secondary (costs). What do you mean by "Move through assessment"?*
> *Consultant: Assessments are transfers of primary and/or secondary costs, using a secondary cost element. Different bases of allocation, such as variable/fixed portions, fixed amount, fixed percentage, may be used.*
> *User: [Looking puzzled]*
> *Analyst: [To User] Suppose the College pays $100 for electricity, and charges all departments based on the assessment and space allocation (then starts to draw on the white board);*
> [Observation – Finance –Cost Allocation Team, 6/2004]

By *illustrating* the consultants' SAP definitions for users, the analyst enabled consultants to *communicate* knowledge about the cost allocation method embedded in SAP more clearly to users. In the ensuing discussions, all team members agreed to adopt the SAP cost allocation methods and documented them in the team's requirements model, indicating that the requirements for cost allocation had been effectively discussed and determined in this session.

Boundary-spanning competence was evident in analysts' ability to enact *translating* and *illustrating* practices when syntactic barriers arose during the user-consultant interactions. Enacting spanning practices effectively depended on analysts' understanding of the lexicon and jargon of both domains, which were developed through their SAP training, prior organizational experience, and business process documentation tasks, as well as their ability to identify incidents

in which a barrier had emerged. Sometimes cues were explicit, such as a question posed by a user or consultant that the other could not address satisfactorily. In other cases, cues were subtle, such as looks of confusion or expressions of frustration from some team members.

Overcoming Barriers Due to Semantic Knowledge Boundaries

Understanding each other's lexicon and jargon was necessary for knowledge about GiantOrg's business processes and SAP functionality to flow between users and consultants, but it was not always sufficient. Barriers due to semantic boundaries emerged regularly in user-consultant interactions, as users struggled to interpret consultants' technical knowledge in the context of their business practices. An incident that occurred during the discussions of the HR/Payroll module illustrated how such a semantic barrier emerged. Users and consultants had been using the terms "Job" and "Position" to refer to the work duties and responsibilities an individual employee was assigned to. However, when the consultant started to explain what these two terms meant for the configuration of the SAP system, users became confused about the consultant's explanation and seemed to have difficulty in relating it to the GiantOrg's context. This confusion put their requirements discussion on hold:

> *Consultant: Nurse (in SAP) is a job, and ER nurse is a position. (This is an) object-oriented concept. (You should) make job general to reduce maintenance costs, and any position required will be inherited from job.*
> *User: Can you clarify the relationship between job and position?*
> *Consultant: A person fills a position, 1-to-1 relationship.*
> *User: [Looking puzzled] …*
> *Analyst: [To user] Job is a general category of positions. An example of job would be "nurse." There are many positions of "nurse" available in the Emergency Room (ER) or the Intensive Care Unit (ICU). Each one of them is considered as a "position."*
> [Observation – HR/Payroll –Org. Management Team, 7/2004]

The analyst *illustrated* the two concepts with an example from GiantOrg's hospital operation, the Emergency Room (ER) and the Intensive Care Unit (ICU), to contextualize the interpretation of "Job" as a category (i.e., "Nurse") and "Position" as the individual instances (i.e., an ER nurse or ICU nurse) holding the job within a work unit. By providing the context-specific illustration, the analyst helped users *interpret* the consultants' technical knowledge of "Job" and "Position" as "1-to-1" and "object-oriented" in a business setting that made sense to the users and allowed them to continue working through the requirements discussion with consultants. This incident illustrates that semantic barriers were subtle and thus difficult to resolve. GiantOrg users seemed to understand consultants' use of the terms "Job" and "Position" in earlier exchanges. The analyst responded to user's verbal cue (questioning) and non-verbal cue (puzzled look) by *illustrating* with an example, helping the users to *interpret* the two concepts consistently with the consultants' technical interpretation.

At times neither consultants nor users were aware that their interpretations differed, and neither raised questions or expressed doubts (verbally or tacitly). In the following incident, a discussion of the financial budgeting process in SAP, users were seeking information on the specific SAP

module that would provide annual budgeting capability. The consultant pointed users to an SAP BW (Business Warehouse) module for budget comparison reports:

> *Consultant: It is important to understand that annual budget is not in CO (the Controlling module), (but) in BW (the Business Warehouse module), which is where you do (budgeting) comparisons.*
> *User: (We have) routines to do budgeting on a monthly basis. (I'm) surprised to know that the functionality is not there (in SAP).*
> *Analyst: [To Consultant] Can you elaborate for participants on the relationship between FM (the Fund Management module) and the budgeting basis of accounting?*
> [Observation – Finance – Internal Costing Team, 7/2004]

Although the users were not satisfied with the consultant's response, the discussion would have moved on, if the analyst had not *probed* for more details on SAP's FM (Fund Management) functionality. The analyst recognized the user's doubt about the missing capability in SAP, but also understood that the SAP module used a budgetary basis of accounting, which might be sufficient to meet users' needs for dynamic budget analysis. Realizing that users and consultants might be interpreting the meaning of "budgeting" differently, the analyst enacted *probing* and thus moved the discussion forward.

Faced with semantic barriers, the analysts enacted *illustrating* and *probing* spanning practices. In contrast with *translating* technical terminology or business jargon to address syntactic barriers, *illustrating* and *probing* practices required analysts to have in-depth knowledge of the business context and comprehensive knowledge of SAP capabilities. Their knowledge of both domains allowed them to relate a technical functionality embedded in the packaged software to the actual business context, thus facilitating business users' and consultants' development of shared knowledge and configuration recommendations.

Overcoming Barriers Due to Pragmatic Knowledge Boundaries

To arrive at workable configuration recommendations for the ERP software, consultants and users needed to consider the potential impact of their recommendations on GiantOrg's business operation. Even when syntactic or semantic barriers were absent or had been overcome, users and consultants could still hold different interpretations of configuration choices, which contributed to pragmatic knowledge barriers. For example, during the discussion of position management in the HR/payroll module (cited below), a pragmatic barrier emerged with regard to SAP's capability for handling concurrent employment, a human resource practice at GiantOrg that allows one employee to hold multiple positions at the same time. Users now understood the Job-Position structure built in SAP, but they did not fully comprehend how that Job-Position structure would affect their reporting at GiantOrg as shown below:

> *User: Can SAP allow one individual holding more than one position? For example, (an individual) has one full-time position at the Hospital, plus working 10 hours for an academic department.*

> *Consultant: Yes, (but) SAP only counts the main position. The 10 hours are handled through time management/budgeting.*
> *Analyst: [to the consultant] Do you mean that employee occupying more than one position would be counted only once in the FTE (Full-time Equivalent) report? For employees working for 2 or 3 different positions, how will the position data affect FTE reports?*
> *Consultant: SAP recommends a solid line (direct) reporting relationship (between an employee and his main position). We suggest looking at indirect reporting relationship as an enhancement to the system.*
> *User:[looking puzzled]……*
> *Analyst: [Pick up a report on user's desk and talk to user] Let's use this sample FTE report as an example. SAP only reports employee head counts based on the main position. But the data about the second and third positions are stored in SAP. We need to build additional functions (in SAP) if we want to create the headcount reports by all positions.*
> [Observation – HR/Payroll—Org. Management Team, 7/2004]

In this incident, the analyst's *probing* elicited further information about SAP's design as well as the consultant's assumption on the direct reporting relationship. Meanwhile, illustrating with a paper copy of an FTE (full-time equivalent) report helped the users "see" the consequence of accepting the SAP configuration. Together, the analyst's *probing* and *illustrating* practices helped users and consultants to visualize the organizational consequence of adopting the SAP design such that the identification of "Positions" in SAP would change the total headcount number reported. Addressing this pragmatic barrier enabled the knowledge *transformed* to account for the organizational consequence of the domain knowledge, thus facilitating the team's discussion of how to configure the module.

The presence of pragmatic barriers challenged all participants in the user-consultant collaboration. In our follow-up interviews, users echoed that not knowing what to anticipate from the to-be-configured system was a major concern. One frustrated user complained, *"I need something visual to see, some prototype or dummy interface*." Not all analysts were successful addressing pragmatic barriers within the configuration team meetings. In the following exchange on how SAP handled flexible account refunds, for example, the analyst did not bring *illustrating* and *probing* practices to bear on the issue at hand:

> *Consultant: (to users) How do you handle flexible benefits refund?*
> *User (Health System): Negative deduction and positive earning.*
> *User (University): Contributions. If employee does not choose, they get the money back.*
> *Users: How to capture it in SAP?*
> *Analyst: Benefits team will discuss it.*
> [Observation-HR/Payroll – Payroll Team, 10/ 2004]

The users articulated their different processes and raised their concerns, but the analyst simply deferred the discussion of the issue to another configuration team, rather than helping the

consultants understand the rationale for the different business processes. The issue appeared in the team design documentation and later emerged as a strategic business issue for further investigation after the configuration team meetings concluded.

When addressing pragmatic barriers, analysts' boundary-spanning competence relied, in a large part, on their skillful use of *probing*. Analysts asked users "how" and "why" questions about business processes, such as "Why are you doing it that way?" or "How would you like to see processes come up in the new system?" We observed analysts *probing* business users to elicit missing information for consultants, even when users did not see a need to articulate the issues or when the design impact of the issue was not obvious to consultants. By persistently asking "why" questions, analysts helped users uncover pre-conditions of their existing business practices and revealed to consultants unique needs and contextual circumstances, allowing each group's knowledge to be transformed to envision possible solutions and consequences.

Addressing Barriers Due to Authority-Related Knowledge Boundaries

The configuration teams, composed of business users, analysts and SAP consultants, were charged with recommending how to modify existing business processes and specify SAP configurations to meet the requirements of GiantOrg. In interviews we conducted eight months into the configuration project, consultants and business users expressed how goal differences had affected their work. Consultants were the advocates of standardization of business processes. When users did not appreciate the value of SAP's generic "best practices," consultants were frustrated, as one consultant commented: "*User participants are not forward-thinking; they are not taking advantage of the best practices in the enterprise system.*" Users, on the other hand, were frustrated that consultants did not appreciate the uniqueness of their business practices. A user complained during an interview, "*Consultants don't understand our business, and (they) just tried to impose everything from the software on us.*"

Goal differences contributed to pragmatic knowledge barriers when users and consultants interpreted and applied knowledge to configuration tasks differently. In the incidents discussed in the previous section, analysts were able to help users and consultants to overcome pragmatic barriers using *probing* and *illustrating* practices. However, in some instances, adopting a "best practice" approach to standardize policies or processes across business units would have a long-term and strategic impact on GiantOrg. In those instances, analysts had to acknowledge that the configuration team did not have the authority to make such decisions. Barriers to applying shared knowledge to make configuration recommendations (the shared goal of the team) that were manifested in such situations were *authority-related*, that is, they were beyond the capability of analysts or the teams to resolve. Instead, analysts utilized boundary-spanning practices (*translating, illustrating, probing*) to help participants develop sufficient shared knowledge so as to understand each other's perspectives and the underlying causes of the conflicting issues and to elicit knowledge from each party that would be relevant to the appropriate decision-making level. However, analysts had to rely on their practice of *escalating* to present team members' concerns and recommendations to the steering committee to ultimately resolve the configuration issues.

Several incidents we observed illustrated how analysts addressed authority-related barriers through their practice of *escalating*. To benefit from the standardization of the ERP package, consultants encouraged users from the different business units to consider the possibility of consolidating seven medical plans, including five offered at the University and two offered at the Health System. However, users from the University immediately rejected the idea of consolidating medical plans, as field notes from this lengthy discussion suggested:

> *User 1 (University): We won't drop the Blue Cross and Blue Shield plan for the University. It is universal. What will be taken away is the key.*
> *User 2 (University): We (the University) are in a different market (from Hospitals). 403b makes us comparable with other educational institutions. The university's tax code is under government regulation.*
> *Analyst: [To consultants] University and hospital employees compare benefits. We will present to the executive committees the potential pros and cons (of this issue).*
> [Observation – HR/Payroll – Benefits Team, 6/2004]

There were no syntactic or semantic barriers evident in the above discussion, and the pragmatic barrier to deciding how user and consultant knowledge might be melded into a solution was overshadowed by the severity of this authority-related barrier. Users knew their organizations would resist giving up flexible benefits, yet the configuration of the ERP package required an agreed-upon policy be specified and documented. In these situations, they also realized they did not have the authority to make the final decision about standardization, which the consultants advocated. Instead, analysts helped consultants to understand the intricacies of GiantOrg's policies and practices for benefits by encouraging users from different institutions to articulate their practices and rationales. The team could then record the details on the issues, labeled as a "strategic business issue (SBI)," and pass the issues along to the PMO and the steering committee with appropriate explanations and analysis. In such instances, the knowledge relevant to the issue was *negotiated* among the team members, although deciding (negotiating) whether to consolidate benefit plans or not was left to the steering committee.

Sometimes an authority-related barrier had embedded semantic and pragmatic barriers. In a discussion of the Finance module's cost allocation method, consultants and users encountered a major hurdle, the two-tier cost structure (the primary vs. secondary cost elements). The ERP system was designed assuming that primary cost accrued at the enterprise level and secondary cost for business areas within the enterprise. However, GiantOrg's four units each had their own business unit structures, and the four units managed cost transfers as transactions between divisions of the four institutions, a third cost structure level referred to as an "intra-divisional transfer." Intra-divisional transfers were substantial, amounting to billions of dollars annually. Users worried about the loss of intra-divisional transaction data as a result of adopting SAP system. Consultant did not understand the complexity of this issue at GiantOrg:

> *User 1 (University): (In SAP) How can we handle the internally-generated revenues?*
> *Consultant: It is not revenue.*
> *User 1 (University): But it is revenue for division one, and cost for division two.*

> *Analyst: [To user] Our consultants' recommendation is always standardization, not divisional or departmental specific accounts. [To consultant] Please correct me if I am wrong.*
> *User 2 (University): Our institution has so many intra-company transactions. We need a clear definition.*
> *Analyst: [to users from Hospital] Hospital folks, what do you think? On the financial statements, you might use primary cost for transactions with related parties (from another GiantOrg institution)?*
> *User 3 (Hospital): [to the Analyst] This issue (intra-company transaction) is a big deal for us. Who has the final say on the major decision here?*
> [Observation – Finance – Cost Allocation Team, 10/2004]

This exchange among participants suggested semantic barriers (what is "revenue" for GiantOrg) and pragmatic barriers (i.e., applying standardization goals to the understanding of transactional flows), but the analyst's *probing* could not resolve this configuration issue at the meeting. Instead, in the subsequent discussion, each participant's knowledge of the situation was elicited and documented and the issue recorded as a SBI (strategic business issue) for the PMO. Relying on their *escalating* practice, analysts facilitated the interactions of the configuration team, which were the first steps in *negotiating the knowledge* relevant to making a good configuration decision for GiantOrg. Actually overcoming this authority-related knowledge barrier entailed a number of additional steps by the PMO. Written communications distributed to the team indicated that a special focus group was formed to investigate the issue and to analyze the potential impacts on the organization. The steering committee utilized the focus group's analysis to decide to customize the SAP system to fit into GiantOrg's unique context, by combining account numbers with cost codes to support intra-divisional transactions. This final configuration decision was recorded and specified in the blueprinting design document.

Authority-related barriers challenged analysts to employ multiple boundary-spanning practices in an attempt to clarify and resolve knowledge boundary issues rather than to simply "pass the bucket" to other teams (as discussed earlier) or to upper management. However, boundary-spanning competency in these instances also required analysts to acknowledge their own and the team's limitation to do so in some instances. By engaging in *escalating*, they could best address these substantial barriers to knowledge flows in the teams' collaborative work.

KNOWLEDGE BOUNDARIES, SPANNING PRACTICES AND KNOWLEDGE OUTCOMES

In multiparty IS knowledge work such as the ERP configuration project reported on here, building shared knowledge across the specialized knowledge domains of participants is critical to effective collaboration. Our case analysis illustrated how barriers to knowledge sharing can develop due to increasingly complex knowledge boundaries (*syntactic, semantic, and pragmatic*), as discussed by Carlile (2002). We identified a fourth type of barrier (*authority-related*), which arose when differences in goals and priorities contributed to differences in the domain knowledge of participants, requiring a higher level of authority to arrive at a solution. By closely observing the interactions among IT consultants, business users, and analysts who served as designated

boundary spanners, we identified four spanning practices that analysts enacted to tackle these barriers and revealed the interrelations between those spanning practices and the increasingly complex knowledge barriers. Overcoming syntactic barriers entailed analysts' *translating* and *illustrating*, resulting in the communication of knowledge. Semantic and pragmatic barriers required *illustrating* and *probing* practices, and removal of those barriers enabled knowledge being integrated and transformed respectively. Finally, overcoming authority-related barriers involved knowledge negotiation, and relied on *escalating* in addition to other three spanning practices. Figure 1 summarizes the findings and provides a guide to our discussion of the patterns we observed among types of knowledge barrier, spanning practices and knowledge outcomes.

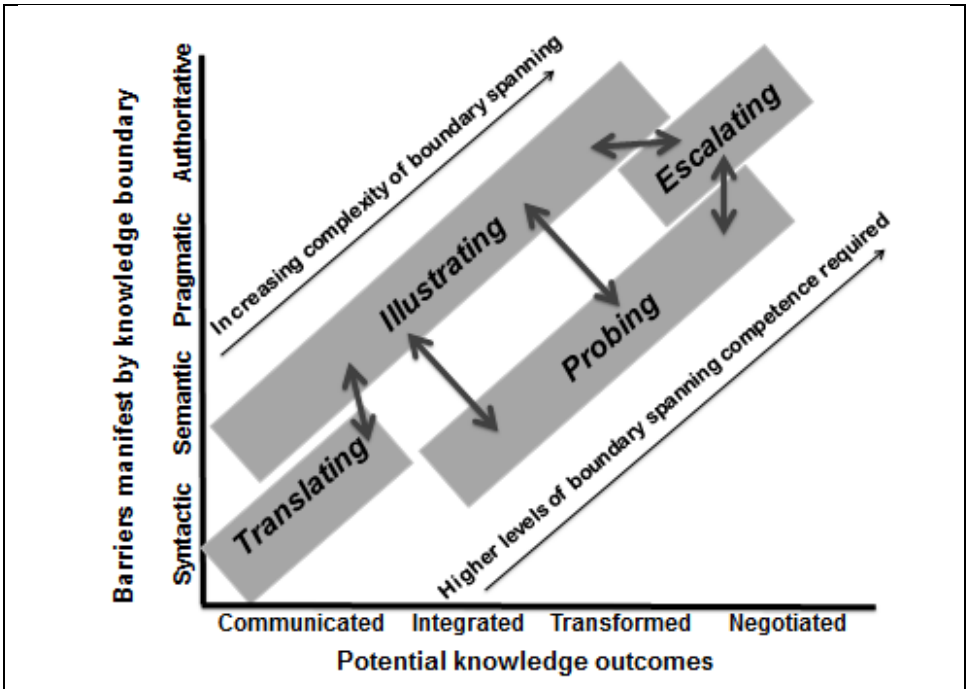

Figure 1: Patterns in Knowledge Boundary Spanning Practices

Knowledge Barriers and Boundary-Spanning Practices

To address *syntactic* knowledge barriers, common language and syntax were needed to *communicate the knowledge* of members of one domain -- whether the technical knowledge of the IT consultants or the organizational knowledge of the business users -- to members from the other domain. Analysts' *translating* practice typically sufficed to enable users and consultants to understand each other (Pawlowski and Robey, 2004), and thus to communicate key ideas. If *translating* was insufficient, analysts tried *illustrating* with examples relevant to either group. Addressed in these ways, syntactic barriers were not inherently problematic (Carlile 2004). At *semantic* barriers, analysts enacted practices that suggested to team members a relevant context in which to *interpret knowledge* from each other's domain. *Illustrating* with context-specific

examples was effective in some instances. In other instances, analysts also employed *probing* to elicit additional contextual details, which they did not know themselves, or to surface underlying assumptions and thus help clarify possible misinterpretations of consultants or users.

Deciding how to best configure the SAP packaged system to fit into GiantOrg's operations required consultants and users to envision the consequences of applying their technical and organizational knowledge when proposing configuration decisions. *Pragmatic* knowledge barriers developed when users and consultants had different understandings of the to-be-configured technical system or the potential organizational consequences of a configuration decision. Analysts drew on *illustrating* and *probing* to help users and consultants visualize its potential consequence. *Probing* with "why" and "how" questions was particularly important to help users and consultants *transform their stock of knowledge* to a shared, contextually-situated interpretation and design recommendation. Analysts' spanning practices facilitated consultants' and users' careful consideration of the standardized principles in the SAP system and the implications for the unique conditions at GiantOrg, reducing the risk of making blind configuration decisions (Pozzebon and Pinsonneault 2005).

It is not surprising that the configuration teams encountered *authority-related barriers* to knowledge sharing in this multiparty project, which involved four previously autonomous business units as well as an external consulting organization. Not only did participants from each unit have different stocks of knowledge to bring to the joint effort, but each had (to some extent) different priorities and goals for what knowledge was most relevant or should shape their joint decisions about system configuration and future organizational practices. Beyond pragmatic barriers, these tensions gave rise to *authority-related barriers* to knowledge sharing when participants did not have the organizational authority to negotiate a final configuration decision that would have substantial organizational implications, but they could influence upper management's decisions by how knowledge relevant to the issue was negotiated within the team's sessions for later presentation. In situations like these, participants may selectively share knowledge that is in their own (organizational) interests (Willem and Scarbrough 2006). Highlighting this political aspect of knowledge, Marshall and Brady (2001: 110) comment, "it is crucial to move beyond a concern with interpretative dimensions of knowledge practices to embrace an understanding of the relationship between knowledge, interests, power and identity." To address authority-related barriers, analysts helped *negotiate the knowledge* relevant to the issue by *probing* and *illustrating*, as well as by *escalating*. Combining these boundary-spanning practices, analysts enabled participants to better understand and acknowledge divergent stakeholder interests, even though final decisions were deferred to higher-level authorities.

As Figure 1 depicts, our case analysis did not suggest a simple one-to-one relationship between knowledge barrier types, knowledge outcomes and spanning practices. Instead, we found that as the complexity of knowledge barriers increased, the development of shared knowledge became more challenging, requiring analysts to enact boundary-spanning practices in concert, iteratively or in an integrated manner. Doing so successfully required a higher level of boundary- spanning competence. As Carlile (2002) notes, syntactic boundaries were the least problematic and translating the jargon or terminology in more familiar terms typically proved to be sufficient. At

the other extreme, authority-related barriers could have embedded pragmatic or semantic barriers, requiring analysts to draw from multiple spanning practices. The barriers to sharing knowledge for some configuration decisions were addressed in stages, from initial *illustrating* and *probing* to elicit sufficient knowledge details, to *escalating* to the PMO, followed by the special focus groups' research and senior management's intervention.

Boundary-Spanning Practices and Boundary-Spanning Competence

Our observational accounts of analysts' boundary-spanning practices may depict analysts as simply following project guidelines and procedures and utilizing typical facilitation methods. However, analysts' enactment of boundary-spanning practices in the flow of conversation, interactions, and debate were skillful, situated actions (Orlikowski 2002), requiring analysts to connect abstract guidelines with detailed circumstances emerging in the process and flow of user-consultant interactions. Analysts had to recognize when a knowledge barrier emerged, enact appropriate practices to help users and consultants overcome the barrier, and assess whether sharing knowledge was sufficient in the situation. We observed numerous incidents in which analysts recognized and acted on subtle cues to tackle an emergent barrier successfully, as well as some incidents when an analyst failed to recognize or to act to overcome barriers.

In this type of complex knowledge-intensive collaborative work of software configuration, beyond simply facilitating the meetings, the analysts on the teams needed to develop overlapping knowledge of the various business units as well as the SAP software, as the prerequisite competence for boundary spanners. Being conversant in both the business domain and technical domain, analysts could more effectively translate and thus facilitate the communications between business users and IT consultants. Translating is critical to IS professionals' bridging activities across user departments (Pawlowski and Robey 2004). Moreover, analysts could draw from their own knowledge to illustrate or to probe for more information from users and consultants. Also important, analysts had to understand when the teams' authority was insufficient and therefore to escalate a configuration decision.

Analysts' knowledge was not simply set in training and then applied in team sessions. Analysts' overlapping knowledge of the technical domain (SAP in this case) and the business domain deepened as analysts facilitated the requirements sessions and interacted with consultants and users over time. As one analyst noted in an interview, "*every time I probed consultants for more information on users' behalf, that (probing) enhanced my understanding of the SAP system*." That is, boundary-spanning competence was not simply trained; it developed and deepened through analysts' enactment of spanning practices. "Knowing in practice" (Orlikowski 2002) is essential to building boundary-spanning competence individually and within an organization. As Orlikowski (2002: 253) comments: "Continuity of competence, of skillful practice, is thus achieved not given. It is a recurrently but nevertheless situated and enacted accomplishment which cannot simply be presumed. The status of competence is more provisional—because it is always to be achieved—than we tend to assume when we treat it as given."

Implications for Practice

Boundary-spanning competence has become an important skill for IS professionals, as they increasingly interact with business users and bridge business units in IS post-implementation support (Pawlowski and Robey 2004). Our study holds several implications for how boundary-spanning competence may be nurtured within organizations. First, the dynamic interplay between knowledge barriers and spanning practices suggests that developing individual competence in spanning knowledge boundaries requires a designated boundary spanner to develop an understanding of how knowledge boundaries may create barriers to effective knowledge sharing and to become skilled in surmounting barriers through practices such as translating, illustrating, probing, and escalating. Second, identifying candidates for knowledge spanner roles as well as planning the development of spanning competence are both important to nurturing this skill set within an IS organization or IS project team. By recruiting individuals with strong functional expertise and organizational experience and by providing them with SAP technical training, GiantOrg provided a strong foundation for their designated knowledge boundary spanners (the analysts) to develop a peripheral understanding of each knowledge community and assume a legitimated role of "bridging" between consultants and users (Levina and Vaast 2005). Those analysts then built on this foundation through their experience during requirements and design configuration phases of the project.

CONCLUSIONS

The success of large organizational IS projects often depends on experts from business functions, IS departments, and IT vendors and consultants working collaboratively to combine their knowledge and expertise in the design and development of an organizational information system. The difficulties in effectively doing so have long been recognized by IS researchers (Curtis et al. 1988; Joshi et al. 2007; Volkoff et al. 2004). Factors contributing to knowledge boundaries (Carlile 2002; 2004; Pozzebon and Pinsonneault 2005; 2012; Robey et al. 2002) and the contributions of boundary spanners in IS activities generally (Levina and Vaast 2005; 2006; 2008; Pawlowski and Robey 2004) have also been investigated. This study contributes to these varied research streams a detailed account of knowledge spanning practices enacted by boundary spanners in a type of collaborative, knowledge-intensive IS work (packaged software configuration). Our study highlights how designated knowledge boundary spanners enhanced knowledge exchange and integration in this multi-party collaboration by skillfully enacting boundary-spanning practices (translating, illustrating, probing, and escalating) in the progress of user-consultant interactions. Our case analysis highlights how knowledge barriers, spanning practices, and knowledge outcomes are interrelated with the competence in knowledge boundary spanning. Boundary-spanning competence is important not only for professionals in the IS field (Pawlowski and Robey 2004; Sawyer et al. 2010), but also for professionals in any setting where the ability to span knowledge boundaries is important (Van Fenema et al. 2007; Walker and Nocon 2007; Willem and Scarbrough 2006). Our study contributes to research investigating organizational challenges in transferring and integrating knowledge in organizations (cf. Bechky 2003; Carlile 2002; Szulanski 1996) by offering an account of boundary spanning as enacted practices, which complements earlier studies of boundary-spanning roles and strategies (cf. Ancona and Caldwell 1992; Star 1989).

We investigated knowledge boundary spanning in one type of collaborative, knowledge-intensive IS project setting: co-located and synchronous collaboration in a U.S. enterprise. We drew on multiple data sources in an in-depth, longitudinal case study that enhanced our analysis of knowledge spanning practices, enabling us to identify four fundamental knowledge spanning practices. Although the empirical findings of this case are not generalizable to other research sites or settings without further study, the analytic generalizations of knowledge barriers, knowledge outcomes, and knowledge spanning practices can help guide empirical research in other contexts (Lee and Baskerville 2003). Empirical studies in other collaborative settings may reveal additional knowledge spanning practices and refine our understanding of how practices interrelate and their efficacy under different constraints.

Two directions to extend our study are particularly promising. First, organizations are increasingly using distributed and multidisciplinary teams to perform systems development tasks (Ratcheva 2009). Distributed, outsourced and global IS development (Levina and Vaast 2008) has become "the new norm" for IS development projects. The analytic categories and interrelated patterns identified here could provide theoretic guidance for empirical studies of knowledge boundary spanning needed to coordinate diverse knowledge and expertise in such geographically distributed knowledge worker teams (Levina and Vaast 2008) or in offshore cross-cultural software development teams (Barrett and Oborn 2010). The barriers to effective knowledge sharing that we investigated, arising between technical and business knowledge domains, are likely to be complicated by differences in spoken language, culture, status, geographic separation, and so on (Levina and Vaast 2008). The sources of shared knowledge that boundary spanners might require and acquire through practice will be more diverse and challenging, thus requiring a wider array of knowledge boundary spanning practices. For example, "translating" might be a multi-faceted practice encompassing language, culture, legal systems, as well as business context and technical knowledge boundaries.

Second, IS development projects are typically carried out over time and across stages of requirements specification, design, development, and implementation. Although critical aspects of IS work may be carried out in face-to-face (or distant but synchronous) project team settings, project artifacts such as presentations, meeting minutes, design model documentations, prototypes or test versions of a system are important vehicles for consultant-user configuration teams to exchange different stocks of knowledge and to record their negotiated configuration decisions. The role of project artifacts as boundary objects (Star 1989) to enable integration and coordination of work by different specialists has been studied in new product development (Bechky 2003; Carlile 2002) and in information system development (Barrett and Oborn 2010; Doolin and McLeod 2012). Although the study reported here focused on verbal exchanges, we did observe analysts drawing upon project artifacts in their knowledge boundary spanning practices, for example using report prototypes for illustration purposes. We also noted that analysts displayed different levels of skill in using boundary objects in their spanning practices. IS boundary objects are embedded in practices (Doolin and McLeod 2012) and are subject to differing interpretations (Barrett and Oborn 2010). Research that examines knowledge boundary spanning practices embedded in or reliant on boundary objects could extend our understanding of how spanning practices are enacted and their efficacy across a broader scope of IS activities and

timing. For example, the practice of probing might be enacted through memos or emails to remote colleagues or through prototype testing, as well as through verbal exchanges.

Knowledge boundaries are an intrinsic aspect of collaborative knowledge-intensive work. The expertise of bounded domains contributes to innovative knowledge work but also contributes to potential barriers to the effective sharing of knowledge across domains. Although knowledge boundary spanners cannot be expected to overcome all knowledge barriers in multi-party collaborations, holding an integrated conceptualization of knowledge boundaries, barriers, knowledge outcomes, and spanning practices will, we hope, help organizations and project teams to better identify and address those knowledge barriers as they manifest.

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Appendix A: Sample Matrix on Knowledge Boundaries and Spanning Activities

Example	**Knowledge Boundary**	**Spanning Practice**	**Knowledge Sharing Implications**	**Data Source**
Project Team / Topic: Payroll/Wage Deduction				
(1) Payroll deduction codes for wage deductions.	Syntactic	Translating	Knowledge about the deduction codes in SAP was *communicated* to users.	Workshop observation in 07/2004; team's requirements model in 09/2004.
(2)Different tax consequence between loan and payroll advance	Semantic	Illustrating and probing	Knowledge was *integrated*. Users understood the meanings of loan and payroll advance for their institutional context.	Workshop observation in 07/2004; team's requirements model in 09/2004.
(3)Different approaches to treat Flexible benefits refund: negative deduction by hospital and positive contribution by the University. Confusions about how SAP will handle it.	Pragmatic	No boundary spanning at the meeting.	The issue, unsolved, marked in the teams' requirements document for further investigation.	Workshop observation in 10/ 2004; Team Design Model in 02/2005.
Project Team / Topic: HR/Benefits Management				
(4)Different definition of full-time employees across the four institutions	Syntactic	Translating	Knowledge about organizational definition was *communicated* to consultants.	Workshop observation in 06/2004; Team's requirements model in 09/2004.

(5)Relationship between employee category (full-time vs. temporary) and eligibility for full-time benefits, e.g., option nurse who works 20 hrs/week & enjoys full-time benefits.	Semantic	Probing	Knowledge was *integrated*. Users understood the meaning of benefits eligibility and employment type for their institutions.	Workshop observation in 10/2004; team design model 02/2005.
(6)Implication of combining "spouse" and "Same Sex Domestic Partner" under one dependent type in SAP. Different tax consequences.	Pragmatic	Illustrating Probing	Knowledge was *transformed*. Users understood the consequence of dependence type on tax, and co-created a new category with consultants, who then coded it into the software configuration table.	Workshop observation in 10/2004; team design model 02/2005.
(7)Consolidating benefits plans across the Health System and the University.	Authority-related	Probing Escalating	Knowledge was *negotiated*. PMO and the steering committee reviewed the team's proposal, called upon a focus group, and resolved the issue.	Workshop observation 06/2004; Team's email; team requirements model 09/2004.

Appendix B: Sample Matrix on the Evolution of Knowledge Barriers

Project Team/Main Issue	**Requirements Meeting (07/2004)**	**Requirements Documentation (09/2004)**	**Functional Design Meetings (10/2004)**	**Design Documentation (02/2005)**
(1) *HR/Benefits Management:* Job-Position Structure	No syntactic barrier; *Resolved* Semantic Barrier (The relationship between job and positions)	*Resolved* Semantic Barrier	*Resolved* Pragmatic Barrier (Job-Position Structure Affected FTE reporting)	*Resolved* Pragmatic Barrier
(2) *Payroll/Wage Deduction*: Different approaches to treat Flexible benefits refund --negative deduction by hospital and positive contribution by the University.	No syntactic barrier; No semantic barrier	No syntactic barrier; No semantic barrier	*Unresolved* pragmatic barrier (How SAP Handle funding flexible spending accounts) unsolved, marked in the teams' requirements document for further investigation.	*Unsolved;* Marked in the team' document for further investigation.

(3) Finance/Cost Allocation: Two-tier cost structure (primary vs. secondary cost center)	No Syntactic barrier; *Resolved* semantic and pragmatic barriers	*Resolved* semantic and pragmatic barriers	*Unresolved* authority-related barrier (financial consequence of the two-tier structure on intra-divisional transfer)	*Resolved* (PMO and the steering committee reviewed the team's proposal, called upon a focus group as a result of the team escalation)

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