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Abstract
This paper takes a dynamic approach to understanding the nature and role of boundary objects by examining them in relation to the social infrastructures within which they are embedded and to the social identities of the groups that share them. It explores the premise that boundary objects are used not only as a translation device, but also as a resource to form and express social identities. It further suggests the occurrence of a dynamic process whereby changes in boundary objects enable changes in social infrastructures and social identities in one group. These changes, in turn, create the conditions for change in bordering groups through shared boundary objects. Based on interviews which were conducted over three years, we illustrate these ideas by presenting three vignettes that describe the introduction of 3D modelling technologies into the AEC industry and the changes that consequently occurred.

Keywords: Boundary Objects, Social Infrastructures, Social Identities, Organisational Change

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The Dynamics of Boundary Objects, Social Infrastructures and Social Identities

Introduction

Information technology is increasingly being used to support knowledge work and collaboration among individuals from different communities of practices, and the notion of boundary objects has emerged as a useful conceptual device to study its role. Issues such as representing knowledge and bridging conceptual differences among various social contexts have been central concerns in that regard (Boland & Tenkasi, 1995). Boundary objects are abstract or physical artefacts which reside in the interfaces between organisations or social communities (these terms will be used interchangeably) and have the capacity to bridge perceptual and practical differences among diverse communities in order to reach common understandings and effective cooperation (Henderson, 1991; Karsten et. al., 2001). Thus, boundary objects have been conceptualised as a basic condition for the emergence of a mutual semantic foundation on which meaningful communication can take place among different social entities such as organisational functions or groups of professionals (Star & Griesemer, 1989; Bowker & Star, 1999; Carlile, 2002).

Past work on boundary objects has focused on their role as *translation devices* that mediate two or more social communities. According to Star and Griesemer (1989), certain artefacts are flexible enough to accommodate different interpretations emanating from the various social groups, yet robust enough to maintain a common identity across all social contexts, thus allowing translation to take place across the boundary. This theme is evident in the work of various authors all demonstrating the occurrence of translation in different contexts (e.g.: Carlile, 2002; Henderson, 1991; Ackerman & Alverson, 1999; Yakura, 2002).

However, for the most part, past research on boundary objects has not examined the internal dynamics of interacting social communities and has implicitly assumed that social communities and the boundary objects they employ do not change over time. In part, this is because the emergence and use of boundary objects have mostly been examined in a context of relatively stable settings and/or for short periods of time.

In this paper, we propose to take a more dynamic approach to understanding boundary objects by examining their relationships with the *social infrastructures* within which they are embedded and with the *social identities* of the groups that share them. Doing so illuminates the role of boundary objects as a resource used by social groups to form and express their social identities, and the dynamic process by which changes in boundary objects enable changes in social infrastructures and identities in one group which, in turn, create the conditions of possibility for change in bordering groups when engaging shared boundary objects.

In this study, we focus on the role of IT artefacts as boundary objects in this dynamic process. Due to its inherent ability to embed complex computational and modelling capabilities and its interpretive flexibility (Bijker, 1995), IT artefacts prove to be particularly interesting boundary objects to study (Carlile, 2002). Communities imbed technology into their working practices and into their group and professional projects (McLaughlin et. al., 1999). These incorporations of technology take many forms and involve diverse evaluations and attributions of meaning. Technological artefacts are used as vehicles to communicate among diverse groups,

and as resources to frame and enact their social identities. However, past studies on IT artefacts, as boundary objects, have not examined their role in the dynamic changes of social identity and infrastructures among interacting organisations.

To explore this dynamic process, we will present an example from the Architecture, Engineering and Construction (AEC) industry in which changes in some of the actors' IT boundary objects are interrelated with changes in their social infrastructures and social identities. We will describe how changes in boundary objects are part of an ongoing process in which an organisational change in one party to an interaction facilitates further changes in neighbouring organisations.

In what follows, we first review the literature on boundary objects. Second, we introduce the theoretical framework and constructs we use in the paper. Third, we illustrate the framework using an example from the AEC industry. Fourth, we present a discussion and fifth, we identify contributions, limitations and suggestions for future research.

Background: Boundary Objects in the literature

The notion of boundary objects was first introduced by Star and Griesemer (1989), who described the attributes of boundary objects that enable them to serve as translation devices: they inhabit several intersecting social worlds and satisfy the informational requirements of each; they are weakly structured in common use and become strongly structured in individual-site use; and they have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable and function as a means of translation. They conclude that the creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting communities (Bowker & Star, 1999).

The concept of boundary objects has been subsequently applied in various contexts such as design teams (Henderson, 1991; Henderson 1998; Subrahmanian et. al., 2003), new product development (Carlile, 2002), accounting systems (Briers & Chua, 2001), production and manufacturing systems (Garrety & Badham, 2000; Karsten et. al., 2001) and implementation of information systems (Yakura, 2002). These studies have expanded the original conceptualisation of boundary objects by adding a variety of distinctions. For example, Garrety and Badham (2000) distinguished between primary and secondary boundary objects in socio-technical projects, the former being the technology itself – the material artefact around which activity is organized, and the latter being other physical or abstract entities that enable communication across social communities (e.g. contracts). Brier and Chua (2001), on the other hand, distinguished between ideal and visionary boundary objects. Visionary boundary objects are conceptual in nature and therefore cannot be argued against (e.g. institutionalised organisational "best practices"). Finally, Carlile (2002) distinguished among different types of boundaries – syntactic, semantic, and pragmatic - that require different types of boundary objects. He argued that as novelty of the situation increases, organisations will face more pragmatic boundaries and they will need boundary objects that allow them to see the consequences of social interactions with other social groups. Thus, Carlile anticipates that boundary objects may be dynamic, but does not elaborate on the change process.

Different artefacts in different contexts have been studied as boundary objects. For example, Yakura (2002) looked at timelines (i.e. a graphical representation of a set of temporal units in the lifetime of a project) as boundary objects, and demonstrated their ability to reconcile diverse socially constructed temporal arrangements. Henderson (1991) emphasized the role of

visual representations as boundary objects in the world of design engineers. Karsten et. al. (2001) studied the role of boundary objects in the process of perspective taking (Boland & Tenkasi, 1995). Finally, Subrahmanian et. al. (2003) discussed changes in design and manufacturing teams and the consequent affects they have on boundary objects. They claimed that changes disrupt common grounds among organisations and therefore open a debate on the role of existing boundary objects, but fall short of exploring the dynamic process by which boundary objects relate to social infrastructures and identities.

Although the types and use of boundary objects have been examined in a variety of organisational and social settings, most research on boundary objects has examined them in a context of relatively stable settings and/or for short periods of time. A few exceptions hint at the potential for dynamic change in boundary objects, but do not explore that dynamic process. In addition, research on boundary objects has not explored the social dynamics within interacting groups, or the changing social identities and infrastructures that are associated with dynamic boundary objects. In short, the relationship between social infrastructures, social identities and the creation and maintenance of boundary objects has remained largely unexplored.

In this paper we argue that boundary objects not only serve as translation devices to overcome informational differences between interacting groups, but that they are also used as *a resource to form social identities* in a primarily relational process that takes place in the interface between groups. We further maintain that boundary objects are an immanent part of a dynamic process in which changes in social infrastructures and identities in one group cascades into bordering groups through the use of mutual boundary objects. In the next section, we will describe these constructs and lay out the dynamics of their interrelations, drawing on the work of Berger and Luckman (1966).

Theoretical Perspective and Constructs

Social Infrastructures

Social infrastructure refers to a contextual background for practice and thought (Star, 2000). A well functioning infrastructure is in the background in the sense that it remains invisible and undisputed as long as breakdowns do not occur. It is contextual because it serves as an infrastructure only in relation to organized systems of practices and meanings, so that what seems natural and taken for granted for members of one community may acquire different meanings and possibly seem artificial and foreign to members of another.

Systems of practices and meanings are similar to Berger and Luckman's objective and subjective worlds (1966). They argue that society is constituted in an ongoing dialectical process composed of the three moments of externalisation, objectivation, and internalisation. The process of externalisation involves the casting of human subjectiveness into the social world and the subsequent perception of this subjectiveness as an objective, external reality. When activities are repeated frequently they tend to be cast into a pattern and performed recurrently in the future as part of a routine and taken for granted way of doing things. This process involves typifications of actions by type of actors. Namely, each institution implies that specific actions should be performed by specific actors. An interrelated set of institutions constitutes an *objective world*, which orders social activities and thought by providing normative guidance and cognitive mapping on the basis of which certain activities carried out by certain people are seen as acceptable whereas others are not. (We wish to emphasize that, often times, institutions are organised around technological artefacts).

Actors are inducted into participation in the social dialectic though a process of socialisation during which specific institutional orders are internalised and role-specific knowledge is acquired. Socialisation also requires the attainment of role-specific vocabularies and the internalisation of values and semantic fields that facilitate routine interpretations and conduct within an institutional area. This way, an objective world is accepted as a given reality and used as a basis for action and thought. The unique repertoire of language, knowledge, values and semantic fields that enable and are exhibited in the participation in the social dialectic constitutes the *subjective world*.

Social infrastructures entail a stream of ongoing practices and concepts which hold particular meanings (objective and subjective worlds respectively) to members of a community. Over time the association of specific practices or concepts with specific intents, or the recognition of certain practices and concepts as expressing certain meanings, becomes accepted as natural and is no longer reflected upon, at which point it recedes into the background and becomes part of the infrastructure. Then it serves as a basis on which people construct new meanings and practices.

Boundary Objects

To be sure, boundary objects are part of the social infrastructure. Analytically it can be argued that they are part of the objective world. This is because they are tangible occurrences in the world. By that we do not mean that they necessarily have a material manifestation but rather that they represent a phenomenon to which people refer and in relation to which they construct meanings. However, boundary objects are unique because they spread across two or more objective worlds. They are an infrastructural phenomenon that is shared by members of more than one community in the course of their interaction. Therefore, they are located at the interface of two or more social infrastructures, a region where one infrastructure starts and another ends[1].

Boundary objects have one objective manifestation. That is, they are embodied in a specific artefact (physical or conceptual) which is recognizable as such to members of more than one community. However, the meanings that are constructed in relation to boundary objects differ across communities (this illuminates the contextual nature of the infrastructure). This is because boundary objects are supported by and interpreted in light of different infrastructures that get produced over time by the interacting communities.

Social Identities

The concept of social identity was developed by Tajfel (1982) as part of a larger social identity theory. Social identity theory claims that individuals will usually strive to maintain a positive image of their self identity. Since some facets of their self identity are derived from the groups which they conceive themselves to be part of, they will tend to perceive those groups as favourable compared to other groups to which they do not belong. Therefore, social identity is constructed in a relational process. This comparative perspective links social identity theory with self categorization theory (Oaks & Turner, 1990; Turner, 1985). The latter views social identity as inherently relational and conceives of social perception as being bound up with capturing the

[1] An interface is a dynamic conceptual construct rather than a stable concrete one. Examples are: communication between a customer and a company through a website, the work of a translator, or crossing time zones. In all these examples boundary objects will be used. E.g., a website in the first example, a dictionary in the second one, and a watch in the third.

meaning of one group in relation to another. Accordingly, social identities are representations of the group-in-context, and are defined not only based on similarities among group members and on shared experiences, but also through differentiation from those without. Therefore, as the nature of the 'other' constituting the comparative frame of reference changes, so too must the meaning of the relevant groups.

Dynamic Relationships among Boundary Objects, Social Infrastructures and Social Identities

We propose a theoretical model that describes the dynamic interplay among social infrastructures, boundary objects and social identities of interacting social groups (See figure 1). The black arrows in the figure connote that the elements in the model are related to each other in a reciprocal manner rather than a causal one. Below, we explain the relationships among the key constructs in detail.

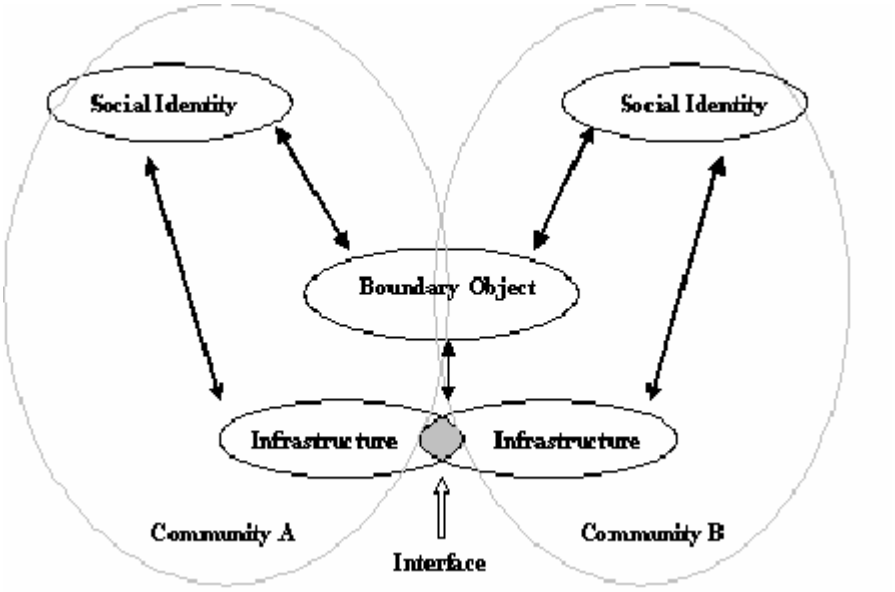

Figure 1. The dynamic relationships among boundary objects, social infrastructure and social identities

Boundary Objects and Social Identities. Communities establish and express their social identities by using boundary objects and therefore, in relation to other communities. This is done in a process of differentiation between the ingroup and the outgroup which takes place at the interface (a conceptual area where at least two infrastructures meet). Certain boundary objects are used to highlight specific aspects of a group identity to differentiate it from the other groups it interacts with. For example, a nation's flag is meant to capture some *unique* essential characteristics of its people's spirit or history and represent them symbolically in a way that both solidifies its social identity and communicates it to other nations. However, boundary objects do not only represent social identities, but may also reshape them. Thus, in the course of history, as

various experiences are constructed in relation to it, a nation's flag may not only symbolize an existing social identity of a people, but actively reshape it.

Social Identities and Infrastructures. Social identities are also shaped through participation in the social infrastructure and in light of a mutually constitutive set of institutions and related meanings that are attached to them. At the same time, social infrastructures are continually formed by recurring activities which are manifestations of social identities. Therefore the two constructs are tied together in a reciprocal relationship. For example, new work groups develop specific social identities as they work together in accordance with normative practices and specialized knowledge and language that enable members to proficiently participate in the emerging social infrastructure, which itself is continually shaped by activities that are expressions of the developing social identities.

Boundary Objects and Interfaces. Boundary objects are embedded in the interface. They are represented in practices, institutions, and artefacts that make up the social infrastructures of different communities and are rendered meaningful in the course of interaction among them. In that sense they are enabled via ongoing interactions. However, boundary objects also enable interactions. Their inherent vagueness is what makes possible the maintenance of ongoing collaborative relationships among communities even in the absence of an agreed upon set of shared meanings. For example, a bi-lingual dictionary would only be necessary in bi-lingual interactions and would otherwise be insignificant. In that sense, it is enabled by the interaction. At the same time, without a dictionary, a bi-lingual interaction would be meaningless and therefore it is made possible because of it.

The constructs that make up our theoretical model are weaved in together in such a way that a change in one will result in changes in the others in a circular process that crosses organisational boundaries. For example, when an element in a community's infrastructure changes, let's say an information system which is essential to the daily functioning of that community, practices and work routines change as well. As a result, definitions and meanings of existing institutions could change (job responsibilities, organisational structure, group objectives etc.), which could lead to a re-conception of the community's perception of itself – its social identity. This, in turn, could facilitate the use of new boundary objects or the reinterpretation of existing ones to communicate the changes in identity to other communities with which the first community interacts. However, since boundary objects reside in the interface of two or more communities, changes in them will then originate further changes in bordering communities which share the same boundary objects.

Our theoretical model offers two important implications. First, boundary objects are used not only as a translation device to bridge informational and practical gaps between communities, but also as a resource to form and inform social identities. Second, boundary objects are part of a dynamic system whose elements are bound up together in reciprocal relationships. When change occurs in one of the elements it will carry over to the others. Most importantly, these changes cannot be accommodated within a single organisation. Transformations in one organisation will cascade to neighbouring organisations through joint boundary objects.

In the next section we will illustrate these ideas using an example from the AEC industry. There, we examine how the use of a new information technology (3D visualisation tools) as a boundary object, initiates the dynamic and reciprocal cycle of organisational transformations, as described in our theoretical model.

Empirical Lens: Vignettes of Boundary Objects and Identities in the AEC Industry

Effective collaboration in large-scale construction projects requires efficient management of information flow and skilful coordination of group activities. This is particularly important in the Architecture, Engineering and Construction (AEC) industry, where the parties involved in the design and construction process are necessarily multidisciplinary and represent diverse design, contracting and supply firms. Participants in a construction project typically work independently while making decisions that inevitably affect the other participants in the construction process. Hence coordination, communication and boundary objects are a central component of all major AEC endeavours.

The observations that follow are based on multiple interviews which were conducted over three years. We interviewed numerous stakeholders in the AEC industry in the United States in an effort to examine the dynamics of organisational change and innovative activities that occurred as digitised, three dimensional (3D) modelling technologies were introduced into the industry by architect Frank Gehry (Boland et. al., Forthcoming). In this paper, we focus on one general contracting company, Hoffman Construction Company (thereafter Hoffman Construction), and examine how their social infrastructure, social identity and boundary objects have changed in a dynamic process of reciprocal adjustments.

Normally, the responsibility to oversee the effective coordination and cooperation among the various stakeholders in a project lies on the shoulders of the general contractor. The general contractor receives the contract documents from the architects and manages the communication and coordination process on behalf of the owner of the building. The contractor is in charge of managing communication channels among the different subcontractors and of mediating communications between the subcontractors and the architectural team. The contractor is also responsible to manage the process of translating the architect's contract documents into detailed drawings for subcontractors and eventually the shop drawings for the material fabricators.

The three vignettes below illustrate the changing dynamics of interactions among the various players in Hoffman Construction's projects in three different points in time, and demonstrate our theoretical model. They depict the changing nature of Hoffman Construction's social identity and social infrastructure when they change their use of boundary objects as the AEC industry moves from a 2D paper-based practice to a digitised 3D-based practice.

The first vignette describes Hoffman Construction's social identity and infrastructural practices prior to using 3D modelling technologies. The second vignette demonstrates how organisational changes instigated by one organisation (Gehry Partners, LLC), cascade to interacting organisations through mutual boundary objects (3D digitised representations), and how social identities and infrastructures change as a result. The third vignette shows how Hoffman Construction's social identity and infrastructure continue to evolve when it partakes in a project where different kinds of interactions among the stakeholders reshape the use of boundary objects.

The Process Manager: Hoffman Construction Prior to Using 3D

Before using 3D modelling technologies, Hoffman Construction has traditionally used 2D computer-aided design (CAD) tools in its construction projects. In the design and construction world, a substantial amount of communication takes place via 2D, CAD-produced visual representations and 2D paper-based representations, which serve as primary boundary objects because they constitute a basic common denominator for the various professional groups, yet hold different meanings for each of them (Henderson, 1991). In a 2D environment, Hoffman

Construction managed the project in a sequential manner. 2D paper-based contract documents are delivered to Hoffman Construction from the architect. The documents specify performance and quality requirements of the building and physical properties of the architects' design intent. Many of the systems that must be included - mechanical, electrical and structural - are shown schematically, but not in elaborate detail. Hoffman Construction distributes these documents to the different subcontractors that are involved in the project. The subcontractors submit back to Hoffman Construction the information associated with their proposed product, which entails specific work plans and shop drawings. The latter are detailed depictions of the manufactured items that go in the building and the systems that tie into them. These shop drawings, and not the contract documents, become the blue prints used for building. Hoffman Construction then has to make sure the shop drawings are in compliance with the contract requirements and then forwards them to the architect for approval. When the drawings are approved by the architect, they are sent back to the subcontractors that can begin their work. The coordinated shop drawings process then begins. Since the contract documents are very schematic and do not specify the construction process, it remains unclear which components of the building need to get built first. In principle, each subcontractor wants to be the first to lay its equipment and product so that they serve as a standard for other subcontractors. In reality it is a 'wild west' situation. For example, who ever provides Hoffman Construction with their shop drawings first, has a chance to set the standard. However, Hoffman Construction tries to structure this procedure by setting up meetings in an effort to regulate the process.

In a 2D-based project Hoffman Construction is situated at a central node in the system composed of the architect, the subcontractors and itself. Much like a poker dealer, it sits at a table as each party lays out their cards for the construction process. Each player keeps their proprietary information to themselves and tries to negotiate the sequence of construction and the location of their components for their own benefit.

The Dispersed Collaborator: Using 3D Modeling Technologies with Gehry's Company

In the late 1990's, Hoffman Construction was the General Contractor on the Experience Music Project (EMP) in Seattle[2]. The building was designed by Frank Gehry. Gehry is famous for his exceptional designs such as the Guggenheim Museum in Bilbao Spain and the Disney Concert Hall in Los Angeles. These unique buildings are designed using 3D modelling software, CATIA[3]. Gehry's first project using CATIA was a large fish sculpture for the Barcelona Olympic Games in 1992. The EMP project was one of the first Gehry projects to use 3D representations as contract documents, and to insist that the main subcontractors adopt CATIA.

Hoffman Construction was the construction manager for EMP, and Dale Stenning was the Senior project engineer. He described the work on EMP as a top-down process. The architect imposed CATIA 3D representations on Hoffman Construction and on the construction team. Structural and mechanical engineers, prime subcontractors, and Hoffman Construction, all had to learn how to use CATIA in one way or another. They were all influenced by it and had to absorb it. As a result, Hoffman Construction's typical role as a general contractor markedly changed. Instead of being a 'poker dealer' and managing a highly linear and structured communication process, Hoffman Construction's presence and role in the project became highly dispersed.

The use of 3D models created a much more tightly coupled and interdependent system composed of architects, contractors, clients and constructors. In this system the architects play a

[2] http://www.emplive.com/visit/about_emp/building.asp
[3] http://www.3ds.com/products-solutions/brands/CATIA/

more central and involved role than in a 2D representation-based process. The 3D models are created by the design team and serve as the central component around which construction efforts revolve (instead of the shop drawings that are produced by the subcontractors, in a 2D-based process). However, since most of the subcontractors are not familiar with the CATIA system, CATIA workstations and operators were embedded in them, and paid for by Hoffman Construction. This is a very unusual situation where the general contractor has de-facto employees in the subcontractors. Usually the two parties maintain a clear separating line between them. But on the EMP there was no clear division.

Although the 3D models were produced by Gehry Partners, their development was a collaborative effort in which both Hoffman Construction and the subcontractors took part. Usually, due to liability issues, the general contractor prefers not to 'touch' the contract documents and rather just shuffle the cards, deal them out and manage the sequence. But on EMP, Hoffman Construction and the subcontractors added information to the 3D models to take them from schematics to construction documents. In that sense, Hoffman Construction and the subcontractors were more involved in the process that they normally would be.

The Knowledge Broker: Hoffman Construction after the 'Gehry Experience'

After the EMP project, Hoffman Construction was involved in the construction of the Seattle Central Library which was completed in 2003[4]. Here, again, Hoffman Construction faced a new situation. The building was geometrically complex, and the architecture team was a joint venture between another international "star", Rem Koolhass, and LMN Architects, a Seattle architects office. The architects had also used 3D modelling technologies in designing the structure. However, due to liability issues, they refused to share the 3D models with Hoffman Construction or the subcontractors. They were only willing to release a limited number of models and even then it was done on a "use at your own risk' basis. Therefore, all official communication between the architects and the other participants in the project was 2D and paper based. However, because of the complex nature of the building and the fact that the work environment was predominantly 3D in nature, Hoffman Construction had to step in and create its own 3D models to enable construction.

Dale Stenning was again the Hoffman Construction senior project engineer, and he commented a number of times that Hoffman Construction took some lessons learned from the EMP project and implemented them with their subcontractors on the Seattle Central Library project. That is, Hoffman Construction was much more proactive in its efforts to create a tightly coupled system to enhance collaboration among the subcontractors. However, it was done more efficiently than on the EMP, since here nothing was imposed on the subcontractors. In fact, unlike the EMP, Hoffman Construction made a strategic choice to recruit key subcontractors (Glazing, Steel, Plumbing, Heating and Cooling) who had prior experience with using 3D modelling technologies in their own practice.

Another indication of Hoffman Construction's proactive conduct was the 3D AutoCAD environment that they set up with which all the subcontractors' proprietary technologies could interface. Thus, the AutoCAD platform served as a central translation device which mediated all computerised communication. The use of 3D models enabled Hoffman Construction to create a collaborative project management context among subcontractors whose interests are often conflicting with each other. It was primarily because in a 3D environment, subcontractors are

[4] http://www.spl.org/default.asp?pageID=branch_central_about&branchID=1

able to 'see' potential consequences of actions prior to taking them. This can potentially lower risk and cost for the subcontractors because the 'unknowns' are less looming.

Further, to enhance communication with and among the subcontractors, Hoffman Construction did extensive surveying work on the project. Usually, the general contractor does some surveying work to provide all the subcontractors with a basic x, y, z, grid that they can measure off of. But on complex projects like the Seattle Central Library, there is so much more detail to the layout process that it is not enough just to give line and grid information. So Hoffman Construction did a lot of detailed surveying work and distributed out the information to the different subcontractors, helping them to set the layout to their installed components.

Playing such a proactive role in the construction process was an opportunity for Hoffman Construction to create a vision that was consonant with the architect's and motivated the subcontractors to collaborate with them and with each other. In that role, Hoffman Construction brought more knowledge to play and as Dale Stenning put it, was able to act more like a knowledge broker than a poker dealer, resulting in different social dynamics among the project team members.

Discussion

The three vignettes demonstrate the reciprocal dynamic relationships among the key constructs shown in figure 1. Prior to working with Frank Gehry, Hoffman Construction's social identity (the process manager or the 'poker dealer'), reflected a traditional construction management company, defined in part by its use of 2D drawings as boundary objects and its ability to draw on standard infrastructural industry practices. However, this identity began changing as Hoffman Construction began interacting with Gehry Company. As mentioned, Gehry Company itself went through major organisational changes when it incorporated 3D tools into its own practice. As our model suggests, when these tools were used as boundary objects on the EMP, the changes within Gehry Partners cascaded to other organisations that shared the boundary objects with them. As we saw, the use of 3D tools as boundary objects disrupted Hoffman Construction's ongoing and taken-for-granted infrastructural knowledge and practices. As a result, Hoffman Construction was no longer able to draw on 2D boundary object to form its relationships with the architect and subcontractors in a way that would reaffirm its 'poker dealer' identity. The new 3D boundary objects dictated new practices for all the involved actors and fundamentally changed the interaction patterns among them. The previously prevalent linear-sequential process was reshaped to a much tighter, collaborative system. In this system, traditional organisational distinctions collapsed, organisational boundaries blurred and, consequently, existing social identities were transformed. Rather then having a distinct, and somewhat removed, position in the construction process (as was the case in a 2D-based process), Hoffman Construction now played a much more involved role, manifested by having its own CATIA operators embedded in the subcontractors, and by taking a hands-on approach with the 3D models that were produced by Gehry.

Whereas changes in boundary objects were the main initial instigator of change, further transformations were enabled because of changing infrastructures. Similar to EMP, 3D tools were also used on the Seattle Central Library project, however, in a very different manner. Unlike Gehry, Rem Koolhass and LMN Architects were not willing to distribute the 3D models. As a result, Hoffman Construction's infrastructural practices changed again, and ultimately, so

did its identity. Under the new conditions, 3D tools were no longer used as a boundary object between the architect and the rest of the actors. Paper documents were used instead. However, due to the complexity of the building, Hoffman Construction and the subcontractors still had to use 3D tools as they are able to accommodate and transfer multiple layers of complex information. Thus, 3D tools were used as a boundary object between Hoffman Construction and the subcontractors and among the subcontractors. But whereas on EMP 3D models were generated by the architects and used by them to communicate with other actors in a top-down manner, here the use of boundary objects was done in a bottom-up process. Namely, 3D models were generated by Hoffman Construction and the subcontractors and were used by them to create a shared platform that enhanced collaboration among them. In that process, Hoffman Construction's social identity was reshaped. They played a much more proactive role which was expressed both in them providing surveying information to the subcontractors and in orchestrating and managing the shared platform. As organisational boundaries and the use of boundary objects were re-charted, so were social identities. Rather then being dispersed across various organisations, Hoffman Construction's role positioned it as a central coordinator and supplier of knowledge.

Contributions, Future Research and Limitations

Our theory and vignettes provide some important contributions to existing literature. First, to boundary objects literature, our study suggests that boundary objects play a more important and complex role than previously thought. Much more than serving as mere translation devices, due to their location in the interface between social communities, boundary objects are used as a resource to construct and communicate social identities. Further, we propose that conceptualising boundary objects as a discrete theoretical construct can be misleading. Instead, we emphasise that boundary objects are tightly connected to the communities that share them. More specifically, they are tied in reciprocal relationships with the social identities and social infrastructures of the communities that share them. Thus, when change occurs in one of these elements it will carry over to the others. Most importantly, these changes cannot be accommodated within a single community or organisation. Changes in one organisation will cascade to bordering organisations through common boundary objects.

Second, our study also suggests that organisational change can be better understood in the context of reciprocal dynamic relationships constituted through the use of boundary objects, social identities and social infrastructures. Some organisational change literature has examined factors that facilitate organisational change or that influence resistance to it (Labianca et. al., 2000). Other more process-oriented studies have examined the actual process of organisational change (Van De Ven & Poole, 1995). IS researchers have been examining the impact of IT on organisational change (Robey & Boudreau, 1999). What is striking in the extant literature is the scant attention paid to the fact that organisations are situated in dynamic and reciprocal social systems that are mediated and supported by boundary objects. Understanding organisational change in such social context is particularly important given that organisations increasingly communicate with one another through various forms of IT. Our theoretical perspective complements traditional theories on organisational change by explicitly incorporating such dynamic and reciprocal inter-organisational social contexts. Our model suggests that IT-enabled organisational change is likely to be unsuccessful if it is internally focused. As shown in the vignettes, any attempt to initiate such change will instigate further changes in neighbouring

organisations through mutual boundary objects which could have real, and often unexpected, consequences.

Another contribution of our study to understanding IT-related organisational change is in our emphasis on IT artefacts (as boundary objects) as a basis to create social identities by organisations or work groups. Whereas the idea of IT artefacts as boundary objects has been previously discussed (Karsten et. al., 2001) we maintain that individuals or groups' use of IT artefacts goes beyond sheer instrumental considerations of gain and loss, and cannot be accommodated or fully comprehended when such logic is applied. In time and through repeated, meaningful and contextual use, IT artefacts become an immanent part of groups' identities and are used by them to define themselves and their work. Resistance to change thus has to do with the pain of having to change identities and not only with the necessity of having to change work routines or to acquire new expertise.

Future research should pay closer attention to the changing dynamics of boundary objects. The meaning of boundary objects changes as the context of their use change. Yet, the social context itself is constructed by the use and interpretations of boundary objects. Therefore we need to examine boundary objects as part of a larger, dynamic social ecology that is composed of social infrastructures and social identities.

Furthermore, within this ecology, it is important to examine the role of IT as boundary objects. To date, research on the topic has been scarce. Our paper provides an initial insight by suggesting that IT should be understood not only as objects that can enter an organisation and change it in any number of ways, but also as an artefact that is used by diverse actors and groups who attach different meanings to it and construct different identities in relation to it.

Finally, due to the scope of this paper, we were only able to describe a small fraction of the change process. A more methodical application of our theoretical model necessitates an examination of a wider set of players over a longer period of time. Future researchers would be wise to follow suit.

References

Ackerman. M. S and Halverson. C (1999) Organizational memory: processes, boundary objects and trajectories. Proceedings of the 32nd Hawaii International Conference on System Sciences.

Berger. P. L and Luckman. T (1967) The social construction of reality: a treatise in the sociology of knowledge. Anchor Books.

Bijker. W. E. (1995). Of bicycles, bakelites and bulbs: Toward a theory of sociotechnical change. Cambridge MA: MIT Press.

Boland. R. J and Tenkasi. R. V (1995) Perspective making and perspective taking in communities of knowing. Organization Science, 6, 4, 350-372.

Boland. R. J and Lyytinen. K & Yoo. Y (Forthcoming) Path creation with digital 3D representations: networks of innovation in architecture, engineering and construction. Unpublished working paper. CWRU.

Bowker. G. C and Star. L. S (1999) Sorting things out: classification and its consequences. Cambridge, Mass.: MIT Press.

Briers. M and Chua. W. F (2001) The role of actor-networks and boundary objects in management accounting change: a field study of an implementation of activity-based costing. Accounting, organizations & Society, 26, 237-269.

Carlile. P. R (2002) A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development. Organization Science, 13, 4, 442-455.

Garrety. K and Badham. R (2000) The politics of socio-technical intervention: An interactionist view. Technology Analysis & Strategic Management, 12, 1, 103-118.

Henderson. K (1991) Flexible sketches and inflexible data-bases: Visual communication, conscription devices and boundary objects in design engineering. Science, Technology& Human Values, 16, 4, 448-473.

Henderson. K (1998) The role of material objects in the design process: A comparison of two design cultures and how they contend with automation. Science, Technology & Human Values, 23, 139-174.

Karsten. H & Lyytinen. K & Hurskainen. M & Koskelainen. T (2001) Crossing boundaries and conscripting participation: representing and integrating knowledge in a paper machinery project: representing and integrating knowledge in a paper machinery project. *European Journal of Information Systems, 10, 89-98*.

Labianca. G and Gray. B and Brass. D (2000) A grounded model of organizational schema change during empowerment. Organization Science, 11, 2, 235-257.

McLaughlin. J and Rosen. P and Skinner. D and Webster. A (1999) Valuing technology: Organisations, culture and change. Routledge.

Oaks. P. J & Turner. J. C (1990) Is limited information processing capacity the cause of social stereotyping?, in W. Stroebe & M. Hewstone (Eds.) *European Review of Social Psychology, 1*. Wiley, Chichester.

Robey. D and Boudreau. M. C (1999) Accounting for the contradictory consequences of information technology: Theoretical directions and methodological implications. Information Systems Research, 10, 2, 167-187.

Star. S. L & Griesemer. J. R (1989) Institutional ecology, 'translations' and boundary objects: amateurs and professionals in Berkeley's museum of vertebrate zoology, 1907-1939. *Social Studies of Science, 19, 387-420*.

Star. S. L (2000) Infrastructure and ethnographic practice. *Scandinavian Journal of Information Systems, 14, 2, 107-122*.

Subrahmanian. E & Monrach. I & Konda. S & Granger. H & Milliken. R & Westerberg. A & The N-Dim Group (2003) Boundary objects and prototypes at the interfaces of engineering design. *Computer Supported Cooperative Work, 12, 185-203*.

Tajfel. H (Ed.) (1982) *Social identity and intergroup relations.* Cambridge (Cambridgeshire) ; New York : Cambridge University Press

Turner. J. C (1985) Social categorization and the self-concept: a social cognitive theory of group behavior, in E. J. Lawler (Ed.) *Advances in group processes, 2*. JAI Press, Greenwich, CT.

Van De Ven. A. H and Poole. M. S (1995) Explaining development and change in organizations. Academy of Management Review, 20, 3, 510-540.

Yakura. E. K (2002) Charting time: timelines as temporal boundary objects. *Academy of Management Journal, 45, 5, 956-970*.

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