New Projects, New Partners: Artifacts and Practices for Accomplishing Work Across Interorganizational Boundaries

Jennifer A. Howard-Grenville
Raymond Paquin
Boston University School of Management
595 Commonwealth Avenue
Boston, MA 02215
Corresponding author contact information:
Phone: 617 358-2279
Fax: 617 353-5244
Email: jahg@bu.edu

March 5, 2006

Paper prepared for presentation at 2006 International Conference on Organizational Learning, Knowledge, and Capabilities, University of Warwick, UK

New Projects, New Partners: Artifacts and Practices for Accomplishing Work Across Interorganizational Boundaries

Abstract

In this paper, we consider the distinct challenges of working across complex interorganizational boundaries and the artifacts and practices that can enable such work. We focus empirically on a growing practice in corporate environmental management, "industrial symbiosis," which brings together specialists from diverse private companies and public organizations to conceive, design, and implement technical approaches that transfer one industrial facility's "waste" to another facility to be used as a product or process input. Successful industrial symbiosis projects involve overcoming significant differences in the specialized knowledge held by members of different organizations, and forging relationships between previously unconnected but newly dependent individuals and organizations. The research literature suggests that boundary practices and boundary objects to overcome such high differences and dependencies may be relatively complex in order to enable individuals to represent and assess diverse knowledge. Our preliminary findings, however, suggest that the boundary practices used to initiate and broker industrial symbiosis projects are disarmingly simple. We explore reasons for this paradox, and then consider more evolved and complex industrial symbiosis projects and identify factors that seem to lead to a set of relatively simple yet effective boundary practices.

(Key words: boundary objects, boundary practices, interorganizational collaboration, environmental management)

We know a great deal about the challenges of negotiating differences between groups holding different specialized knowledge within organizations (Brown & Duguid, 2001; Carlile, 2002). We also know a great deal about how such challenges are overcome to accomplish work through the actions of individuals as boundary spanners (Allen, 1977; Hargadon & Sutton, 1997), the use of artifacts as boundary objects (Star 1989; Karsten et al, 2001; Carlile, 2002; Bechky, 2003) and the use of particular boundary practices (Tyre & von Hippel, 1997; Brown & Duguid, 2001; Merali, 2002; Carlile, 2004). Much less is known, however about the challenges and processes at *interorganizational* boundaries. Here, individuals from diverse private and public organizations may come together to collaborate on a specific task or a series of tasks that require cooperative work across organizational boundaries. This work is governed neither by market nor hierarchical mechanisms of control, and therefore tends to be governed by looser institutional norms and less clearly defined practices, often requiring complex negotiation and information exchange between parties (Lawrence, Hardy, & Phillips, 2002). In such settings, we might expect quite elaborate boundary practices to emerge, perhaps associated with complex boundary objects that are capable of representing significant differences in the various participant's knowledge and interests (Karsten et al, 2001; Carlile, 2004; Howard-Grenville & Carlile, 2006).

In this paper, we explore the challenges of work across interorganizational boundaries, with attention to the practices and artifacts used to accomplish this work. We focus empirically on a growing practice in corporate environmental management, "industrial symbiosis," which brings together specialists from diverse private companies and public organizations to conceive, design, and implement technical approaches that transfer one industrial facility's "waste" to another facility to be used as a product or process input. Modeled on symbiotic relationships between natural organisms, the approach improves facility's environmental impacts by reducing their consumption of virgin materials or their disposal of waste, and it often has economic gains for the parties because it reduces costs or introduces a new revenue stream. Industrial symbiosis projects bring together members of two or more industrial facilities, possibly with local government authorities and/or environmental regulators. Detailed information exchange on wastes, resources, and manufacturing process parameters may be required, as well as joint technical and engineering development to transform or purify wastes. Importantly, industrial symbiosis projects bring together members of disparate organizations and industries who may have no prior relationships. For example, rather than discharging it into a river, a coal-fired power plant may redirect its waste heat to a pharmaceutical manufacturer to be used as process steam. In other cases, firms that are geographically distant may enter into exchanges of materials that are more readily transported.

In our empirical study, we use a knowledge perspective grounded in attention to the practices and artifacts used at the interorganizational boundaries to explore how industrial symbiosis projects are initiated and evolve. A knowledge perspective enables us to consider the kind and extent of difference and dependency across the interorganizational boundary (Carlile, 2004) and to assess the adequacy of boundary practices and artifacts for representing such differences and dependencies and creating common ground (Bechky, 2003; Carlile, 2002). Our preliminary findings suggest, somewhat surprisingly, that there are a set of disarmingly simple practices and artifacts used to initiate and develop symbiotic relationships between companies. The effectiveness of these practices, we speculate, rests partly in the fact that individuals with similar roles in disparate organizations come together and are able to quite quickly understand each other's concerns because they operate in an extended "epsitemic network" (Brown &

Duguid, 2001: 205) where common local practice enables them to engage in more “global” communication (Knorr-Centina, 1999). A second possible reason for the effectiveness of relatively simple boundary practices lies in the context surrounding the development of industrial symbiosis projects and the orientation of those who participate. We also consider the more complex practices that are needed as industrial symbiosis projects become more complex, either as partners engage in joint technological development with high novelty, or as they gradually progress in their relationships, taking on more complex material or resource exchanges.

This research makes several contributions to the literature on boundary practices and boundary artifacts. First, it builds on understandings of knowledge integration across boundaries by considering specifically how practices and artifacts enable work across *interorganizational* boundaries. Studies of boundary practices have typically focused on relatively stable product development activities within a single organization (Dougherty, 1992; Karsten et al, 2001; Carlile, 2002; Bechky, 2003; Carlile, 2004) where a common context and shared organizational goal perhaps mask some of the differences that are present when multiple goals are desired, when technical and nontechnical considerations must be negotiated (Bechky, 2003), or when projects are undertaken relatively autonomously between organizations (Scarbrough et al., 2004). Our preliminary findings lend support to the observation that shared occupational or professional knowledge may actually help rather than hinder the creation of common ground (Robertson, Scarbrough, & Swan, 2003) in interorganizational collaboration. Yet differences in the organizations’ goals, power, time frames for action, and favored metrics likely complicate the boundary practices and artifacts as industrial symbiosis projects become more complex and/or progress to detailed implementation stages.

A second contribution of the research is to bring attention to broader contextual factors and orientations of participants that may influence how and how effectively knowledge is shared across interorganizational boundaries. Here our preliminary results suggest that broader institutional pressures and incentives contributed to bringing industrial and other participants together to solve problems associated with waste, and that individuals within these organizations strongly believed that their problems could *only* be solved through collaboration across organizational boundaries. Thus they had an orientation of openness to collaboration that may have been essential to their ability to adopt and use relatively simple boundary practices.

Finally, our analysis has practical implications for those engaged in industrial symbiosis projects, shifting the attention away from simply the material and energy flows themselves, and towards the associated interorganizational practices that can make the differences and dependencies at the boundaries clear and enable joint action.

In the remainder of this paper, we first briefly review the relevant literatures on boundary practices, interorganizational collaboration, and industrial symbiosis. We then describe the methods used to study a large, multi-year, facilitated industrial symbiosis program in the UK and describe our preliminary analysis on this ongoing longitudinal research project. Next we present our findings on the relatively simple boundary practices and artifacts used, followed by findings on the more complex practices. We conclude with a discussion of the implications of our findings and directions for future research.

Interorganizational Boundaries, Knowledge Integration, and Industrial Symbiosis

A considerable literature exists on the strategic importance of (Grant, 1996; Spender, 1996), challenges to (Dougherty, 1992; Brown & Duguid, 2001) and mechanisms for (Dougherty, 2001;

Karsten et al, 2001; Carlile, 2002; Bechky, 2003) integration of knowledge between groups having different specialized knowledge and associated different norms, interests, and practices. Knowledge integration is defined as "an ongoing collective process of constructing, articulating, and redefining shared beliefs through the social interaction of organizational members" (Huang, 2000: 15). Within organizations, knowledge integration can be achieved by the "externalization" of tacit, situated knowledge (Nonaka, 1994) through close, frequent interactions between groups (Hansen, 1999), co-location (Tyre and von Hippel, 1997), the use of material boundary objects for joint problem-solving (Bechky, 2003), or the work of individual knowledge brokers who translate meaning (Hargadon and Sutton, 1997). Effective knowledge integration leads to coordination of activities, synthesis of expertise, and the development of new knowledge (Huang, Newell, & Pan, 2001) and capabilities that are critical to an organization's capacity to innovate and learn (Grant, 1996; Spender, 1996; Carlile, 2004).

While considerable attention has been paid to issues of knowledge integration within product and process development settings that engage specialized groups within a single firm (Tyre & von Hippel, 1997; Carlile, 2002; Bechky, 2003), knowledge integration with others outside a firm's boundaries such as suppliers and customers is also recognized as important to innovation and new product development (Huang, Newell, & Pan, 2001; Karsten et al, 2001). However, relatively little is known about the particular practices and artifacts that characterize work across interorganizational knowledge boundaries (for exceptions, see Dougherty, 2001; Levina & Vaast, 2005), or about the difference between these practice and artifacts and those that are found effective for intraorganizational knowledge integration.

The literature on knowledge integration and that on interorganizational collaboration offer several reasons why we might expect boundary practices and artifacts to be different for interorganizational, rather than intraorganizational, knowledge integration. First, the complexity of a boundary and the practices needed to traverse it differ with the degree of difference, dependency, and novelty that characterize the boundary (Carlile, 2004). Difference is a relational property at the boundary that captures the different amount (e.g., the distinction between a novice and expert) or type of knowledge (e.g., the distinction between terminologies and techniques used in different domains) accumulated on each side (Carlile, 2004). Dependence captures the degree to which the work of one party relies on coordination, interaction, or exchange with another party or parties. Without dependence, difference across a boundary is of no consequence (Carlile, 2004). Finally, novelty captures the introduction of new demands (e.g. from customers), new requirements (e.g, new safety standards) or new technologies that must be incorporated into coordinated work. Novelty complicates difference and dependence because it implies prior collective knowledge can not necessarily be reused (Carlile, 2004); in other words, if differences and dependencies are known, novelty makes them unknown again.

Knowledge integration across interorganizational boundaries likely involves dealing with different amounts and types of difference, dependence and novelty than is present across intraorganizational boundaries. The differences and dependencies most consequential within single organizations lie in differences between specialists who have different functions (e.g. engineers and technicians, engineers and managers, etc.) or between specialists who have different expertise and hence different commitments and interests (e.g., product styling engineers and engine performance engineers, as in Carlile's auto development teams) (Dougherty, 1992; Bechky, 2003; Carlile, 2004). Between organizations, differences of this nature will still be present, but, on top of these, differences in organizational structure, organizational culture, and organizational goals (especially in diverse industries) will likely be consequential to knowledge integration. Indeed, empirical studies of organizations engaging in collaborative work with outsiders suggest that effective integration requires the development of a new field of practice and the negotiation within this field of new norms (Levina & Vaast, 2005). Further, such work can challenge or change the identity of participants, or of organizations (Merali, 2002) which can then produce difficulties for internal knowledge integration (Merali, 2002; Levina & Vaast, 2005). New types of dependency are also present. As with intraorganizational knowledge integration, participants rely on each other for information sharing and the synthesis and coordination of related activities. But unique to interorganizational knowledge integration may be issues of confidentiality and the protection of intellectual property (Merali, 2002), and a lack of trust or reciprocity due to the absence of a shared context. Finally, novelty may arise more frequently across interorganizational boundaries because members are not familiar with the technological trajectories of each other's industries.

A second key reason to expect boundary practices and artifacts to differ for interorganizational knowledge integration, as opposed to intraorganizational knowledge integration, is found in the literature on interorganizational collaboration. Collaboration is defined as "a cooperative, interorganizational relationship that is negotiated in an ongoing communicative process and that relies on neither market nor hierarchical control (Lawrence, Hardy, & Phillips, 2002). While successful industrial symbiosis relationships typically lead to a formal business contract between two companies to specify the conditions of a material or resource exchange and any associated financial transaction, they begin and develop as collaborative processes. Collaborations are characterized by norms and practices that tend to be less well developed than the more highly institutionalized governance mechanisms surrounding market or hierarchical transactions, leading to more complex negotiations around them

(Lawrence, Hardy & Phillips, 2002) and greater decentralization and fluidity in the creation of new knowledge (Powell, Koput, & Smith-Doerr, 1996). Empirically, collaborations that are both highly “involved” (i.e., characterized by deep interactions, partnerships, and bilateral information flows) and highly “embedded” (i.e., characterized by connections between the collaboration and a broader interorganizational network) are found to be most effective for knowledge creation (Hardy, Phillips, & Lawrence, 2003). This suggests, first, that the boundary practices for interorganizational collaboration may be emergent, coming out of the particular issues of the collaboration, and further, that they may be complex and take a great deal of time to develop.

Indeed, existing literature on industrial symbiosis suggests such challenges at the interorganizational boundary. While much of the work on industrial symbiosis has focused on the technical and engineering issues, sufficient data have now accumulated on the trajectory of a number of industrial ecosystems, either planned or emergent to suggest that we need to know much more than information on material and energy flows in order to understand, predict, or initiate successful industrial symbiosis projects (Baas & Boons, 2004; Chertow & Lombardi, 2005; Ehrenfeld & Chertow, 2002; Ehrenfeld & Gertler, 1997; Heeres, Vermeulen, & de Walle, 2004; Jacobsen, 2005; Malmborg, 2004; Mirata, 2004). Empirical accounts point to numerous non-technical reasons for the failure of industrial ecology projects – failures of communication, coordination, trust or reciprocity (Heeres et al., 2004) – as well as numerous explanations for successes, including effective brokering, education, repeated interactions, and learning over time (Baas et al., 2004; Chertow et al., 2005; Ehrenfeld et al., 2002; Jacobsen, 2005; Malmborg, 2004). Our focus on the initiation and development of industrial symbiosis projects enables us to consider the emergence and operation of interorganizational boundary practices and objects, and to reflect on how they might differ – in complexity or form – from their counterparts used to integrate knowledge across intraorganizational boundaries.

Setting and Methods

To understand the practices and artifacts used to integrate knowledge across interorganizational boundaries, we focus empirically on the National Industrial Symbiosis Programme (NISP), a three-year effort to facilitate the development of industrial symbiosis projects throughout the United Kingdom. Building on the success of three regional pilot programmes, this effort seeks to link individual industrial facilities with each other, and with regional economic development authorities, local government agencies, and regional environmental agencies, to enable facilities to learn about and develop symbiotic linkages. Now nearing the end of the first year of its planned three year national expansion, we began to study NISP in the middle of its first year as a national program (the earlier regional programs had been in place for about two years before the national program was initiated). While our longitudinal research is at an early stage, the setting provides an opportunity to observe the use, development, negotiation and change of practices and artifacts by NISP and its member organizations as they seek to develop joint projects that address technical, environmental, and economic needs and constraints.

Currently, NISP has over 1200 members from UK companies and other organizations (e.g., universities, regional development authorities, etc.). It is organized into ten geographical regions and the program in each region is "delivered" by a regional coordinator and small team of employees, and coordinate by a national office (Laybourn & Clark, 2005). Unique among industrial symbiosis programs, NISP both operates on a large scale (the entire UK), but also sees its role as primarily a facilitator of symbiosis rather than an organization that "sets up" such projects. Its mantra is that it “works with the willing,” engaging companies and others on a voluntary basis rather than trying to directly induce cooperation or impose certain projects on firms. Participation in NISP is free of charge to members and enrollment requires only “a verbal commitment towards collaboration and concomitant disclosure of resource information to facilitators and other members” (Clark, 2005). NISP only rarely enters into confidentiality agreements with its members (in cases of technology development involving research partners) and considers this important to the creation of an open, trusting network of potential collaborators.

NISP also casts a very large net in terms of what it “counts” as resources that can be exchanged by members. Beyond simply energy and materials, NISP encourages members to think creatively about the land, facilities, transportation and expertise (“ideas”) they have that could be used more productively. Rather than positioning themselves as a “waste exchange” NISP sees itself as enabling improved resource efficiency for its diverse members, with resources defined very broadly.

Data Collection and Analysis

We collected data through three primary methods: interviews, direct (nonparticipant) observation, and document analysis. The multi-method data collection enables us to generate more robust and valid perspectives than a single method would allow (Emerson, 2001). As the research continues, we also plan to collect survey data on companies’ perspectives of the emerging interorganizational collaboration networks, and to continue interviews, observations and document analysis for a number of other companies and projects. For this paper, we focus only on initial data from open ended interviews with NISP staff (9) and industry participants (3), direct observation of an industry “quick wins workshop,” and direct observation of a NISP staff strategy meeting (1). We stress that our findings are preliminary, but the design of the study, planned to span at least one year, will enable us to test and refine these initial findings as we continue the work.

Interviews. Open-ended interviews were conducted with 9 NISP staff members at their office by one of the authors. These interviews were intended to learn about NISP's goals and practices, how it engaged companies and other organizations to initiate collaborations, and its plans for development and expansion of the program. The interviewees also shared in detail several examples of successful industrial symbiosis projects that had been completed or where underway. In-depth, open-ended interviews with 3 members of 2 participating industrial facilities (one large auto manufacturer and one large brewer) were also conducted by both authors at the respective facility sites. The industry interviews probed the firms' environmental practices, the interviewees' perspectives of the regulatory and other drivers for environmental actions, their engagement in industrial symbiosis activities, and their relationship with NISP. A tour of the manufacturing facility and recycling area were taken in the case of the auto manufacturer.

Direct Observations. A NISP staff meeting focused on strategy and key changes associated with the considerable growth of the program at the national scale was observed by one author. All NISP headquarters staff were present, including those who deliver the program at the national (and one regional) level, and those who interface directly with local government councils and with the academic research community to facilitate creative industrial symbiosis solutions. In all, 13 members of the NISP staff were present at the meeting. A second direct observation was performed by both authors of one industry "Quick Wins" workshop. Described in more detail below, these workshops are standard and key aspects of the NISP program delivery in the various regions. They bring together representatives from diverse industries and companies for a half-day to exchange information and learn about potential synergies with other members. The workshop we observed had 21 members representing 16 organizations present. We were able to talk informally with many of the members throughout the workshop to understand their businesses, the resources they sought to use more efficiently, and their engagement with NISP and others around industrial symbiosis.

For both interviews and direct observations, extensive notes were taken by the authors present. These notes comprise the primary data sources for this paper. We supplement them with documents collected from NISP staff members and at the quick wins workshop. These documents include case studies written by NISP, press releases, internal documents on particular roles and issues for NISP, presentations, and the NISP website.

Our analysis of the data so far is preliminary, but we read our interview notes for emergent themes (Glaser & Strauss, 1967; Miles & Huberman, 1994) that appeared from several of the data sources. For example, we took particular note of themes that arose from both industry and NISP staff interviews, or from both direct observations and interviews. We consider these themes here as preliminary findings and will use further analysis of this and newly collected data to test and refine the themes as the study progresses.

Boundary Practices and Boundary Artifacts for Industrial Symbiosis

The earlier discussion drawing on the literature on knowledge integration and interorganizational collaboration suggested that practices and artifacts to enable knowledge integration across interorganizational boundaries would be relatively complex. However, much of what we found was disarmingly simple. We discuss particular practices and artifacts below, both simple and more complex ones, and draw analogies between them and dating and matchmaking to highlight various salient aspects of these interactions.

Simple Boundary Practices

Two simple boundary practices were observed, the "Quick Wins" workshops and the use of a resource database.

Quick Wins Workshops: "Speed Dating"

"Quick Wins" workshops are the industrial symbiosis equivalent of "speed dating." Speed dating involves a group of singles who gather for a facilitated session of short 5-10 minute 'dates' in quick succession - often followed by an unstructured 'meet and mingle' time. Those individuals with mutual interest in each other exchange contact information, then decide on their own whether and how to pursue future contact. A similar approach takes place in the Quick Wins workshop, though (as discussed below), instead of leaving future meetings to chance, other NISP practices as used to continue to engage firms overtime. We draw the analogy with speed dating as a way of making sense of the boundary practice enacted through the Quick Wins workshop. While NISP staff do not typically use the term, at least one participant in the workshop we observed volunteered it as an analogy.

Quick Wins workshops are regularly held throughout the ten NISP regions as a primary method for the initial engagement of members with the program, and often as the primary introduction for members to industrial symbiosis. Each workshop hosts between 20 and 40 representatives from different firms. Facilitated by the NISP regional coordinator and other regional and national staff, the workshops open with a presentation on the NISP program and its goals, the structure of the program delivery, and case studies highlighting successful industrial symbiosis projects facilitated by NISP. At the workshop we observed, the presentation was fast-paced and energetic, with the presenters focused on moving through the formal material in order to allow the participants to "get down to the synergies" and the "business" of the morning.

Participants were seated facing each other around square tables that accommodated 8 to 10 people, and immediately following the presentation were asked to introduce themselves to others at their table and begin their work on potential "quick wins" or "synergies."

Each table held a large poster board grid in its center that had both columns and rows for various types of resources (materials, facilities, energy, land, transportation, and expertise). One axis was for resources that participants "had" or "wanted to supply" to others, the other was for resources participants "needed" or "wanted to source" from others. Participants filled out small yellow and green slips of paper for what they needed and what they had, respectively. The slips included space for a brief description of the resource itself (e.g., used tires), the quantity of the resource needed or available, the name of the individual and company, and the "availability" of the resource (e.g., whether it is needed or supplied on a continuous basis or in batches, whether it is available now or in the future). In observing this phase of the workshop, both authors were struck by how quickly participants were able to fill out the slips of paper, and how many they filled out (up to 8 to 10 "wants" or "needs" per participant in some cases). Several participants representing complex manufacturing facilities (e.g., an automaker and a factory house builder) had come prepared with detailed spreadsheets of their resource flows, broken down by material and month. Those who did not come with such data clearly knew it in their heads and were able to very rapidly write down details of what they had and wanted and the quantities and availability.

At each table a NISP staff member collected and compared the yellow and green slips to identify any immediately apparent "quick wins" or "synergies." These were written on pink slips of paper where the resource and the names of the two companies were noted. Potential synergies identified were numerous. At one table with seven participants (including one regional and one national NISP staff members), 24 green slips for "haves" (wants to supply) were completed in the initial round and from these 11 immediate synergies identified and recorded on pink slips. Once each table had completed the initial round of matches, they passed their yellow slips (indicating "wants to source") to the next table. Participants then looked for matches between their green slips and the new yellow ones; again, pink slips were completed when potential synergies were identified. Similar to what one imagines occurring during speed dating, potential matches were often met with excitement by the participants who would smile, clap or express their surprise or delight at having found a potential home (or source) for their resource. The yellow slips continued to be passed to the other tables until all tables had seen all of the slips and explored potential matches.

Following this process, company participants were given unstructured networking time with snacks and drinks while NISP staff members collected all of the paper slips and summarized the potential synergies by resource type. A NISP staff member then announced the total potential synergies found and went through them by type of resource, mentioning the participants who could contribute in each case. At the workshop we observed, 60 potential synergies were identified, with the majority in the category of materials, 10 in expertise, 3 in land, and one in services. Examples of potential synergies included using waste vegetable oil (e.g., from university kitchens and other cooking operation) as a resource for bio-diesel conversion, reusing waste timber for a variety of uses, reusing waste tires to produce asphalt, recycling concrete, and treating wastewater for further reuse. The NISP staff member also announced a synergy that she called "quite cute really" that involved the reuse of second-hand "wellies" (rubber boots)! Once the synergies were announced, further time was left for informal networking and participants actively sought out others with whom they had identified potential synergies, exchanged business cards, and talked about their resources and processes. A stand-up buffet luncheon followed with further networking.

The goal of the quick wins workshops is to generate potential interorganizational synergies as the first step for developing industrial symbiosis projects, and they are often the first point of active engagement for members in NISP. The workshops are often quite successful. According to one staff member who has run several of these workshops, two to three potential matches are usually made for each attendee, with a follow through rate of roughly 40% - (meaning the firms actually initiated the projects based on potential matches identified at the workshops). The rate at which projects are successfully completed based on a synergy identified at a workshop is less well known, partly because of the time it requires to move some of the ideas to implementation, and partly because NISP staff members observed that many of the initial ideas are transformed into other types of synergies as participants develop a relationship and learn more about each other's processes and resources.

Resource Streams Database: "Online Dating"

Similar to an online dating site where one creates a profile then searches for potential 'matches' among other profiles; the resource streams database is an online searchable repository for member firms' resource streams – containing resource streams collected from Quick Wins workshops as well as those input later by firms as need arises. Though the database lacks the interactive, interpersonal approach of the Quick Wins workshop, it hosts resource streams for the entire UK network - thus potential matches made here are not limited by who happens to attend a given workshop. As of March 2006, that meant the database contained information on over 1700 resource streams (haves and wants) from over 600 individual industrial sites throughout the UK.

After attending a half-day user training seminar, member firms are then free to post, search, and contact others it the database as relevant to their needs.

The database has been prepared by NISP staff to be a simple, “one-stop” interface that is nonetheless sophisticated enough to handle detailed resource information. As such, it is both a powerful and somewhat flexible boundary object as it enables the representation, sharing, and accessing of complex information (Carlile, 2004). Specific features of the database are added to make it easier to enter resources and use. For example, a user can enter that he or she has scrap steel and the database contains a common formulation of steel to which the user can make adjustments to match the particular composition (e.g. % of carbon, etc.) available or needed. A great deal of other detailed information can be entered including purity of chemicals, and details on the availability of the resource. Common European Union waste classification codes are also included in the database to create a common language for the myriad resources and compositions possible. Despite a design to make it easy for participants to use, the database has not been used as extensively as it might, perhaps because of the level of detail required (especially relative to the level of detail provided at Quick Wins workshops) and perhaps because the national program is at a relatively early stage and trainings on the database are ongoing. The database automatically searches once a week for matches based on the materials that are entered. Regional coordinators and other NISP staff receive these weekly reports and also actively scan the database for potential synergies and follow up by contacting the two parties separately to garner detail and inform them of the synergy.

The Success of the Simple Boundary Practices

Though simple, these practices are by no means randomly successful; several factors facilitated their successful use. We observed in the Quick Wins workshop and were told by NISP member firms and staff that getting the 'right' people involved was important. Those involved in the workshop and the database are those who – to some degree – were responsible for managing the logistics of production resources in their organizations. For example, many of the workshop participants had roles in their companies that involved waste management or recycling and they had an in-depth knowledge of the materials produced by their facilities. Only relatively few were production or Environment, Health and Safety (EH&S) staff and even those that were focused on their facilities' resource streams. Though particular roles did differ within their respective firms, they likely shared common practices and norms around managing resource and waste streams, giving them common ground made possible by their participation in a particular professional or "epistemic" community (Robertson et al., 2003; Swan & Newell, 1995).

A shared professional background and somewhat common practices or experiences, albeit gained in different firms, likely reduces the difference and novelty encountered when individual begin to explore industrial symbiosis projects with others, at least early on. Additionally, many of the workshop and database matches are "low hanging fruit." They typically involve relatively simple transfers of waste resources from one organization to another, are based on established practices, and involve little or no additional processing of resources. Combined with the shared motivations of reducing their firms' costs (either due to landfilling or due to virgin resource purchase), these low boundary barriers may explain part of the 'disarmingly simplicity' of the above practices.

More Complex Boundary Practices

Several more complex boundary practices were also observed, many of them involving NISP members more actively taking on a brokering role to bring together two organizations, and also to develop multiparty collaborations across the corporate, government, and research sectors.

NISP Regional Coordinators: "Matchmakers"

In addition to the above activities, NISP regional coordinators (RC's) also engage in more intensive 'matchmaking' services which facilitate more complex industrial symbiosis projects. From the matchmaker perspective, RC's perform a number of services. RC's follow up on potential synergies uncovered in the workshops and database, supporting member organizations as they develop these projects. RC's also visit facilities to learn in more depth about the organizations' current and future resource needs. Such detailed information, combined with NISP's own broad network of member organizations, helps RC's to work with these organizations on future 'synergies' for industrial symbiosis which are perhaps less obvious to the organization.

It is in this role as matchmaker that NISP and member organizations often get into more complex project ideas and boundary practices. Projects coming from these meetings are often more complex because they involve additional processing of current resource streams and/or the development and implementation of new technologies for further waste reduction. In these situations, difference and novelty become much greater; as organizations often need to reframe their perspectives and/or restructure their processes to see continued environmental improvement. For organizations that do change their perspectives, however, NISP practices move from connecting two organizations with simple resource requirements to more complex business and research activities. One example of this involves Alutrade (an active NISP member organization), a large aluminum and steel recycler in the UK. In 2003, Alutrade came to NISP for guidance on a planned £1million upgrade in its aluminum recycling capabilities, increasing Britain's aluminum recycling capacity. NISP introduced Alutrade to its regional development authority (RDA), as well as relevant local authorities and community groups; and in the process helped secure a £95K grant to Alutrade to offset some of its investment costs (NISP, 2005). In this kind of case, NISP seems to lend valued social capital (Burt, 2002; Uzzi, 1996) to the project by introducing key parties to each other and acting as a broker to bring them together.

Another example of this more complex practice involves NISP’s ongoing work with a large brewer. One project which NISP and the brewer are pursuing involves seeking alternative ways to reuse brewer’s yeast from the production process. Currently, brewer’s yeast is reprocessed into Marmite (a food spread sold primarily in the UK) and similar products but the declining Marmite market is making this approach less attractive for the brewers. In exploring other uses, NISP tapped non-business connections (non-profit and academic research and other environmentally-focused organizations) for alternatives. The outcome of this search suggests a potential reprocessing approach that would yield a valuable new revenue stream for the brewers. Though the technology for this approach is not yet proven, NISP and the brewer are jointly sponsoring research to test its feasibility. As a representative of the brewer stated, “it is worth £50k to find out [if this process works], because disposing of used brewer’s yeast is becoming a bigger problem for us.”

Other more complex boundary practices are present in initiating industrial symbiosis projects through NISP, but only relatively few projects and relationships have progressed to the point of invoking them. These more complex practices include NISP-coordinate industry focused workshops and meetings (e.g. to work on resource efficiency issues in automotive manufacturing supply chains). In these cases, were it’s hard to get competitors to talk to one another, NISP provides a legitimating ‘third party’ where competitors can meet on neutral ground and discuss common problems and solutions. A second type of more complex boundary practices involve multiparty collaborations that bring in academic or other research partners (as in the brewer example above), local government authorities, or environmental authorities. These more complex boundary practices, and their relationships with the simpler practices observed, will be part of the focus of our ongoing study.

The Role of More Complex Boundary Practices

In settings where difference and novelty were higher, NISP's practices became necessarily more complex. The two examples above are illustrative of the NISP's activities in developing more complex industrial symbiosis projects. RC's are not simply facilitating existing resource exchanges here (as they do with workshops and resource database matches); rather they are becoming resource advisors. Their practices become more involved as they work with member organizations to develop new potential synergies through some combination of additional processing of existing resources and adoption or development of new technologies. As such, RC's are also more likely to leverage NISP's broader network of organizations (academic and non-profit research groups, other environmentally-focused organizations, local and regional regulatory agencies, etc.) which also facilitates more diverse sharing and creation of knowledge between new parties (Carlile, 2004).

Discussion: Why Are These Boundary Practices Adequate?

It is too early in our research to conclude that the boundary practices and artifacts described here are sufficient to support effective interorganizational collaboration to achieve industrial symbiosis. But there are several factors – both contextual (originating outside the organization) and individual (originating from the individuals involved or at least within the organization) – that seem to suggest why such practices may prove to be adequate. The first factor is contextual.

As discussed above, those involved with NISP tend to have a similar perspective on resource management. But this similar perspective was not entirely due to shared practices and professional affiliations. Indeed, the institutional context surrounding waste management in the UK has created significant pressures for companies to find alternatives to landfilling their waste materials. A landfill tax, introduced in 1996 as a mechanism to reduce quantities of waste going to landfill and encourage the development of more sustainable waste management practices, represents a significant regulatory driver to which virtually all NISP members are subject. While the landfill tax did not fully enter force for several years, it now is planned to increase yearly at a rate of at least £3 per ton of waste (DEFRA, 2004). Landfill taxes in 2004 were £15 GBP per ton, and are planned to increase to a maximum of £35 per ton. This significant cost increase is important and salient to NISP members; many mentioned it independently as a key driver for their exploration of industrial symbiosis. Other pressures exist for improved resource efficiency, including the government-funded Carbon Trust, an organization set up to help businesses achieve the UK government's aspiration for a 60 % reduction in carbon emissions and the creation of a low carbon economy by 2050 (Carbon Trust, 2006).[1] Further, laws to progressively divert biodegradable waste from landfills are in place. For all of these, businesses can obtain support from a number of groups similar to NISP, and often can receive technical or monetary assistance to make changes. These powerful regulatory and economic incentives to participate in industrial symbiosis and related environmental practices cannot be overlooked. Considerable research suggests that companies' environmental practices are strongly shaped by a combination of regulatory, economic and social pressures (Hoffman, 2000; Gunningham, Kagan & Thornton, 2003) and where such pressures compellingly coincide one may expect similar, though not identical, corporate responses (Howard-Grenville, 2005).

[1] Carbon dioxide emissions are a key contributor to global climate change, and come primarily from the burning of fossil fuels for energy and transportation

Finally, individual orientations seem important to the operation of both the simple and more complex boundary practices. We found suggestions of three types of orientations that facilitated the work at the interorganizational boundary. First, they have an orientation towards openness in pursuing environmental and sustainability issues – believing that their firms cannot make the necessary gains (prescribed by more stringent environmental regulations or corporate objectives) on their own. As one member put it, "you can only be good if you seek good advice." Another noted the importance of openness to the development of industrial symbiosis linkages by stating that ""Networks develop because people see in a systems view." This openness makes it easier for NISP to engage these organizations and also to bring other relevant parties into new projects with them. Second, these members have a level of trust with NISP and their RC's based on past project success. This trust is key to NISP's ability to successfully broker the necessary relationships to achieve novel industrial symbiosis projects with these organizations (Burt, 2002; Uzzi, 1996). Lastly, these members have relative autonomy in how they will meet their organization's resource and waste goals; thus they can pursue those avenues they see most promising without needing corporate approval for every action, suggesting a tendency for such companies to be more proactive on environmental management (Howard-Grenville, Nash, & Coglianese, 2006).

Concluding Thoughts

To summarize, we found that many of the activities at the interorganizational boundaries to initiate and develop industrial symbiosis projects were, contrary to our expectations, disarmingly simple. We drew an analogy with "speed dating" and "on-line dating," respectively, to describe the practice of the "Quick Wins" workshop and the resource database. Both were relatively easy and low-cost for participants to engage in, and both led to a few quickly identifiable synergies that could be pursued in greater detail. The factors that seemed to contribute to the successful use of these boundary practices and artifacts including getting the “right” people in the room (those with an in-depth knowledge of resource flows, quantities, and needs for their facility, and allowing all manner of resource synergies, including those that did not require complex transformations or investments in technology.

While we suspect that the common roles and experiences of participants played an important role in their being able to quickly and easily exchange valuable information (Brown & Duguid, 2001; Robertson et al, 2005), we also note that there were strong incentives originating from outside the organization that made entering into industrial symbiosis projects a compelling business logic. The conditions for interorganizational collaboration were therefore ripe – by definition industrial symbiosis requires two or more parties to enter into an exchange and, as others have observed, contextual and institutional factors can shape both the opportunities for and the necessities for collaboration (Lawrence, Hardy, & Phillips, 2002).

But beyond these institutional and business logics, our interviews and observations hinted at specific orientations of the individual participants that likely enabled the successful use of both the simple and complex boundary practices. Many seemed to believe that openness to others, seeking advice from others, and accessing dispersed resources were important to solving particular problems. Further, they believed that NISP staff and practices could enable them to do this in a way that was not possible if they acted alone. The interviewee representing the auto manufacturer noted that if he contacted another (named) auto manufacturer to discuss common recycling concerns, “they would say get lost … they would be suspicious.” But NISP was “a neutral party,” according to this interviewee and hence could arrange meetings and facilitate interactions that otherwise could not happen. This combination of an orientation to openness and trust, and the creation by NISP of valued social capital to link participants are essential features to explore further. Others have noted that the internal images members of a company have of their innovative capabilities and their interaction with outsiders critically shape the effectiveness of their innovation (Dougherty, 2001). Our future research will probe the interaction between the orientations of individuals, the internal context that shapes these orientations, the external contextual factors that compel interest in industrial symbiosis, and the use of the particular boundary practices and artifacts to better understand the initiation and development of interorganizational collaboration.

References

Allen, T. 1977. *Managing the Flow of Technology*. Cambridge, MA: MIT Press.

Baas, L. W. & Boons, F. A. 2004. An industrial ecology project in practice: Exploring the boundaries of decision-making levels in regional industrial systems. *Journal of Cleaner Production*, 12: 1073-1085.

Bechky, B. A. 2003. Shared meanings across occupational communities: The transformation of understanding on a production floor. *Organization Science*, 14: 312-330.

Brown, J.S. and Duguid, P. 2001. Knowledge and organization: A social-practice perspective. *Organization Science*, 12, 198-213.

Burt, R. S. 2002. The Social Capital of Structural Holes. In M. F. Guillen & R. Collins & P. England & M. Meyer (Eds.), *New Directions in Economic Sociology*. New York: Sage.

Carbon Trust. 2006. http://www.thecarbontrust.co.uk/carbontrust/about/about5_1.html

Carlile, P. R. 2002. A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, 13: 442-455.

Carlile, P. R. 2004. Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization Science*, 15: 555-568rid.

Chertow, M. R. & Lombardi, D. R. 2005. Quantifying economic and environmental benefits of co-located firms. *Environmental Science & Technology.*

Clark, W. 2005. Paper presentation, International Sustainable Development Research Conference, Helsinki, June 2005.

DEFRA (Department for Environment, Food, and Rural Affairs, UK Government). 2004. £284 M Landfill tax recycled to help businesses make the most out of their waste. News release. November 22.2004. http://www.defra.gov.uk/news/2004/041122c.htm

Dougherty, D. 1992. Interpretive barriers to successful product innovation in large firms. *Organization Science*, 3: 179-202.

Dougherty, D. 2001. Reimagining the differentiation and integration of work for sustained product innovation. *Organization Science*, 12: 612-631.

Ehrenfeld, J. R. & Chertow, M. R. 2002. Industrial symbiosis: The legacy of Kalundborg. In R. U. Ayres & L. W. Ayres (Eds.), *Handbook of Industrial Ecology*. Cheltenham, UK: Edward Elgar.

Emerson, R. M. 2001. *Contemporary Field Research: Perspectives and Formulations* (2nd ed.). Prospect Heights, IL: Waveland Press.

Glaser, B. G., A. L. Strauss. 1967. *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Aldine de Gruyter, New York, NY.

Grant, R. 1996. Prospecting in a dynamically-competitive environment: Organizational capability as knowledge integration. *Organization Science*, 7: 375-387.

Gunningham, N., Kagan, R. & Thornton, D. 2003. *Shades of Green: Business, Regulation, and Environment*. Stanford, CA: Stanford University Press.

Hansen, M. T. 1999. The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly*, 44: 82-111.

Hardy, B., Phillips, N., & Lawrence, T. 2003. Resources, knowledge, and influence: The organizational effects of interorganizational collaboration. *Journal of Management Studies*, 40: 321-347.

Hargadon, A. and Sutton, R. 1997. Technology brokering and innovation in a product development firm. Administrative Science Quarterly, 42: 716-749.

Heeres, R. R., Vermeulen, W. J. V., & de Walle, F. B. 2004. Eco-industrial part initiatives in the USA and the Netherlands: First lessons. *Journal of Cleaner Production,* 12: 985-995.

Hoffman, A. 2000. *Competitive environmental strategy: A guide to the changing business landscape*. Washington DC: Island Press.

Howard-Grenville, J. 2005. The persistence of flexible organizational routines: The role of agency and organizational context. *Organization Science,* 16: 618-636.

Howard-Grenville, J. 2006. Inside the 'black box': How organizational culture and subcultures inform interpretations and actions on environmental issues. *Organization & Environment*, 19:46-73.

Howard-Grenville, J. and P. Carlile. 2006. The Incompatibility of Knowledge Regimes: Consequences of the Material World for Cross-Domain Work. *European Journal of Information Systems*, special issue on Knowing in Practice. Forthcoming.

Howard-Grenville, J., Nash, J., & Coglianese, C. 2006. The internal license to operate: Organizational factors and their influence on corporate environmental practice. working paper.

Huang, J. 2000. Knowledge integration processes and dynamics: An empirical study of two cross-functional programme teams. Unpublished Phd thesis. Warwick Business School, University of Warwick.

Huang, J., Newell, S. and Pan, S. 2001. The process of global knowledge integration: A case study of a multinational investment bank's Y2K program. *European Journal of Information Systems*, 10: 161-174.

Jacobsen, N. B. 2005. Industrial symbiosis in the making: Bridging social and technical explanations - The case of Kalundborg, Denmark. Paper presentation, International Sustainable Development Research Conference, Helsinki, June 2005.

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

Knorr-Centina, K. 1999. *Epsitemic Cultures: How the Sciences Make Knowledge*. Harvard University Press. Cambridge, MA.

Lawrence, T., Hardy, B., and Phillips, N. 2002. Institutional effects of interorganizational collaboration: The emergence of proto-institutions. *Academy of Management Journal*, 45: 281-290.

Laybourn, P. & Clark, W. 2005. National Industrial Symbiosis Programme: A Year of Achievement: 39. Birmingham, UK: National Industrial Symbiosis Programme.

Levina, N. & Vaast, E. 2005. The emergence of boundary spanning competence in practice: Implications for implementation and use of information systems. *MIS Quarterly*, 29: 335-363.

Malmborg, F. v. 2004. Networking for knowledge transfer: Towards an understanding of local authority roles in regional industrial ecosystem management. *Business Strategy and the Environment*, 13(5): 334.

Mirata, M. 2004. Experiences from early stages of a national industrial symbiosis programme in the UK: Determinants and coordination challenges. *Journal of Cleaner Production*, 12: 967-983.

Merali, Y. 2002. The role of boundaries in knowledge processes. *European Journal of Information Systems*, 11: 47-60.

Miles, M. B. and A. M. Huberman. 1994. *Qualitative Data Analysis: An Expanded Sourcebook*, 2nd ed. Thousand Oaks, CA: Sage.

Nonaka, I. 1994. A dynamic theory of organizational knowledge creation. *Organization Science*, 5: 14-35.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, 41: 116-145.

Robertson, M., Scarbrough, H., & Swan, J. 2003. Knowledge Creation in Professional Service Firms: Institutional Effects. *Organization Studies*, 24(6): 831-857.

Scarbrough, H., Swan, J., Laurent, S., Bresnen, M., Edelman, L., & Newell, S. 2004. Project-Based Learning and the Role of Learning Boundaries. *Organization Studies*, 25(9): p1579-1600.

Spender, J. C. 1996. Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal*, 17: 45-62.

Star, S. L. 1989. The structure of ill-structured solutions: Boundary objects and heterogeneous distributed problem solving. In M. Huhns and L. Gasser (eds.), *Readings in Distributed Artificial Intelligence*. Menlo Park, CA: Morgan Kaufman.

Swan, J. A. & Newell, S. 1995. The role of professional associations in technology diffusion. *Organization Studies*, 16(5): 847-874.

Tyre, M. and von Hippel, E. 1997. The situated nature of adaptive learning in organizations. *Organization Science*, 8: 71-84.

Uzzi, B. 1996. The sources and consequences of embeddedness for the economic performance of organizations: The network effect. *American Sociological Review*, 61: 674-698.