CONNECTIONS, COLLABORATION, AND COLLECTIVE KNOWLEDGE: FOSTERING KNOWLEDGE SHARING COMMUNITY

By

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Abstract

This study's purpose was to explore ways of bridging conspicuous barriers to collaborative knowledge sharing among a specific group of IT Professionals (ITPs) supporting a heterogeneous school of arts and sciences at a large public research university. Forming the core of the study were a structural-cultural lens, a design-based research methodology, and a reliance on qualitative and social-network analysis (SNA) techniques. The study's key design feature was a long-term problem-based learning (PBL) experience implemented as a means for developing meaningful social arrangements to promote knowledge sharing among 12 participants, including myself as a participant observer. With participants subdivided into three small groups based on technical knowledge and relative preference for working independently, this 24-week PBL intervention revolved around a collaborative project to co-design an online knowledge sharing system. As facilitator, I attempted to guide structural elements like interactional format and frequency, emphasizing direct knowledge exchanges between participants. To inspire collaborative inclinations, I attempted to elicit ongoing discussion of meaningful ideals such as those embodied in the Open Source community. Ongoing collection and interpretation of several data sources informed attempts to make in-process adjustments throughout the study. Data included individual semi-structured pre- and post-intervention surveys, quantitative every-other-week SNA surveys, and semi-regular participant and facilitator journals, as well as every-other-week small-group logs and audio recordings of whole-group meetings. The study's exploratory nature, context specificity, and non-experimental methodology warrant cautious interpretation. However, analysis suggests that opposing orientations – towards people on the one hand and processes on the other – corresponded with differences in knowledge sharing across the three small groups in which participants worked

closely throughout the study. More specifically, "people-centric" structural and cultural factors like face-to-face interactions and values like fairness, inclusion, dialog, and transparency appeared to be related to the promotion of knowledge sharing relationships in the study context. Group compositional traits including similarity in social position, but regardless of collaborative skills and inclinations, appeared to be relevant factors as well. By suggesting the importance of people-centric sensitivities, (in)equality in social position, and structural rhythms, the findings may inform future attempts to foster knowledge sharing community among ITPs more generally.

Dedication

To my advisors, present and past, for believing in my potential and nurturing my growth in matters personal and professional.

To my IT colleagues, for patiently enduring and enthusiastically giving their whole selves to the cause.

To my family, especially my partner in life, for giving me the freedom and unwavering support I needed to finish what I started.

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Chapter 1: Introduction

"Just Google it" is perhaps the quintessential catchphrase of our time. It both reflects the enormity of information available to the modern learner yet belies the real difficulty of navigating an ever-growing surfeit of "facts" of varying quality. Current educational theories recognize that learning in today's world is not about amassing and cataloging facts for future recall. That role now belongs to the Googles of the world. Rather, as Rogers (1969) rather prophetically put it, modern learning is about "learning how to learn" and becoming a lifelong learner. It is about actively discovering, critically evaluating, and adapting disparate viewpoints and findings in the service of particular objectives. It is, in other words, about learning how to intelligently decipher and strategically leverage modernity's abundance of information on the way to continually building understanding, knowledge, and solutions.

As an Information Technology professional (ITP), this view of learning resonates with me because it reflects the realities my team and I face on a regular basis. Even after all the technological advancements to date, Moore's Law – the doubling of computing power that occurs roughly every two years – rather astonishingly remains in effect (Cumming, Furber, & Paul, 2014). As the incessant march of technological evolution and proliferation continues, we ITPs must continually learn and adapt to an expanding world of complex technological possibilities. For our team, a group of ITPs supporting a sizable school of arts and sciences in a large research university, this need is compounded by our location within a setting characterized by a diversity of disciplines, freedom of thought, and a correspondingly heterogeneous mix of technologies. In our endeavors to sustain and improve the use of information technology in this environment, "The Web" (the so-called sum of all human knowledge) is undoubtedly a useful tool, and one upon which we rely heavily. Yet it remains a sometimes dubious, inert source of

information. How we are to effectively interpret, evaluate, adapt, build upon, and apply such information to the complex needs within our context – i.e., how we are to continue learning in the modern sense – remains a significant and ongoing challenge for us.

Statement of the Problem

As an aspiring "scholarly practitioner" (Belzer & Ryan, 2013), I see the value in applying academic theory and research to such learning-related problems of practice. One promising theme among educational thinkers focuses on the collaborative and communal aspects of learning. For instance, conceptual frameworks such as problem-based learning (PBL; Hmelo-Silver, 2004; Hmelo-Silver & Barrows, 2006; Torp & Sage, 2002), knowledge building communities (KBCs; e.g., Scardamalia & Bereiter, 2006; Zhang, Scardamalia, Reeve, & Messina, 2009), professional learning communities (PLCs; Hord, 1997), communities of practice (COPs; Lave & Wenger, 1991; Wenger, 2008), learning organizations (e.g., Argyris, 1977; Watkins & Marsick, 1993), and the many inquiries into peer learning more generally (e.g., O'Donnell & King, 1999) all emphasize the ways in which learning relates to social processes at various scales. Through all of these lenses, learning can be seen as a *joint* enterprise that encompasses more than individual cognition, one that manifests in and through a variety of social patterns and practices. Such thinking shifts the onus of continual learning away from the relatively limited capacities of individuals towards ways in which we ITPs might leverage our collective strengths and support each other's learning needs in our challenging field. It also highlights possibilities for improving our *group's* knowledge and collaborative practices and thus learning at a super-individual level.

Such ideas do seem to be gaining popularity these days. Teachers, for instance, are increasingly turning towards inquiry-based or other collaborative instructional approaches to

prepare our youth for participation in modern society (Minner, Levy, & Century, 2010). Through Professional Learning Communities, teachers are also leveraging collaboration to support each other's professional development and the sharing of best practices (Hord, 1997). Many academics and scientists, furthermore, are embracing cross-disciplinary, collaborative modes of investigative work (Morrison, Dobbie, & McDonald, 2003; Wagner & Leydesdorff, 2005), possibly because of the ballooning complexity within their own fields and a growing interdependence between advanced specializations. Indeed, science itself is about contributing to a growing body of knowledge by taking up and building upon the ideas of others.

Perhaps a similar approach, one in which knowledge is pooled and solutions jointly pursued, would also help the ITPs in our group meet their needs for ongoing learning in our ever-changing technical landscape. As a large and diverse school in a public research university, our setting presents a fairly complex set of challenges while providing relatively modest resources. Our roughly 30-member[1] IT group, for instance, supports the technology needs of scores of departments and centers and thousands[2] of faculty, staff, and graduate students from fields spanning both the arts and sciences. As a consequence, IT staff must possess an eclectic set of knowledge in order to function in this setting. However, as individuals, even the most well-versed staff members cannot possibly know, much less be expert in, everything that is required to support all aspects of this environment. Learning how to better draw upon all of the knowledge, experience, talent, and problem-solving abilities that our group collectively possesses would surely make it easier to meet and perhaps even exceed these demands.

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[1] The precise makeup of this group varies depending on who is included. For example, technical staff from some areas at the university have recently become affiliated with our group through reporting relationships, but their activities are not entirely integrated into our operational model at this time. Including these staff in the count would put the number closer to 40.

[2] The complexity of our environment makes it difficult to know who to count for the purposes here. Different counts put the number between 1,000 and 5,000.

Yet if this kind of knowledge sharing and collaboration is to be the goal – if we are to learn how to learn collaboratively – our IT group faces significant challenges. Based on my 17 years of experience in this setting, I think there are four factors that are among the most significant: (a) the way we currently divide our labor in order to meet a diversity of needs; (b) the expectations we hold for ourselves, particularly our emphases on self-sufficiency and individual responsibility; (c) the de facto role of learning in our workplace solely as a means rather than an end; and (d) the impact of expanding responsibilities and group size on our ability to engage and relate to one another.

Division of labor. One of the most apparent obstacles is that our responsibilities spread us mentally and physically across our large and diverse environment. As the scope of our operation has grown over time, some of our staff (roughly 25%) have come to specialize in rapidly expanding services such as web design and programming that are somewhat cross-departmental in focus. However, the breadth and diversity of our school have led to most other IT staff "specializing" in the support of one, two, or a handful of departments (depending on their size and complexity). In these cases a single ITP is assigned to work closely with a given department's chairperson and other leaders to meet all of their daily computing needs, thereby giving the ITP "site-specific" knowledge (Honig, 2003) of the particular people and requirements in those settings. Our clients also seem to prefer the attentions of a dedicated IT person rather than, say, a stable of "interchangeable" but less personally-known IT people, and IT staff often enjoy such personalized relationships as well. Thus, this arrangement serves some useful and desirable functions. Oftentimes, however, these localized needs are not entirely distinct from those encountered in other departments, making them at least theoretically amendable to the payoffs of shared knowledge and collaborative efforts. Yet the daily rhythms

of the job, idiosyncrasies of specific contexts, and separation from other IT employees all seem to promote working in isolation rather than jointly with IT colleagues.

Emphasis on self-sufficiency. Accompanying these patterns of (non-)interaction between our IT staff is also a set of expectations for where responsibilities and obligations lie. Besides the pride and sense of satisfaction that many dedicated ITPs seem to derive from independently mastering complex problems, our organizational model naturally creates an expectation that responsibility for any given department (or web project) "belongs" to the particular individual assigned to support it. Thus, to an ITP needing assistance or input, collaborative outreach may feel somehow subpar or obtrusive. Even when such outreach does occur, other IT staff in the group may not feel particularly motivated to "ignore" the pressures of their own responsibilities in order to lend aid. Indeed, if such requests are not accompanied by an obvious demonstration of due diligence and complete details regarding the challenge at hand, the requestor may be more likely to meet with apathy or even hostility than genuine collaborative engagement. No matter the response, accountability for meeting the needs in any given department usually does fall to the assigned ITP, reinforcing the sense of individual rather than joint ownership of problems.

Value of learning in our workplace. The purpose for our group's existence also seems to matter when it comes to finding opportunities to collaborate and support each other's learning needs. Unlike formal learning environments where the express reason for affiliating is to learn, our official function as an IT group is not to learn per se but rather to get work done. As employees, learning is something we ITPs do in order to be productive, not something that is considered productive in and of itself. In part this means that we rarely come together solely to share knowledge and learn from each other. Given the pressures of limited time and competing

responsibilities, activities that do not have an obvious and immediate productive payoff seem "wasteful" or at least less critical. In-house workshops or similar events may be appreciated by some as pleasant deviations from the status quo, but such events are not currently a mainstay in the way we do things. Indeed, they rarely happen at all, and that seems unlikely to change dramatically in light of our ongoing workload. Thus, if we are to reap the benefits of our collaborative learning potential, we will need to find ways to begin threading knowledge sharing and collaborative engagement into the fabric of our everyday work patterns, to make them a more regular, normal, and accepted part of "business as usual."

Organizational evolution. Our IT group has changed fairly substantially over the last decade and a half. Due to some trends towards centralization both at the university level and within our own school, a growing array of areas has come under our IT group's official support umbrella. This means more people and more technologies for us to support, requiring more IT people on staff. Consequently, the number of ITPs in our group has roughly *tripled* during this time period. Such a trend makes it difficult for IT staff to get to know all or even most of their teammates or their particular strengths, much less maintain the sense of connection and relevance that could promote knowledge sharing and collaboration with them. Ironically, then, while the addition of personnel means a potential increase in our pool of total knowledge and skills, it seems to have become more difficult for any given ITP to make use of it. Instead, individual staff sporadically engage only a handful of others at best, and oftentimes confine their interactions entirely to those exposed by formal processes and the official chain of command – purely pre-planned or top-down "rational-technical" avenues (Scott & Davis, 2007) that often cannot account for all organizational realities. Furthermore, because of our group's physical dispersion and heavy reliance on electronic forms of communication, there seems to be little

opportunity to experience the kinds of spontaneous rapport-building and knowledge-exposing interactions that might "naturally" offset this tendency.

To summarize, the problem of interest here is twofold. On the one hand, as professionals tasked with implementing, supporting, and intelligently wielding an array of rapidly changing technologies, our IT group would seem to benefit from improved knowledge sharing and joint problem solving. As individuals, for instance, we could lean on each other more, complement one another's knowledge, learn together, and solve problems better or more quickly. On a group level, we might also learn by turning such advantages into an operation with more time and ability to innovate and improve while still maintaining a high level of customer service and delivering well tested solutions. On the other hand, however, there are several factors in our current interactional patterns that inhibit this kind of collaborative arrangement – things like our perpetually divided foci, expectations of individual self-sufficiency, pressures that deprioritize learning for its own sake, and growing disconnectedness between members in the group as we continue to expand our ranks. Thus, finding ways to overcome or mitigate such barriers will be important to improving our ability to learn from and with each other.

Purpose of the Study

The preceding observations, starting as they do with a social perspective on learning, intentionally focus on factors in the social environment that impinge upon our ITPs' means and motivation to engage in collaborative practices. Such environmental factors are rather powerful "social facts" (Durkheim, 1951), created by people but largely beyond the direct control of individuals. As such, no single study or intervention is likely to fundamentally change them. Accordingly, the purpose of this study was not to attempt any radical alterations to our group's

environment but to explore some ways of making better use of our group's collective strengths and collaborative learning potential given the impact of these larger realities. That meant attempting to introduce smaller changes that directly offset or compensated for these factors in some strategic way. However, the ability to do this at all first required recognizing their influence.

Sociological thinkers have provided two big concepts that may be useful in framing a study such as this: social structure and culture. As Gusfield (1981) in particular has noted, social life can be seen in terms of patterns that *organize* social activity as well as cultural elements that provide *meaning* to it. The four factors outlined in the problem statement exhibit both structural and cultural elements. For instance, interactions between members of our group are patterned in part by the way job responsibilities are divvied up, but the value we place on self-sufficiency and the meaning of "productivity" fuel the way we interpret and respond to collaborative outreach. Does our independence on the job lead us to value self-sufficiency, or do our values reinforce our tendency to work independently? These elements are intertwined in everyday life. Yet however hard it is to separate structural and cultural influences empirically, conceptually they are useful ways of calling attention to qualitatively different forces at work.

Significant educational thought seems to be at least implicitly organized around these two big concepts as well. Lave and Wenger (1991), for example, examined how the "peripheral participation" of novices evolves towards expert status through progressive encounters with community activities as well as values and standards. Scardamalia and Bereiter (2006) described Knowledge Building Communities as not only requiring particular interactional patterns for the achievement of knowledge development but also as intertwined with a "knowledge creating culture" that prioritizes community progress over individual content acquisition. Even PBL,

which is perhaps the most tactical of these frameworks with its application of authentic ill-structured problems as key learning mechanisms, espouses not just the central importance of collaborative activity; it also emphasizes the desirability of particular skills and traits such as inquisitiveness, flexible thinking, tolerance of "messiness" and uncertainty, and an ethos of lifelong learning (Hmelo-Silver, 2004). Thus, social structure (interactional patterns) and culture (meaning making) are foundational elements in all of these socially-oriented educational frameworks, suggesting that employing these ideas as organizing concepts is also useful for my purposes here.

This study, then, was an attempt to use the complementary lenses of social structure and culture to help understand and overcome some of the primary obstacles to collaborative knowledge sharing among ITPs in my workplace. At the study's center was a somewhat long-term collaborative project (a roughly 6-month "intervention") meant to parallel though not disrupt some of our usual workplace activities. Offered to potential participants as a voluntary technical challenge, this "special project" was designed around the tenets of problem-based learning, as this framework lends itself well to structural and cultural tinkering while also dovetailing nicely with the problem-solving activities that characterize much of our IT group's work. By following a design-based research methodology, which emphasizes learning from iterative design refinements, I explored some key mechanisms meant to help our ITPs counter the more atomizing aspects of our environment by developing the collaborative skills, habits, and mindset necessary for building knowledge sharing community in our workplace. To the extent that such communal activity and ethos was achieved within the context of this study, the lessons learned may serve as a guide for shaping interactions among our group more generally, or may at least form the basis for more directed inquiry. Embedded as it was within our workplace, among

actual coworkers, over the course of roughly half a year, there was likely some blurring of lines between the activities in which the participants engaged as part of the study and those they encountered outside of it. Thus, while I must confine my attention to the study proper, I also welcome the possibility that the study could serve as a broader catalyst for collaborative activity in our workplace.

Research Questions

Concepts as broad as "structure" and "culture" offered many possibilities for shaping this study. However, the focal points for this particular inquiry flowed from the most apparent contributors to our IT group's relatively haphazard knowledge sharing patterns: i.e., our physical dispersion and divided foci, our highly individualistic notions of responsibility and expectations of self-sufficiency, the need to get work done and the way we interpret "productivity," and our relative unfamiliarity with and disconnectedness from one another. The overarching question was whether it was at all possible to address these "environmental" difficulties without some kind of formal, possibly large-scale reorganization. Even if such changes were within this researcher's sphere of influence, I suspect they would be unlikely to succeed in generating a real collaborative climate without attending to mechanisms that shape the everyday experiences of people in this context. This is partly why both social structure and culture matter: leaders might impose some degree of structure through formal policies and procedures, but they cannot force people to experience these arrangements as meaningful or valuable. To the extent that collaboration and knowledge sharing depend on a genuine desire to engage others, any attempts to foster a collaborative environment need to provide both interactional opportunities (structure) as well as motivational supports (culture), including – perhaps especially – for those relationships that happen on informal levels.

The research questions guiding this exploratory study therefore addressed both structural and cultural factors while focusing on the kinds of elements that were, at least at the onset of the study, most conspicuously absent from the daily interactions of the IT group in question. Specifically, I sought answers to the following questions:

1. How might particular social structures or ways of organizing interactions among ITPs in this workplace setting provide the most useful opportunities for collaborative knowledge sharing?
2. In what ways might particular cultural themes, values, or visions inspire or motivate these ITPs to pursue understanding and solutions in a more collaborative fashion?

While these questions could very well apply to all ITP interactions within this study's broader setting, for practical reasons I focused most intentionally on interactions that happen within the boundaries of the collaborative project at the center of study. This approach was intended to keep the study manageable but also allow participants to safely (i.e., without greatly disrupting existing productivity) experience and experiment with different elements, highlighted in the literature review, that are linked to positive team dynamics in various ways. Still, usual workplace relationships may be a meaningful baseline for interpreting patterns within the project framework. It is also my hope that interactions around the project were a representative enough "microcosm" of usual relationships that answering the research questions within these boundaries lays some foundations for understanding and promoting knowledge sharing more generally in this setting.

Chapter 2: Literature Review

Various portions of the literature are relevant to a study like this one. Here, I first examine structural factors affecting team functioning, including the possible importance of team makeup and member characteristics in affecting team dynamics. Next, I reflect on the potential relevance of the ideal of Openness embodied in the Open Source Software movement as a meaningful cultural theme to incorporate into the study. I then consider an example of a successful learning environment whose elements are similar to the ones I would like to foster among the proposed study's participants. Finally, I consider the promising role of particular types of collaborative activity such as PBL as a mechanism for approximating the kinds of arrangements suggested by the other themes, while also promoting collaborative skills, norms, and peer learning.

Social Structure, Communication, and Opportunities

According to Wasserman and Faust, one of the primary tenets of social network analysis (SNA) is that such social structure – particularly who tends to interact with whom and how often – can enable or constrain individual behavior (as cited in Carolan, 2014). From this perspective, ongoing relational ties or connections between people can be seen as "opportunities for transmission of resources" (p. 4). By extension, therefore, the absence of particular kinds of interaction is also relevant in the context of engendering collaboration and knowledge sharing among teams. Indeed, the expression of these patterns might be said to define the presence or absence of "teamwork" itself.

Several scholars and practitioners have turned to SNA and related concerns, such as proximity and communication media, to examine on a formal (i.e., non-substantive) level the patterns of communication that characterize the most innovative or productive teams. Pentland

(2012), for example, employed electronic badges to collect "sociometric" data (who physically interacted with whom, for how long, etcetera) on about 2,500 people in 21 diverse organizations over seven years. The interactions among members of most effective or productive teams exhibited several trends, among them (a) roughly equal but brief input from all team members, (b) direct connections between members (i.e., not mediated by a leader), and (c) periodic attempts to acquire information from outside the team. Notably, Pentland ranked face-to-face interactions as most valuable for team communications, followed by phone and video-conference, with email and texting being least valuable.

Along similar lines, though using more conventional interview data, Kratzer, Leenders, and van Engelen (2009) used an SNA lens to examine the structure of inter-team interactions among two multinational product development programs. Together, the two programs consisted of 50 teams in 22 countries. Considering concepts like network range (degree of contact with other teams), tie strength (frequency of interaction), and network efficiency (lack of redundancy in relationships), Kratzer et al. mapped out interactions among the teams. They found an apparent positive relationship between network range and team creativity according to ratings by team members and leaders. Specifically, greater contact with other teams seemed important for originality and multitude of problem-solving approaches produced and/or considered. They also suggested there may be a kind of "sweet spot" regarding tie strength, with too little or too much intensity of interaction – much less than or much more than weekly interaction – diminishing creativity. Finally, similar to Pentland's (2012) findings, their analysis also suggested that direct contacts with others were better than mediated ones. For example, teams that maintained "redundant" interactional connections with others (i.e., where network efficiency was lower due to more direct contacts between members of the teams) rated higher in terms of creativity.

Although this study's focus was at a slightly different level of analysis (inter-team versus intra-team interaction), these findings nevertheless suggest that social structural factors can have an impact on team success.

Other studies in this vein include Stryker and Santoro's (2012) field study in a large technical life-sciences company, which looked explicitly at physical distance between teammates' workstations. They found that close proximity and visibility, coupled with ample formal and informal spaces for collaboration opportunities, were associated with increased levels of face-to-face communication. Similarly, Chong, Eerde, Rutte, and Chai's (2012) study among 81 new product development teams suggested that the effect of proximity on face-to-face communication was mediated by different types of time pressure. Pressures that challenged teams but promised benefits for high performance improved communication in face-to-face situations, whereas time pressures perceived as potentially threatening did not. Finally, both Grosse (2002) and Weimann, Hinz, Scott, and Pollock's (2010) research on communication among "virtual teams" suggested that communication is best supported by using mediums that are most appropriate for particular topics or tasks. Email, for instance, may not be well-suited to complex exchanges. Furthermore, face-to-face communication in some form, even for virtual teams, was found to be important for creating shared meaning and common ground among team members.

Even this brief glimpse at SNA-related studies suggests there is ample reason for paying attention to social structure's impact on collaboration and knowledge sharing. Such studies, for example, highlight the likely importance of contact frequency (e.g., weekly intervals may be ideal), format (e.g., face-to-face interactions matter), and mode (e.g., multiple unmediated relationships may lead to optimal outcomes). As these studies focus predominantly on a formal

or structural level of analysis, however, they do not capture much of the interactional substance or meanings that may help achieve these desirable patterns or help translate them into better teamwork. It is possible, for instance, that particular structural arrangements are the outcome of successful collaborative relationships, not their genesis. Such arrangements may also be a necessary but not sufficient condition for creating collaborative relationships: Creating opportunity does not necessarily mean it will be acted upon. Still, acting upon an opportunity that does *not* exist is impossible. Especially in the workplace, where structures are not necessarily created for the purposes of learning, it therefore seems important to attend to such matters of opportunity if collaboration and knowledge sharing are to be achieved.

Team Composition

A large segment of the literature focuses on traits that characterize the most effective or productive teams. Typically these "composition" traits have to do with the particular make-up of the members. For instance, heterogeneity among team members may have either a positive or negative impact, depending on the environments or roles in which the team members work. Bercovitz and Feldman (2011), for example, studied teams of academic scientists engaged in new product development. Using patent and licensing grant information, their quantitative analysis suggested that those teams who had unique combinations of expertise, and who managed not to become overburdened with extra coordination costs, were more likely to successfully achieve patents or licenses on their innovations. By contrast, in their case-based evaluation of a collaboration engineering product implemented among tool and dye workers in a German automobile factory, Bittner and Leimeister (2014) portrayed heterogeneity as a challenge to the shared understanding necessary for effective team communication, something the product must overcome.

Careful analysis of the factors that constitute hetero- or homogeneity and what it means to be successful, effective, or innovative may be worth pursuing. On their face, however, these kinds of opposing examples suggest that the importance of heterogeneity or homogeneity among team members may depend on the purpose of the team. Teams with primary tasks that rely mostly on inventiveness and creativity (e.g., new product development) may benefit from a diversity of expertise, while teams whose work relies primarily on precise standardization (e.g., factory work) may benefit less or even incur costs from heterogeneity. However, one implication is that, when tasked with solving problems in ways that are not wholly predefined or prescribed, ITP teams might benefit from a degree of heterogeneity in skills. Certainly, when particular problems require a range of knowledge that is unlikely to be wholly possessed by single individuals, it makes sense to form teams around the complementarity of their members' knowledge.

Team size is another potentially important compositional trait. Bercovitz and Feldman (2011) examined team sizes that ranged from two to 15 members and found a small positive relationship between size and the probability of patent or license attainment. Yet the average team size across the 1425 teams observed was still only 2.89. Because these researchers also highlighted the challenge that larger team sizes might pose in terms of coordination difficulties, it might be inferred that smaller team sizes are easier for members to manage on a logistic level. In his review, Hoegl (2005) also expressed a degree of surprise that teams often reach sizes as large as 10 or more when the literature has traditionally suggested greater effectiveness among smaller teams. Among collaborative educational researchers as well, there is a similar recognition that group size matters. In reviewing evidence for the effectiveness of cooperative learning methods, for instance, Slavin (1980) recommended that cooperative learning groups be

limited to four to six members. Similarly, in explaining the basic principles that make cooperation work, Johnson and Johnson (1999) repeatedly advised dividing students into groups of around four students.

One challenge in applying findings about team heterogeneity and size is that many teams, such as the one at the center of the proposed study, are not necessarily nimbly crafted and recrafted to meet very specific or short term needs. Rather, team membership may evolve gradually in a somewhat ad hoc fashion as new hires are selected more for their general qualities and range of talents than their ability to fulfill a particular strategic need. Thus, based as they are on longer term hiring processes, team makeup and size may appear to be variables that are beyond easy or practical manipulation. In addition, the purpose of particular teams is unlikely to be completely singular or fixed over time, making the "ideal" mixture of traits for achieving a given team's current purpose something of a moving target. However, Hoegl's (2005) logic suggests that one way to apply these kinds of insights might be to subdivide larger teams and concentrate members into multiple sub-teams with the appropriate size and compositions, perhaps even creating "core" teams with additional support from "extended" team members for greater flexibility. In particular, small sub-teams with diverse sets of expertise may be temporarily formed when circumstances demand more creative insight or innovation. As a corollary to this logic, it might also be worthwhile to aggregate some of the responsibilities normally left to individuals and instead assign them to sub-teams formed specifically on the basis of targeted traits.

This last bit of reasoning actually suggests much about the importance of promoting voluntary collaboration and knowledge sharing in the workplace. Because traditional formal structures are unlikely to institutionalize all the processes necessary for meeting organizational

goals (Wenger, 2008), they may be ill-equipped to adapt to changing or unpredictable circumstances. However, individuals that work in an environment that supports collaboration and knowledge sharing can overcome many challenges by flexibly relying on the overall strengths of the team. Perhaps part of the key, then, is to think of successful teams and teamwork as things that are dynamic and somewhat informal in nature.

Openness and Transparency

Another theme is worth noting because of its relevance in the lives of many ITPs – especially those that work in technologically heterogeneous environments, such as the ITPs in this study. Many scholars, particularly economists and business analysts, have paid a fair amount of attention to the reasons behind the success of the Open Source Software (OSS) movement. In contrast to software that is released only in binary form, "open source" software is software whose un-compiled, clear-text programming code is freely available to the public (von Hippel & von Krogh, 2003). Such code makes it possible for people with programming knowledge to understand how the software works, and is typically accompanied by licensing terms such as those in the GNU General Public License (see gnu.org/licenses) allowing anyone to modify and redistribute the code with minimal restrictions. Such software, furthermore, is most often created and maintained by a "loosely-knit community of programmers" (Hertel, Niedner, & Herrmann, 2003) who volunteer their time and effort. Given the prominence of rational self-interest in much economic thought, this phenomenon is particularly interesting because of its apparent deviation from more traditionally imputed motives like personal economic gain.

The Apache web server is an example of a popular OSS project. Looking at the more "mundane but necessary" aspects of the OSS movement (i.e., provision of technical support as

opposed to programming), Lakhani and von Hippel (2003) examined three years of forum posts and over 300 questionnaire responses from voluntary contributors to Apache help forums. Their findings suggest that contributors provided technical assistance for a number of reasons, including the desire to reciprocate for help they had previously received, the desire to help "the cause" or community, reputational benefits, and because it is fun or relaxing. Similarly, Hertel et al. (2003) studied the motivations influencing contributors to another extremely popular OSS product: the Linux operating system. Their analysis of questionnaire responses from 141 Linux contributors suggests that, as happens in many significant social movements, personal identification with a community was important. In this case, respondents cited identification with both Linux user and developer communities. Positive reactions from significant others and sociopolitical motives stemming from the support of "independent software" were also important among these respondents. These are only two examples but there is clearly something more than economic calculus happening in such cases.

To be sure, these are not cases of pure altruism either, as pragmatic motives remained important as well. For instance, the Apache supporters spent only 2% of their time on the forums providing help, and typically provided information only on issues to which they already knew the answers. Likewise, the Linux contributors also cited personal advantages for contributing – e.g., because they had a need for the software they developed. However, the larger point stands: "Openness" as an organizing principle or model appears to have the potential to motivate people in multiple ways, even when direct compensation or pure self-interest is not involved. For ITPs who often interact with open source software products and consume and possibly even add to the contributions of a larger community of people around the world, this could prove to be an engaging model to consider emulating in some way.

What openness is to software development, transparency may be to communication and information flow within organizational settings. Here the evidence seems more scant, but there is convincing commentary and enthusiasm surrounding collaborative communication software such as Slack (slack.com), which is based partly on the idea that collaboration demands "being able to see into different parts of the organization" (Butterfield as cited in Manjoo, 2015). According to O'Toole and Bennis (2009), the connection between transparency or "candor" in an organizational setting and improved performance is complex but makes sense from a variety of angles. For instance, besides allowing leaders to benefit from the insights and knowledge of all team members, it also allows disagreements among team members to surface, which helps to maintain a healthier, more innovation-friendly mix of perspectives. This is akin to stomping out bugs in the world of software: more eyes and brains focused on the potential problems mean fewer snafus and better solutions.

One major challenge inherent in applying notions of openness and transparency is that some see it as going "against the grain of group behavior and, in some ways, even against human nature" (O'Toole & Bennis, 2009). Information and knowledge can be a source of power. Even for those operating at lower ranks or levels of responsibility, a monopoly or near-monopoly on important information or know-how can also be seen as a means of maintaining job security. Additionally, there are costs to consider – costs in effort, energy, time, and forgoing of more clearly self-benefiting activities. So, while motivations like "the community" and "the cause" cited by open source contributors indicate that "human nature" is *not* based entirely on self-interest, attempts to leverage openness and transparency as motivational sources might be more likely to succeed if they minimize the perceived risks to self-interest while making the benefits as salient as possible.

Knowledge Building Community

Here it may be useful to consider a learning framework and intervention design that both inspire and lend some credibility to the case I wish to build here. Knowledge Building is a perspective on learning that emphasizes education's role in preparing learners to become part of our modern "knowledge-creating civilization" (Scardamalia & Bereiter, 2006). As a theory, it encompasses several themes that emphasize things like the community basis for knowledge advancement, collaborative problem solving, and understanding as a socially emergent phenomenon. It also emphasizes the importance of artifacts that serve as means for advancing knowledge at the community level, and thus argues that the state of "knowledge is not about what is in people's minds at all" (p. 100). In other words, this perspective, like the one I laid out earlier, is very much grounded at the social level.

A search for *knowledge building community* in Google Scholar confirms that it is a fairly popular perspective, with the most popular sources being cited by others hundreds or thousands of times. Knowledge Forum is the computer environment that grew out of this perspective, and it appears to be equally popular. One notable design experiment conducted by Zhang, Scardamalia, Reeve, and Messina (2009) also seemed to uphold the usefulness of Knowledge Forum as a learning intervention. Using social network analysis and qualitative analyses in a study that spanned 3 years, these researchers demonstrated that Knowledge Forum, combined with flexible group structuring that ultimately allowed "opportunistic collaboration," had noticeable effects on innovative production of knowledge at the collective level. This combination, for instance, successfully encouraged students to engage in "collective cognitive responsibility" for the community's overall level of knowledge while also achieving their individual learning goals.

The enthusiasm for this model and results like these suggest it has tapped into something significant. The main features of the intervention appear to be the students' ability to build their ideas in connection with those of others (i.e., to share knowledge and collaborate). Particular mechanisms within the Knowledge Forum interface, such as "rise above" notes, allow the ideas to be linked together in non-linear and creative ways. Additionally, while the system provides the means to interact collaboratively, the norms and expectations of the environment – motivated and sustained in large part through the teacher's facilitation and influence – continually guide attention towards the overall picture, the state of community knowledge, and on each person's role in improving it. Thus, the particular affordances of the overall intervention design come not just from the technology but also from the development of social standards and communal inclinations in the classroom. Together these act as aids to the development of collective knowledge, with each community member being able to access and build upon any other member's contributions.

The essential elements of this design and their theoretical rationale are a useful model for the study I am conducting here. Zhang et al. (2009), for instance, found ways to organize activity around collaborative knowledge-building activities while also sustaining motivation by making such activities meaningful, by cultivating their social importance. One potentially important distinction, however, is that these researchers used an already well-formed technological system in order to build knowledge community around a predefined curriculum. In contrast, among technology professionals in an informal learning environment like the workplace, the process of developing or adapting a technological system might itself represent a useful kind of "curriculum" with potential motivational and learning value. A custom environment also promises to more closely match these participants' ongoing collaboration

needs while avoiding the potential difficulties of forcing a particular technological "solution" on people who, by profession, are both well-equipped and accustomed to looking for faults in such systems. Therefore, the *idea* of a Knowledge Building Community coupled with the development of a technological environment *like* Knowledge Forum, is perhaps more useful for my purposes than a direct or wholesale application of previous efforts in this arena.

Collaborative Learning

In the context of these findings, collaborative learning techniques appear to offer some particular advantages. Such techniques, for example, traditionally involve forming (a) relatively small groups of (b) members with heterogeneous skill sets (Johnson & Johnson, 1999; Slavin, 1980). Thus, to the extent that such techniques can be applied in the workplace (e.g., in specially designed projects or activities, such as those that were a part of this study), they may offer opportunities for teammates to experience and possibly come to value some of the benefits of working in "ideally composed" teams, as mentioned earlier, even when usual work configurations do not afford these benefits. Moreover, because the very purpose of collaborative learning techniques is to structure activity around collaboration, these techniques directly create interactional opportunities for collaboration and knowledge sharing to take place. That is, similar to what happens in Knowledge Building contexts, they create a bit of social structure supported by norms that sanction and encourage collaborative activity. In turn, these experiences could provide those involved with at least a glimpse of alternate ways in which interactions could happen. In these ways, then, collaborative learning techniques appear to be a logical component to include in a study such as this one.

In addition to these benefits, collaborative learning techniques bring with them all the learning advantages for which they were specifically designed. PBL, for example, motivates and

engages learners by posing a relevant, authentic problem to be solved (Torp & Sage, 2002). Good PBL problems, furthermore, are open-ended and complex enough to challenge learners and thereby expose significant learning opportunities, potentially resulting in improvements in critical thinking and problem solving skills (Hung, 2006; Jonassen & Hung, 2008). Most interestingly, however, when posed in the context of a group project, problems with an appropriate degree of difficulty may also extend these benefits to the development of collaborative skills and dispositions, as learners must learn how to effectively communicate and draw on each other's knowledge and skills in order to solve the problem (Hmelo-Silver, 2004). Indeed, for my purposes especially, PBL-style problems may be considered to be "good" precisely when they promote this type of communication and exchange.

This line of reasoning suggests that the PBL framework might be purposely exploited to encourage collaborative knowledge sharing. This is precisely the rationale behind making it central to this study's intervention design (also discussed in the Method section). In this case, for example, participants were tasked with building or adapting an "online knowledge sharing system" that they designed to meet their own group's knowledge development, management, and dissemination needs. As a technological project, this task could be experienced as an authentic extension of these ITPs' usual technology-focused problem-solving activities – and one that provided some practical payoffs on the job. Yet the open-ended nature and scale of the objective, as well as the demand it posed for a wide variety of skills, encouraged collaborative exchanges as participants pursued solutions to a variety of issues, thereby exposing several opportunities for collective and individual learning. This choice of problem also offered the added benefit of producing a lasting mechanism (the online system) for ongoing knowledge exchange even past the end of the study, a mechanism that the participants' own investments

helped to make useful and engaging. Thus, PBL was a doubly useful framework in the context of this study's conduct and potential after effects.

In sum, then, a number of themes in the literature are useful guides for the inquiry at hand. Probably the most foundational point is that collaboration and knowledge sharing can only happen when social arrangements provide the necessary opportunities and motivation. Regular connections to other people, known to social network analysts as "relational ties," are the social structures that represent those opportunities. Work on "ideal" team traits further highlights the kinds of elements that innovative teams – arguably, the best collaborators – tend to exhibit: things like unmediated connections with other team members, face-to-face contact, and balanced input among relatively small teams of individuals with complementary knowledge. The notions of openness and transparency provide ideas for inspiring the kind of open exchange and communal focus that seem important for genuine knowledge sharing community to emerge. Knowledge Building Communities offer a useful model of a successful collaborative approach that shows how collaborative activity can be organized around communal themes, giving it both structure and meaning that promote the development of collective knowledge. Finally, work in collaborative learning supports many of these notions, including the desirability of structuring activities around relatively small, diversely-skilled teams. These techniques, especially as illustrated as in PBL, provide a flexible blueprint for promoting content learning and problem solving but also development of collaborative skills and outlooks. As such elements ran counter to several problematic factors identified in the focal context of this study, they offered a reasonable basis for exploring the ways in which knowledge sharing community might be

fostered in this setting. They therefore formed the backbone of the study's interventional approach and, by extension, its research design.

Chapter 3: Method

As this study focused on a single group of IT professionals embedded within their own workplace setting, it was essentially a case study designed to account for and respond to the dynamics in this group's context. The study therefore employed a design-based research (DBR) framework, a methodological approach that is particularly suited to conducting research in situ – i.e., in naturalistic settings (Brown, 1992). As a "design experiment," the study centered around the implementation of a theoretically-informed "complex intervention" (Sandoval, 2004) that evolved over time in response to ongoing outcomes and observations. While changing study elements in this way cannot reveal precise relationships between individual variables in the way that classic controlled experiments can, this approach warrants at least qualified claims about what "works" within a complex ecology (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003), such as the one that forms this study's setting. Given the exploratory nature of this study, DBR's emphasis on clarifying theoretical connections and suggesting relationships for further consideration seems particularly useful.

Drawing on some key factors highlighted in the literature, along with insights from my personal participation in this context, the intervention at the heart of the study attempted to implement structural and cultural elements to promote collaborative knowledge sharing within this IT group. The high-level conjecture I tested was whether a collaborative experience that was purposely designed to accentuate such elements could elicit improved knowledge sharing patterns that culminated in an overall state of improved, more accessible collective knowledge. The primary vehicle for this was a PBL-like collaborative project in which participants, guided by my use of PBL facilitation techniques (Hmelo-Silver & Barrows, 2006) and incorporating my own input as a participant observer, jointly envisioned, assembled, and adapted an online

"knowledge sharing environment." As it turned out, the primary components of this environment were a centralized knowledge base embedded within a larger open source project management suite, along with a separate but perhaps equally important extemporaneous communication tool. However, driven as it was by an open-ended and complex project (Hung, 2006; Jonassen & Hung, 2008), the process of evaluating, selecting, and implementing the solution exposed opportunities for developing collaborative inclinations and skills and possibly some technical content knowledge. This particular project objective was selected for its on-the-job relevance and potential to aid in perpetuating knowledge sharing indefinitely among these participants and their colleagues. Indeed, this online system has persisted beyond the end of the study, thereby offering ongoing support to collaborative activity via a mechanism in which the participants themselves have invested their ideas and energies.

However, engagement with the collaborative process itself, not necessarily the end product, was the primary focus of the intervention. The ultimate goal was for interactional patterns within the project framework to gravitate towards one in which participants willingly and regularly exchanged knowledge, or otherwise worked in concert towards the solution of challenges that arose during the project – similar to the "opportunistic collaboration" that Zhang et al. (2009) observed. That is, although I expected participants to work independently or in small groups, I also envisioned an ideal state in which they would freely draw on, build upon, or contribute to the knowledge of any other participant as needed. As in the Zhang study, which started with relatively static collaborative groups that eventually evolved into flexible as-needed interactions, this study's intervention also included opportunities to try out variations in collaborative partnering arrangements. Thus, regardless of the state of collaboration that occurred or did not occur at the whole group level, including an explicit small group element in

the design also provided space for different structural and cultural elements to manifest, and thereby created additional opportunities for insight into arrangements at varying levels of social life that promote knowledge sharing in contexts like this one.

In keeping with the spirit of triangulation characteristic of mixed methods studies (Creswell, 2014) and the process-tracing orientation of DBR, a variety of data was collected and reviewed throughout the study to help gauge changes in collaborative patterns and inform design refinements. Most of these data were qualitative in nature, and were analyzed both inductively and deductively according to established qualitative analysis practices (Creswell, 2014; Fitzpatrick, Sanders, & Worthen, 2011; Patton, 2002). However, a significant portion of the analysis and findings came from basic social network analysis (SNA) data collection and analysis techniques (Carolan, 2014; Hanneman & Riddle, 2005), as these are specifically attuned to uncovering and measuring interactional patterns.

Embodied Conjecture

Design experiments are often accompanied by an explicit statement of the theory-based elements that drive their intervention design. While distinct from the research design per se, in DBR the intervention's design is a central methodological component, as it constitutes the fundamental means for making observations, for collecting data. The fledgling "theory" or conjecture informing my intervention approach started with the particular and potential affordances of PBL. As viewed through a structural-cultural lens, for instance, PBL's focus on the collaborative problem-solving process can be seen as a flexible organizing of interactions around certain types of activities (collaborative problem solving), while its facilitation techniques might well be used to shape the meaning and value participants derive from such activity (cultural components). I therefore started with the idea that a PBL-like project – i.e., a project

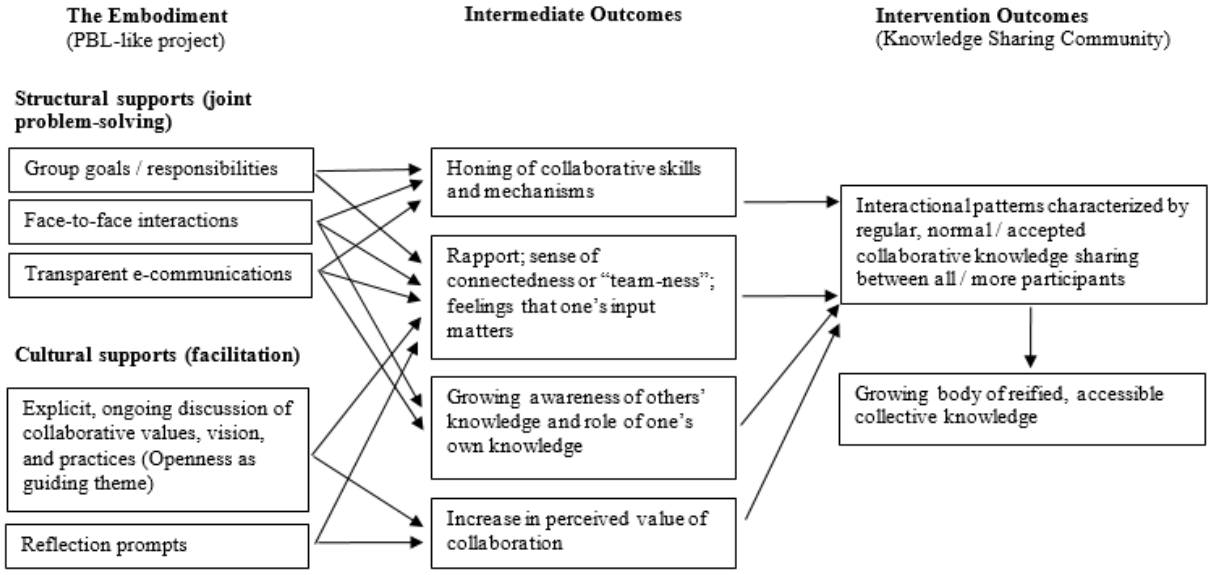
that is complex, ill-structured, and geared towards jointly solving a series of problems in service of a larger objective – can be tailored to target the kinds of collaboration prerequisites that seemed to be most lacking in the everyday interactions of this study's participants. Thus, while my interests in PBL include its use of collaboration to develop content knowledge, I am here more interested in PBL's potential to help articulate the elements that promote better collaboration among participants in this setting.

Figure 1 shows the more specific aspects of this conjecture as "embodied" (Sandoval, 2004) within an overall intervention logic model. As depicted here, the design foregrounds the centrality of structural supports that included group level responsibilities, regular face-to-face interactions, and communications that purposefully engaged the entire participant group because these factors were in direct contrast to the individual-level responsibilities, almost exclusively-electronic interactions, and relatively contained or directed communications that characterized relationships pre-study. From the participants' point of view, however, these new patterns were designed to flow logically from the nature and relevance of the central project, which was explicitly presented as an opportunity for us to learn to work together more closely in order to build something of value to our group: a knowledge sharing system that will make it easier for us to do our jobs well.

As facilitator, I presented a basic framework for organizing our activities around whole-group and subgroup face-to-face meetings, the frequency and format of which the participants could tune as needed as the project progressed. Group-accessible electronic communications and materials helped to continue progress between meetings. The latter included variations on relatively standard media like email and an in-house content management system but also introduced the experimental use of groupware known as Slack (slack.com), which ultimately

became part of the end solution. Although the emphasis was initially on working as a unified group, some division of labor was still necessary, which is one reason that participants also worked in subgroups. This subdivision also offered the ability to gauge the relative value of working together in larger numbers versus smaller numbers, with our existing independent work patterns acting as a rough baseline. The specifics of who did what remained negotiable, but in the vein of "collective cognitive responsibility" associated with Knowledge Building Communities (Scardamalia, 2002), I tried to steer participants away from assigning tasks to single individuals and instead emphasized the desirability of everyone continually thinking about and working jointly towards the whole group's progress. To provide explicit cultural supports for knowledge sharing, I also took opportunities to discuss collaborative ideals like those exhibited by the Open Source community, to encourage in-person feedback from all participants during group meetings, and to present opportunities for individuals to reflect, in writing, upon their experiences.

Figure 1: The embodied conjecture



The embodied conjecture portrays the suspected relationships between structural and cultural supports exposed by a PBL-style project designed to promote collaborative knowledge sharing community.

Many, if not all, of these elements fit well within the context of PBL and other collaborative learning approaches. For instance, the forming of smaller subgroups or teams is a common tactic for approaching larger projects within a collaborative or cooperative learning environment. The emphasis on group goals and responsibilities as well as reflection is also part and parcel of collaborative learning models. What is innovative about this plan in the context of PBL and these participants – i.e., what makes it an "intervention" – is not necessarily its macro-level components but (a) the problematizing of collaboration itself and (b) the deviation from this group's usual modes of interaction. In sum, then, I conjectured that emphasizing particular structural and cultural supports via a relatively long-term PBL experience would encourage the emergence of knowledge sharing community: i.e., a state where individuals would more regularly contribute their knowledge through interactions and artifacts, ultimately making it a more accessible part of the group's collective toolkit. This would happen, I postulated, by way of additional opportunities to develop and practice collaborative skills, to build rapport and a sense of connectedness especially through face-to-face contact, to understand what others know and that one's own knowledge matters, and to experience first-hand the value and power of leveraging the interactive input of others. As highlighted in the literature review, many of these same traits and patterns are the very kinds of factors associated with innovative and productive teams in a variety of settings. Thus, my approach here was intended to see whether and how they might be nurtured in our context.

Participants

Given the communal focus of the study, it seemed important to be as inclusive as possible in the recruitment of participants. Therefore, all fulltime staff members from the group in

question were invited to participate. (In order to minimize performance anxiety and related concerns, the group's director was not invited to participate but did express support for the study.) This created a total pool of about 30 potential participants spanning different IT job types: programmers and web designers (~25%), and system administrators (~75%). Potential participants also spanned different paygrades, although most were no more than two grade levels apart. The majority were male (~85%) due to the make-up of this particular group. Years of service in the group ranged roughly from 1 to 20 years. From this pool, 11 people agreed to participate. Despite the self-selecting nature of the sampling process, the participant group was fairly representative of the overall pool in terms of these basic demographics (see Appendix Q for additional / summary details).

Researcher Role

My own role in the group is worth noting, both for recruitment purposes as well as conduct of the study itself. Because I am an Assistant Director in this group and therefore occupy something of a leadership position, albeit one with no direct reporting relationships involving the participants, a third party was employed to solicit participation in the study in order to safeguard against the potential for any perceived or actual threat of coercion. However, perhaps of more interest is that my existing relationships with many of the participants offered some distinct advantages to involving myself as an active participant in the study. I have not always occupied my current role, for example, and therefore have firsthand experience of many of the conditions that others in the group encounter on a regular basis. Additionally, even as my own job responsibilities have changed over the years, one of my primary functions has nearly always been to lend aid to others in our group. These experiences give me insight into our collaboration challenges and, I believe, also establish some credibility and trustworthiness in the

eyes of the participants themselves. As much as I wanted this study to jibe with the scientific principles of objectivity and reproducibility, creating even small amounts of social change is not an entirely straightforward or dispassionate process. Thus, inserting myself as facilitator and co-problem solver among participants with whom I may have some positive influence seemed both justified and practical, particularly considering the importance of "softer" cultural elements in the study.

Materials

The complex nature of the intervention combined with the exploratory nature of the study meant that there were several variables or themes of potential interest. The study's grounding in DBR also meant that data should be collected in a variety of ways and on an ongoing basis. As this necessitated a fairly eclectic approach, several data sources were employed. These included an initial survey, audio recordings of group meetings, subgroup progress logs, individual journal entries, facilitator journal entries, social network survey questions, and a concluding survey. All surveys were administered electronically via Qualtrics (qualtrics.com) and were confidential though not anonymous. Other written responses were submitted electronically via appropriate group or individual channels within a restricted Sakai (sakaiproject.org) site.

Initial survey. This survey gathered a variety of closed- and open-ended data including demographics, self-assessed technical skills, knowledge / estimates of others' skills, perceptions of the value of and barriers to collaboration in our workplace, and impressions about our group's functioning as a team (see Appendix A). The first round of several brief SNA surveys was also included as a portion of this survey (see Appendix D). These measures served dual purposes as a baseline for later comparison and also as a mechanism to glean insights into the participants'

experiences as part of the IT group in question, particularly as they relate to collaboration and knowledge sharing.

Group audio recordings. As a starting point, a roughly 90-minute whole group meeting occurred every two weeks throughout the study. The whole group format was intended to allow all participants to come together, share insights and opinions, and generally stay connected; and the frequency of such interaction was thought to be regular enough to approximate the "sweet spot" suggested by Kratzer et al. (2009) but spread out enough to allow for subgroup meetings (described below) to happen. These whole-group meetings were audio recorded. The volume of data that was collected over the course of the study, in addition to the actual workload involved in running the study and participating in the technical project, made it infeasible to systematically codify all audio recordings as they were collected. Instead, this task was done post-study. However, targeted review of the recordings and transcripts helped to cross-check impressions from other data sources and remain in touch with participant reactions. Given this study's particular focus on face-to-face interactions and the ability of such recordings to capture more than self-reported impressions or memories, this data source was an important means of directly observing some key interactions. For instance, these recordings captured non-verbal communications such as tone of voice that suggested the presence or absence of rapport, and provided context to extemporaneous comments. They also helped to capture the degree to which different participants actively engaged in the meetings.

Subgroup logs. Part of the intervention plan involved the forming of subgroups to work collaboratively on a variety of tasks related to the central project. I therefore created three small groups consisting of 4 participants each (including myself), taking care to obtain some degree of heterogeneity by mixing participants on the basis of self-rated skills and attitudes toward

collaboration as indicated in the initial survey. Participants were advised to hold face-to-face meetings with their subgroup members at least once per week. As a means of coordinating and summarizing their progress for the larger whole group, subgroup members were also asked to jointly keep a public (i.e., accessible to all participants in the study) log summarizing their activities, including any notable technical or non-technical findings and/or obstacles, as well as any solutions to such obstacles (see Appendix B.) As a data source, the logs were intended to provide some insight into how collaboration fared at this level of interaction. However, these logs were also to act as part of the intervention itself in that such transparency was expected to enable participants to maintain a sense of connection to the activities of others while reflecting on their own progress and planning their next efforts. While I advised participants to consider sharing insights into interaction mechanisms that facilitated collaboration particularly well or particularly badly, the log format and content were largely left open-ended to allow participants to consider a wide range of factors they saw as relevant to their progress.

Individual journals. Despite the social focus of the study, it remained important to pay attention to individual reactions. After all, social life ultimately depends on the actions of individual people. Therefore, participants were asked roughly every two weeks to provide private insights (i.e., viewable only by the researcher) into their own experiences. Prompts were provided in order to guide focus towards aspects of the collaborative process (see Appendix C), but these journal entries were generally opportunities to provide open-ended responses about anything each individual participant wished to relate. In total, 10 sets of prompts were provided. As a data source these private communications helped to capture unanticipated or less guarded responses to the intervention elements and thus provided a better total picture of how things were proceeding. Such writings also doubled as an element of the intervention in that they provided

participants an opportunity to privately reflect on their experiences and potentially come to value aspects of these experiences.

Facilitator journal. As a complement to participant responses, I also maintained my own journal on a weekly basis. These entries included my own reactions and observations regarding the state of ongoing collaborative efforts, the state of the project's progress, and insights regarding collaborative elements that seem to work particularly well or badly. They also served as a mechanism for me to think about potential refinements to the intervention design – e.g., meeting frequency, subgroup makeup, cross- and intra-group interactions, collaborative themes worth discussing or revisiting during whole group meetings, etcetera – especially after reviewing recent additions from ongoing data collection.

Twice-monthly SNA survey. In order to gauge changes in interactional patterns such as increases in knowledge sharing frequency or exchanges among new or increased numbers of participants, two complementary social network analysis questions (see Appendix D) were presented to participants every two weeks. These provided a more quantitative measure of collaborative contact between participants as a means of more easily noticing any changes in patterns that arose during the intervention. While these questions also evoked self-reported data, they do leverage the common SNA technique of using complementary forms of the questions (e.g., asking about experiences as relational sources and targets – in this case, as knowledge givers and receivers) and overlap or disparities in responses from all participants to form a more complete picture of relationships (Hanneman & Riddle, 2005).

Final survey. At the conclusion of the study, the initial survey (minus demographic questions) was again administered in order to provide a basis for comparing initial and ending states and gaining final insights. Combined with other data collected along the way, this

instrument helped to form a more complete picture of the intervention outcomes and the factors involved in producing them.

Procedures

Broadly speaking, activities were organized around the problem-solving process. The study invitation specifically mentioned "exploring ways to help IT teams like yours improve how they collaborate and share knowledge with each other." The discussion that I led at the kickoff meeting further defined the problem as a need to find ways to share knowledge more readily and more easily, help the group work together more smoothly, improve the ability to learn from each other, and draw lessons from interactions within the project about "what works well and what doesn't" in these regards. The ultimate project goal was to develop an online knowledge sharing system that would become a means of tapping into the group's collective knowledge, but the process of designing and building the system were to provide practice at working more collaboratively while pursuing this common objective. Such practice, I suggested, could provide insight into the kinds of collaborative features or arrangements that were most desirable. Except for the broadest directives of creating an "online knowledge sharing system" and working both at a whole-group and small-group level, most decisions about specific approaches to these goals emerged over time through decisions and actions taken by the participants.

As it happened to unfold, the ill-structured problem of collaboratively building an online knowledge sharing system translated into a series of smaller challenges related to envisioning and implementing a system with features that would meet the knowledge sharing needs identified by the participants. Such needs also included concerns for the larger IT group. The possibility for coding the system from scratch remained open, but the group gravitated instead toward evaluating existing products for their adaptability to meeting the identified needs. Once

formed, each of the three small groups self-selected products of interest and began their evaluations concurrently with the evaluations of the other groups. The plan was that, following such evaluations, the whole group would then choose the best candidate and jointly work on molding it into its final form.

Throughout the endeavor, regularly scheduled whole group meetings and subgroup meetings served as basic interactional structures for keeping the collaborative project on track. Electronic communications and other, extemporaneous or loosely-planned interactions were also important in meeting the demands of the technical project. Given the embeddedness of the study in the workplace where other priorities often arose, as well as the somewhat unpredictable nature of any open-ended project, the scheduling of activities needed to remain flexible. However, the PBL framework helped structure progress at an overarching level by identifying several phases of a problem-solving project. Torp and Sage (2002), for example, identify nine: participant preparation, meeting the problem, identifying knowledge needs and ideas for addressing the problem, defining concrete parameters of the problem, gathering information, generating solutions, determining the optimal solution, presenting the solution, and debriefing the problem.

Though the boundaries were somewhat fuzzy and overlapping, these stages were a rough guide for facilitating the project. For example, the initial meetings focused on defining the problem and motivating participants through some discussion about ways we might individually and collectively benefit by having a knowledge sharing system. This involved instigating group discussion of some of the challenges we faced daily in our environment. However, the "participant preparation" aspect of these early phases also involved some discussion that set the tone of the project: e.g., as something that would require both patience and initiative-taking as we learned to coordinate our efforts, as an opportunity for us to get to know each other better and

work more closely, as a chance to learn new things while leveraging all of our talents, achieving excellence, making our jobs easier, etcetera. That is, preparation included some discussion of norms, values, and expectations – cultural lenses through which participants might interpret the activities and their experiences. These notions were revisited periodically as we moved on to later aspects of the PBL process: i.e., the work of considering alternatives and ultimately co-designing and implementing a solution to meet the technical project's goals.

A high level schedule of activities, including data collection points, is summarized in Appendix E, and a sample whole group meeting agenda is included in Appendix F. The overall plan was to meet as a whole group initially, engage in some preparation and discussion, and within the first two meetings, form subgroups with somewhat clearly defined tasks. As a starting point, whole-group meetings (roughly 90 minutes each) continued to happen every two weeks to coordinate overall activity and contact, with subgroups meeting on their own to do much of the investigative work necessary for the project. As the project continued, I attempted to guide interaction patterns towards ones that involved exchanging ideas not just with subgroup members but also directly with members from different subgroups. In whole group meetings, this involved using recognized PBL facilitation techniques such as questioning, re-voicing opinions or concerns, inviting further explanation, etcetera (Hmelo-Silver & Barrows, 2006). Outside of whole group meetings, facilitation required other strategies: e.g., reminders of next steps, technical observations, suggestions for meeting strategies – all of which were also opportunities to continue modeling collaboration-friendly sensibilities and values.

Like the PBL framework itself, the plan was flexible and non-prescriptive. It therefore rested most fundamentally on an ongoing vigilance for opportunities to guide and shape the structural and cultural elements involved. Regular data collection and analysis, the structural-

cultural lens itself, and attention to PBL tenets and processes all enhanced the possibility of recognizing and successfully acting upon such opportunities. The state of the technical project also served as a practical indicator of how the collaborative process was faring and suggested when adjustments were needed.

Data Analysis

The DBR framework guiding this study called for data analysis to take place on an ongoing basis throughout the study, as it was this type of analysis that would inform changes to the intervention. As a practical matter, this was difficult to achieve in any formal or exhaustive fashion: participating in the day-to-day aspects of the technical project, collecting data, and managing the study, all while also attending to my job responsibilities, made these 24 weeks quite challenging. Thus, while the study was underway, my analysis efforts focused primarily on organizing and reviewing data as they were collected in order to form and maintain "a sense of the whole" (Creswell, 2014, p. 198). Throughout the proceedings, I regularly submitted whole-group meeting audio recordings for transcription by a hired third-party (rev.com) and reviewed the output, although I ultimately relied on the audio itself as a richer basis for conducting in-depth analysis later. I also stayed abreast of subgroup and individual responses to maintain ongoing familiarity with the state of various activities. The latter communications often presented opportunities to further interact with the other participants, and I frequently used them as a means for providing and seeking additional input. All such elements fed into ongoing reflection and informal analysis via the weekly facilitator journal entries conducted throughout the study, which themselves served as a data source for later review.

Post-study analysis consisted of two essential activities: (a) making sense of the abundance and variety of responses collected throughout the study, particularly the open-ended

responses; and (b) calculating basic social network metrics from SNA survey responses and interpreting them within the context of other data, including changing perceptions of participant knowledge. In the case of open-ended data, I first used a variety of semi-automated and manual manipulation techniques to prepare the data for analysis. For example, html-based journal entries were rendered to clear text and then wrapped at standard column lengths to create formatting consistency across the entries. Text-based facilitator notes were similarly standardized to uniform line lengths. Using Microsoft Excel, I then further organized and analyzed the data using established qualitative processes such as identification of key excerpts, note taking, and application of codes (Creswell, 2014, pp. 196–200). In the case of journal entries, I looked systematically at every 5-line segment and engaged in a "first cycle" technique known as structural coding (Saldaña, 2009, pp. 66-70), identifying categories of activity relevant to the embodied conjecture in particular and a structural-cultural lens in general. Audio recordings were similarly analyzed using 5-minute intervals as the unit. Each group log and other short open-ended responses were similarly analyzed but in whole form – i.e., with no systematic subdivision into smaller segments.

Codes generated in this way aided in the identification of recurring elements and emerging themes across the various data sources. This involved an iterative process of reviewing the codes and data and their most salient connections to the broader theoretical constructs of structure and culture, as well as the theorized connections embedded in the intervention design – a process similar to the second-cycle coding methods Saldaña calls "focused coding" and "theoretical coding" (2009, pp. 155-159,163-167). Through this process, individual codes like *barriers, constraints, (dis)connectedness, distributed leadership*, *division of labor, efficiency, face-to-face, honing, humor, logistics, mechanisms, negotiation, rapport, value*

of collaboration, and *voluntary* formed the basis for identifying broader categories or themes: e.g., the tactical benefits of in-parallel small-group work versus costs to whole-group opportunities; the competing demands of democracy versus practicality; the tradeoffs between ad hoc flexibility and pre-planning, between meeting in person or interacting virtually, between valuing equality versus efficiency, between exploiting voluntary effort and existing rhythms versus instituting broader structural-cultural supports for sustainable collaborative relationships. Through further consideration of the data vis-à-vis these themes and the themes vis-à-vis the data, SNA analysis, and the sense-making inherent to the writing process itself (Brandt, 1992), the more encompassing theme of opposing forces or *dialectical tensions*, most broadly between *people* and *processes*, thus gradually emerged over time and ultimately became a central conceptual lens in my thinking about the study (see Appendix O for examples).

In the case of social network survey data, which came directly from Qualtrics in numerical form, I first engaged in minor cleanup and transformation of the data to make it suitable for direct SNA analysis. Using Microsoft Excel, I further structured the 12 SNA datasets into a series of consistently formatted workbooks that facilitated repeated calculations and recalculations as necessary across the entire collection. This arrangement, for example, allowed some flexibility when refinements to formulas were necessary. In addition to the creation of a well-organized data corpus, use of Excel for these basic calculations, as opposed to a powerful SNA-centric program like UCINET (Borgatti, Everett, & Freeman, 2002), also facilitated interpretation and presentation of the data by way of Excel's already-familiar formatting and chart functions. Nevertheless, formulas for basic SNA measures such as network density (the percentage of dyadic relational ties present out of all such possible ties) were based

upon well-accepted definitions in the literature (see, e.g., Hanneman and Riddle (2005)) and spot-checked for accuracy against UCINET output.

Reliability and Validity

Although there seems to be at least some debate about its role in certain types of qualitative research (e.g., see Armstrong, Gosling, Weinman, & Marteau, 1997; Morse, 1997), inter-rater reliability is considered by many to be a staple in the promotion of reliable and thus ultimately valid observations in social scientific research. Still, especially in the context of competing concerns, it may also be important to engage in "thinking about research decisions in terms of what is lost and what is gained, rather than what is ideal" (Luttrell, 2000, p. 500). As the sole researcher in this study, carried out as it was among the daily entanglements of my workplace, and over a substantial period of time, I traded off pursuing this form of reliability in favor of spending finite resources differently: i.e., on attempting to regularly gather, comprehend, and respond in-process to a range of data wide enough to make this exploratory study as insightful as possible. This both avoided the potential privacy, interpretive, and logistic complications of exposing a third party directly to the inner workings of my workplace context while allowing me to devote more energy to the many challenges of executing the study.

This is not to say, however, that I ignored concerns for reliability more broadly. As indicated by the steps laid out above, I attempted to be mindful, methodical, and consistent at every phase of the data collection and analysis. Although qualitative researchers often acknowledge that there is and must be some degree of creativity in qualitative analysis, relying on a structured plan minimized the inconsistencies of approach and insight that even one researcher can bring to the research process. Periodic review and purposeful re-execution of

analytical processes also served as a check on consistency in calculation, coding, and interpretation more generally.

Threats to validity are another concern. Did the measures, analytical approach, and research design in general address the kinds of things I intended them to? Did my own roles as researcher, facilitator, study participant, and member in this IT group skew any patterns that I saw or did not see? As a largely qualitatively-based case study, this study's validity is not meant to rest on its wholesale generalizability or direct applicability to other contexts. Rather, its validity depends greatly on "whether the findings are accurate from the standpoint of the researcher, the participant, or the readers of an account" (Creswell & Miller, as cited in Creswell, 2014, p. 201). As an application of DBR, the study's validity might also depend on the extent to which its complex intervention achieved the intermediate and final outcomes as predicted, or on its ability to at least partially explain where and how the intervention failed. As DBR emphasizes connections to broader theoretical and conceptual constructs, validity in this way might in turn create some relevance to a larger audience. In any case, from the framing of the problem statement onwards, my own perspectives certainly influenced the direction of the study: I have leveraged my experiences in the study's context and among its participants to gain insight into a problem of practice that matters to me. Such influence is unavoidable and not necessarily undesirable.

Nevertheless, there are several ways that research design can help to avoid undue bias and maintain scientific validity. Creswell (2014), for example, outlines several strategies, including triangulation and prolonged "time in the field." Fortunately, these are hallmarks of DBR. Because DBR is a methodological approach that seeks to trace processes in messy, real-world environments, its practitioners typically rely on both a variety of data sources over a non-

trivial amount of time in order to gather a rich and complementary dataset capable of shedding light from a variety of angles. With several data collection strategies spanning roughly half a year, this is exactly what I attempted to do via this study's research design.

A related strategy is member checking, in which interim or final findings are vetted against participant perceptions. Such checking, or feedback, was an integral part of the design in that I interacted with participants on a regular basis and continually weighed their reactions and responses as my evolving understanding and ongoing interpretation shaped my attempts to promote collaborative knowledge sharing. I also engaged in more traditional member checking by way of post-study discussions with several participants as a means of checking my own analytical interpretations.

Finally, reflectivity and clarification of bias are other strategies in which researchers might engage to promote validity. As earlier comments illustrate, I have acknowledged that my connection to the study context and participants means that complete objectivity is not attainable. However, inclusion of my own reflections in the form of journal entries as an explicit source of data in the study also permits peer review of my biases in the intervention and conclusions. The act itself of keeping such a journal also provided ample opportunity for me to think about the ways in which my role as scholarly practitioner, participant observer, and ITP affect my view of the subject matter and events that occurred throughout the study. In conjunction with the other strategies, this helps ensure that the research process and findings were not overly influenced by my own subjectivity but nevertheless informed by it.

Chapter 4: Design Implementation and Outcomes

From early February through mid-July of 2016, eleven volunteers and I participated in what came to be known as the Bace project. (Bace, pronounced *base,* stands for Building a Collaborative Environment.) The first collaborative venture of its kind in our workplace, Bace was our attempt to co-create a knowledge sharing system designed to ultimately facilitate more regular knowledge exchanges amongst our larger IT group. The project goals also included learning how to work more collaboratively, sharing knowledge amongst ourselves as we Bacers pursued a solution to our common Problem of Practice (Belzer & Ryan, 2013) of better tapping into our collective knowledge and talents as a more normal part of everyday business. It is the structural and cultural mechanisms through which we achieved or failed to achieve these goals that are of interest to this study.

Much happened over the course of these 24 weeks, making a complete or representative presentation of the data a less than straightforward task. In addition, my own experiences as a participant observer make it difficult to leave out details that occupied so much of my and my fellow Bacers' attention. Indeed, there are probably several data-driven narratives that could describe and explain different aspects of our individual and collective experiences. Yet, when considering the research questions that started this endeavor, there is one theme that stands out above the others: a basic tension between an orientation towards people versus an orientation towards processes. At the whole group level, changes in knowledge sharing throughout the course of the study did not readily highlight the presence of this tension. However, when looking at differences across the small groups, a notable correspondence emerged: knowledge sharing coincided more clearly with structural mechanisms like face-to-face interactions over virtual ones, as well as with apparent values such as inclusion, dialog, and fairness over a

predominant focus on elements like process, efficiency, and effectiveness. Such orientations may thus have important implications for promoting knowledge sharing community in contexts like the one in this study. Indeed, when reviewing whole-group experiences through this lens, the tension becomes somewhat more apparent even at that level: at its core, the whole study revolved around trying to shift habits and processes in ways that would accommodate better relationships between people.

The data behind these conclusions are largely qualitative in nature and therefore difficult to convey succinctly. Thus, although I take a somewhat more traditional approach in the latter half of this chapter, I will first rely on some analytical and interpretive narrative to convey contextual details regarding the way events unfolded. Indeed, it is not uncommon for qualitative researchers to go beyond pure description and mingle presentation of data with its analysis and interpretation. As Wolcott (1994, pp. 10–11) puts it, sometimes "the goal is to make sense of what goes on, to reach out for understanding or explanation beyond the limits of what can be explained with the degree of certainty usually associated with analysis." Experience, he furthermore says, is one way of obtaining data. To convey these data in a way that promotes understanding, then, I feel compelled to describe in some part the experience that I actively lived alongside my colleagues who volunteered. Such narrative includes use of singular and collective first-person voice (e.g., "we Bacers"), as I believe this perspective often best conveys the essence or meaning of the experience while also remaining true to my collegial relationship with the participants.[3] Bace was not just something I witnessed: I was a part of it. To some extent, then, my own synthesis of these events might even be considered data in and of itself.

[3] Use of first person also helps to minimize the problems of anthropomorphism and ambiguity that may arise from forced attempts to appear objective via use of third person (American Psychological Association, 2010, pp. 69–70).

Regardless of narrative or voice, however, the descriptions and analyses that follow do derive from a large cache of evidence. Besides a dozen SNA surveys, this evidence includes roughly 23,000 words in 23 facilitator journal entries, 13,000 words from 55 participant journals, 15,000 words from 68 group logs, and nearly 17 hours of audio recordings from whole group meetings, not to mention open-ended commentary from surveys and elsewhere.

The Bace Experience

So what, then, was this thing called Bace and what has come of it? I would like to report that this special project of ours was an unqualified success and that it tidily resolved all major difficulties in collaboration and knowledge sharing in our setting. The reality, however, appears to be more nuanced. While the experience seemed to make a positive impact overall, we Bacers did not find a complete, neat, or all-encompassing solution. For instance, attendance rates, social network data, varying degrees of participation in project activities, and even data submission rates throughout the study show variable levels of engagement and progress over the course of the project, with multiple periods of relative inactivity and sometimes indiscernible changes in knowledge exchanges during the project. Apparent enthusiasm and commitment also varied across the participants.

Despite the difficulty of pursuing an additional, voluntary project amidst the ongoing requirements of our jobs, however, we together overcame a number of technical, social, and organizational impediments, and engaged in varying degrees of knowledge sharing amongst ourselves. We also succeeded in instantiating a repository for our collective knowledge: an online system, based on Redmine (redmine.org), that incorporates many of the features we co-defined as desirable. Broadly speaking, this system also includes a synchronous and

asynchronous communication tool, Slack (slack.com), that has since become an entrenched communication and impromptu collaboration mechanism for our larger IT group.

Perhaps most important, though, is that we seem to have cultivated some positive collaborative attitudes and sensibilities, even as we continue our struggle to achieve better knowledge sharing in our environment. Consider, for instance, some excerpts from the final survey:

> These experiences made me appreciate the value of collaborating and sharing knowledge to find solutions to problems.
>
> I intend to organize more frequent meetings… to help to remind us that we are a team and that there are others that we can reach out to for assistance.
>
> [I am] more willing to engage in collaborative problem solving!
>
> [Bace] opened my eyes to the potential for collaboration… encouraged me greatly… [made me] more inclined to reach out.
>
> I plan on working more closely with folks. I realize most members of our group are more than willing to assist when asked directly.
>
> Getting this mentality into our group as a whole will be incredibly helpful.
>
> We should be striving to regularly engage [in knowledge sharing].

Well after the end of the study, I continue to notice a qualitative difference in many of my post-study interactions with other Bacers. It is as if we have an ease, an understanding, a *connection* that was not always there. I often feel us acting as a kind of implicit team even when

working amongst our non-Bacer IT colleagues. Indeed, saying the word *Bace* in certain contexts is often enough to elicit a smile or knowing nod.

Since the introduction of our customized Redmine knowledge sharing instance, which we dubbed *Grokbox*[4], and our Slack team to the larger IT group in late January of 2017, a collaborative spirit seems to be slowly catching on. Some telltales may lie in basic usage statistics. For instance, there has been some respectable, if not explosive, growth in the submission of articles into the system. Before inviting the larger group's participation, Bacers had submitted around 30 articles to the fledgling Grokbox. After about eight months, the number grew to 87[5] articles authored by 17 of its 40 member-accounts, including submissions by 7 non-Bacers. System logs showed 223 logins during this period, out of the 358 total logins including pre-invitation Bacer activity. Available Slack statistics at that time also showed prima facie upticks in usage from an average of roughly 9 weekly messages per member during the study to roughly 34 weekly messages per member since the invitation. While the import of such statistics is far from clear, they seem to be early indicators that our project had instigated some positive, if slowly emerging, changes even beyond Bace participants.

In short, then, while the Bace story is not one of radical transformations or unqualified successes, *something* happened, and it still seems to be happening well after the end of the study. Thus, it seems there may be some interesting lessons to be gleaned from the experience. What, then, were its essential elements?

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[4] Close runners up were *Beacon* and *Hive*.

[5] At close of writing, the count is ~~112~~ ~~194~~ 219.

Bace Process and Product

PBL as a catalytic lens. In a nutshell, this study was an attempt to introduce social change, and social change is rarely something that can simply be "implemented." I needed a hook that would meaningfully engage the participants, preferably one that would also pave the way for new and additional activities required by the research process. As an overarching organizational approach, the PBL framework ably set the stage for the activities in which I wanted my co-workers to partake. As several experiences throughout the study reminded me, interesting problems are especially engaging for problem-solving ITPs. This was powerfully illustrated, for instance, when one Bacer brought a particularly challenging work-related problem to the group via Slack early in the study. Over the course of two hours, seven of our 12 Bacers interacted electronically, posing questions, making suggestions, responding to others' lines of reasoning, and ultimately solving the problem through the power of our collective strengths. With this kind of experience reminding us of the potential benefits of our Bace efforts, the idea of solving our larger knowledge sharing challenges – particularly because they impacted our entire IT group – seemed to resonate with these participants. As one participant put it, "…everyone in our group seems to 'get it', meaning, there is clear and uniform acknowledgment of the problem…."

Interestingly, as I attempted in PBL style to "prepare the learners" to "meet the problem" (Torp & Sage, 2002), I found that an explicitly problem-centric approach also enabled me to expose the participants directly to the scholarly notion of problems of practice fundamental to my program of study as a doctoral student, and in particular to the problem I wished to solve. Thus, I was able to present a logical connection between the practical IT project I was proposing and the academic study for which they volunteered. This logical connection helped me to

navigate the potential awkwardness I anticipated in assuming the foreign role of researcher among co-workers who knew me primarily as a fellow ITP. It also helped to minimize or at least rationalize the intrusiveness of the research process into our otherwise IT-centric activities – a process that, as it turned out, provided candid communication opportunities I did not fully anticipate and could not have easily brokered in my ordinary relationship with the participants. The research framework provided an excuse to talk about things in ways we rarely did in regular work life, thereby relieving us of some of the usual constraints. It was, in other words, a structural lever that created opportunities for the construction of new meanings.

By providing an opportunity for us to communicate openly about our challenges on the job, discussing the problem of our knowledge sharing practices encouraged some collective introspection into the kinds of relationships we wanted to promote in our workplace. With the goal of building a system that would appeal to our larger IT group, we Bacers had to think about features that would attract our colleagues' interest as well as those that would distract, detract, or fail to engage them. Thus, conceptualizing our ideal knowledge sharing system led us to think and talk about our likes and dislikes, satisfactions and dissatisfactions with our current knowledge sharing habits as well as our work-related exchanges more generally: i.e., designing our system was helping us to define our values.

Our own experiences and desires, past and present, were natural guides throughout this dialog. For instance, having our own recollections of unpleasant or dissatisfying exchanges, we eschewed features like downvoting or other negative rating systems that are popular on some collaborative platforms for fear of insulting or alienating others rather than welcoming their input, including partial input based on imperfect knowledge. The difficulty of facing alone the challenges of our field was something to which we could all relate, and so "the last thing we

wanted to do" was to dampen potentially helpful contributions of knowledge that would-be contributors might already fear is somehow inferior in its incompleteness or in their inability to convey it perfectly. From this thinking, it followed that we needed to allow ourselves and others the room to be wrong sometimes, *to not always know the answers*. This is not particularly easy in our workplace, where a rating of "does not meet standards" on one's yearly performance appraisal can impact real and perceived job security, and where projecting an air of confidence and competence feels necessary for retaining others' respect and support. Nevertheless, within the smaller, perhaps safer setting of our voluntary project, we began to question what meeting standards should mean. Rather than always expecting each other to provide wholesale fixes or *solutions*, perhaps providing and courting collaborative *input* should become a bigger part of our core values and practices. Our emerging values were thus developing a potential to influence the ways we interacted; culture could help to re-form structure.

Besides allowing for the development of such social supports, the non-prescriptive nature of the PBL process also exposed natural opportunities for learning new technologies and engaging each other technically. For example, the process of evaluating various products as potential solutions entailed searching for candidates, researching their features, and installing several of the most promising products to evaluate them in a direct, hands-on fashion. Many of these were open source products based on a LAMP (Linux Apache MySQL PHP) stack, which was both familiar in terms of its ubiquitous presence in our environment and yet relatively new to several participants in terms of their direct hands-on experience with such components. This in turn introduced a range of technical challenges in getting said products installed, configured, and working well enough for evaluation purposes. Tasks ran the gamut from issuing basic commands at a Linux (or Windows) terminal, to interacting with frameworks like Ruby on Rails

and Node.js, creating and automatically backing up MySQL databases, trying out different virtualized platforms, probing for security flaws, and playing with skins and other aesthetic components. Such tasks required participants to draw upon a variety of knowledge, spanning categories very much like those on which they were asked to evaluate themselves and others pre- and post-study (see Appendix P): besides requiring familiarity and expertise in specific environments like the Windows and Linux operating systems themselves, the success of such activities rested upon participants making broader analytical connections between a variety of components – e.g., networking, web technologies, databases, virtualization, and anything else that was needed to solve problems and make a given product work.

In many IT shops, the technical breadth and depth of this kind of work spans several job roles. Although most of us Bacers call ourselves "jacks of all trades," which is something of a necessity in our heterogenous environment, each of us also tends to occupy our own bailiwicks, mastering those areas required by our individual job functions while possessing significantly less knowledge in others. Thus, addressing the full scope of these challenges would have been quite difficult for single individuals working alone. However, with each other's help we were able evaluate several candidates: Spiceworks, Kace, and Twiki, for example, were among the early candidates selected, tried, and eliminated in this way before MediaWiki, Drupal, and Redmine became more popular contenders. Most of this work occurred within the boundaries of the small groups, with each small group following my broad instructions to self-direct most of its own activities and evaluate products of its own choosing. However, ongoing facilitation in and between whole group meetings helped to keep such efforts aligned with the larger project goals and the activities of the other small groups as each of us sought to continue finding the time to work on our "extra," voluntary project. At the whole group meetings, the focus on keeping

abreast of developments within the small groups was accompanied by input, troubleshooting advice, and feedback about specific features or product suites. Discussion there also focused on steering the overall direction and timeliness of the project, allowing us to maintain a collective vision, benefit from each other's insights and knowledge, and ultimately meet the technological goal of instantiating our knowledge sharing system despite the challenges we faced.

Thus, by flexibly organizing our interactions around a problem-solving theme, the PBL framework not only promoted the achievement of practical objectives and opportunities to exchange knowledge across a spectrum of technological domains; its loose but effective structural supports also left room to introduce the cultural tone that I as facilitator wanted to establish as the backdrop for our activities. The participants related to the problem and considered it worth solving to our individual and collective benefit. In turn, the awakening desire to better connect the incomplete but still-valid knowledge from individual minds reminded us that we are all equally uninformed in some ways and thus helped to establish a rather egalitarian ethos that undergirded the heavily democratic process we would end up following throughout the project. These jibed well with the autonomy implied in the voluntary nature of the project and, I hoped, would encourage participants to jointly feel ownership and responsibility for the project's success. These were structural and cultural elements that challenged our usual modus operandi. They would soon become the locus of an ongoing tension between getting things done efficiently and getting things done *collaboratively.*

Democratic beginnings. One of our first joint decisions was whether to develop our own online system from scratch or to instead evaluate existing products for their potential to fulfill our needs. This open-endedness, a PBL trademark, was built into the study design precisely to allow activities to flow naturally from the talents and interests of the people who

opted into the study. As it turned out, only one of the participants was a programming expert. A second also worked closely with web technologies. However, the participants were mostly system administrators conversant with many aspects of technology, including the web, but not necessarily expert enough to construct a brand new online system without some rather herculean effort. We therefore thought it more practical to select a system that best encapsulated the kinds of features we wanted, and that would allow us some degree of customizability to adapt the system to our specific desires and needs. In this case, our normal penchant for practicality produced a quick and easy democratic decision.

Efficiency is king. The fact that we were pursuing a solution with no strict prescriptions for how to accomplish it meant that we needed to find a way to proceed with our investigations. As a time-honored collaborative technique (e.g., see Johnson and Johnson (1999), O'Donnell and King (1999), and Slavin (1980)) breaking into smaller groups as a starting point – in our case, three groups of four – made sense and also promised to make meeting, even just electronically, more practicable than frequently coordinating the activities of 12 busy people with often frenetic schedules. Proceeding along these lines also gave rise to the whole group's next democratic decision: whether, in geek speak, to proceed "serially or in parallel."

The consensus was that it would be more efficient for the three small groups to work in parallel, with each concurrently evaluating a product of its own choosing. Given the task of surveying a large field of potentials, this seemed logical and possibly even necessary. We thusly reasoned that divvying up the task in this way would improve our chances of finding and implementing a suitable candidate within the roughly six months allotted for the project. This approach, however, would incur two tradeoffs: a) the small group evaluating a given product would gain the most intimate knowledge of it, at least initially, and could therefore have

disproportionate, perhaps *unfair* influence in deciding whether the product could meet the whole group's needs; and b) working on separate products, even reporting back to the whole group on a bi-weekly basis, divided our foci and time together and thereby diminished opportunities for spontaneous, as-needed "opportunistic collaboration" (Zhang et al., 2009) at the whole group level. In other words, our pursuit of efficiency had potential costs in terms of fairness, and direct costs in terms of the breadth of knowledge sharing relationships that could develop.

While the former was something for which we thought we could and, to some extent, did compensate through demos, discussion at the whole group meetings, and somewhat objective scoring mechanisms, the latter costs only became apparent over time. Indeed, it was not until the final weeks of the study, after a final product was chosen, that we officially dissolved the small groups to explicitly work as a whole group towards fully implementing our system. By this point, however, energy levels appeared to be waning and our project was soon to be about as complete as we would make it before its wider debut several months later, cutting short this new arrangement. While losses at the whole group level may have been somewhat offset by gains made in familiarity, rapport, and even a variety of knowledge sharing among small group members, we still perhaps missed some opportunities for collaborative knowledge sharing among the larger group.

Equality, distributed leadership, and inefficiency. Although this deficit may have been an outcome of the choice to divide into small groups in the first place, it could also have been a product of other structural and cultural factors that perpetuated the small-group phase beyond its usefulness. As facilitator, for instance, I anticipated that we would spend some time evaluating and choosing a product, and then spend nearly as much time or more as a whole group adapting it into something that met our unique needs. In actuality, the bulk of our effort was

spent in the research / evaluation and final decision-making phases: roughly 14 and 6 weeks respectively.

Part of my vision for collaboration in the project stemmed from the state of "collective cognitive responsibility" Zhang et. al (2009) reported. I consequently promoted the idea that all Bacers should have an equal voice, that we should follow a distributed leadership model wherein we would all (in theory) contribute to shaping the course of the project. In many ways, these notions were in direct opposition with our desire and ability to be efficient. My notes, for instance, make several references to a tension between maintaining progress on the one hand and fairly sharing workloads and leadership responsibilities on the other. Although my roles as facilitator and researcher made me something of a de facto leader, I oftentimes purposely attempted to avoid dominating or dictating our activities in order to provide more space for others to take the lead – something I came to think of as strategic silences on my part. At other times, I simply failed to contribute to leading the project because of my own time and energy constraints. In either case, however, it seemed to me that our progress tended to sputter or stall if I stepped too far away from a leadership role. A similar experience was relayed by another participant who frequently took the lead in directing activities: "hanging back" from that role often resulted not in others taking up leadership activities but instead created a kind of paralysis that contributed to a lack of direction and steady progress.

Yet, while I was attempting to flatten the leadership structure, others may have been expecting more hierarchy: e.g., "Although I like the free spirit collaboration of the project, there may need to be a chain of command here"; "…we don't absolutely need to be so strict when it comes to coming to a decision and sometimes executive decisions for the group need to be made to spur progress." Feedback during the early stages of the project also suggested that participants

were sometimes unclear on what was expected of them, what they "should" be doing, etcetera: i.e., they were waiting for more specific direction and seemingly experiencing some discomfort in the absence of that. Perhaps the pre-existing relationships among us Bacers carried with them old expectations of who should be leading and who should be following; or maybe we had differing definitions of what progress is or, for that matter, what leadership is; or maybe distributed leadership requires cultivation that is more deliberate than leader-types merely refraining from behaving as they ordinarily might. In any case, the ideals of distributed leadership and equal input in some ways became impediments to our efficient progress toward a desired technological end state.

A good example of this kind of *democratic inefficiency* can be seen in our use of a rubric (see Appendix H) and various other strategies for making our final choice of product. These mechanisms were our attempt to fairly account for all participants' opinions and give them equal consideration, if not weight, in the decision-making process. The rubric in particular was intended to provide a scoring mechanism that was more quantifiable and thus more objective and fair than simple statements of opinion and the making of arguments by individuals who perhaps tend to be more outspoken or persuasive than others. However, sometime after embarking on the use of the rubric, it became evident that measures made by such a tool could potentially be manipulated or distorted, willfully or inadvertently, by differing definitions of whether a given criterion was met – e.g., if a product required a third-party add-on to meet the criterion, did that count as meeting the requirement? What if it performed the function but in a somewhat awkward or inelegant fashion? What constitutes inelegant?

We agreed in principle to avoid making overly fine distinctions in these regards but, recognizing their incomplete objectivity, ultimately decided not to rely solely on the scores

produced by the rubric to choose our product. Instead, the scores would only inform our decision as we also considered feedback from a select few non-Bacer colleagues (a whole separate process unto itself) and then went through what turned out to be two rounds of voting. First, each participant ranked the three final candidates by survey. This produced no clear winner but did result in one final contender (MediaWiki) having a comparatively low set of rankings, which allowed us to eliminate it from consideration with relatively minimal dissent. After a discussion period in which we reviewed some of the open-ended commentary on the products, we then opted to do an in-person vote for one of the two finalists, deciding ahead of time that a simple majority would rule. (Although I was an active participant throughout these proceedings, as facilitator and researcher I felt the need to avoid overly influencing outcomes and thus refrained from the voting process.) The final tally was six to four with one abstention in addition to my own.

This decision process worked in that a choice was made, was made in as democratic a fashion as we could conceive, and even considered input from non-Bacer colleagues. However, the process of choosing clearly took a good deal more time and effort than any executive decision or even a rubric-less, straightforward vote would have, especially given that a delay in these stages usually translated into one or more bi-weekly cycles transpiring. Our attempts to be fair and equal had obvious and direct efficiency costs.

Facetime, fun, and smash face. In constructing this narrative, it occurs to me that one of the most fundamental tensions present in an experience like Bace, and probably much of work life, is between the need to get things done and the need to derive satisfaction and meaning from our interactions – even to have some "fun," as more than one participant alluded. For us Bacers, the need to get things done applied not only to completing the tasks necessary to bring our

special project to fruition, but to do so while continuing to do our jobs at the same time. In the face of such competing demands, targeted results seem unlikely to happen under conditions of complete disorganization, where the only structure is the proverbial path of least resistance. On the other hand, an exclusive or extreme emphasis on efficiency threatens to remove all spontaneity and make employees feel like Marxian automatons, enslaved by "process" and alienated from their own humanity.

Real life almost always falls somewhere in between such theoretical extremes, and life in our IT group is by no means devoid of genuine human connections. Yet I do think that the mostly electronic pre-study relationships between many of us Bacers – being defined primarily in terms of business procedures, official hierarchy, and distributed loci – were not always so robust in terms of those human elements. Being participant driven, heavily democratic, and structured around regular in-person meetings, the Bace experience provided a noticeable contrast.

To be sure, we did learn a number of practical lessons about the efficiency and effectiveness of different meeting formats and collaborative strategies. For instance, my small group often fell back to using video meetings when meeting face-to-face proved too challenging to fit in, but we discovered that this strategy often minimized coordination costs and worked well for demonstrations and other one-to-many agendas. Another group raved about the productivity gains of working collaboratively on a problem in a computer lab, where participants could communicate many-to-many without technological encumbrances while still directly interacting with the problem itself. From contrasting experiences with pre-planned whole-group meetings, which were prescheduled at the onset of the study, versus the more ad hoc meeting strategies often employed for small group get-togethers, we also learned that flexibility in planning comes

with associated costs in logistical overhead: an ad-hoc approach necessitated relatively burdensome (re)negotiations over meeting times and places even though fewer people were involved. By contrast, while requiring some rigidity and commitment, prescheduling meant that little time or attention was consumed on an ongoing basis for logistical tasks like coordinating meeting times. The larger practical lesson: the best organizational approach is probably not fixed but is instead dependent on the specifics of how many people are involved, how often they need to meet, and what needs to get done.

However, some of the most striking comments from participants focus on the human elements of the Bace experience, such as getting to know others more personally, spending time together, and even developing feelings of respect and friendship:

> [Lunch with small group members was] some of the best times at work I've had recently… I remember … relishing the opportunity to meet with them in person ... It was fun to listen, and I remember thinking this is actually how people develop relationships.

> Building personal connections within our group, even talking about things that are not even work-related, seems important too…. When we know each other better, we'll automatically become a more cohesive unit, and some of those walls will start cracking.

> [Regarding our larger IT group, in contrast to Bace] Maybe we need to spend more time together … in the same room or space ... If we are more comfortable around each other we will be more likely to reach out.

> Meetings were a good reminder that we work with a pretty good group here at the University.

> I have a much greater respect for all involved [in the project] and the … work we do to support [our school].
>
> Initially I was concerned about being isolated given my team members and their history. Luckily it has been quite the contrary. They have been extremely receptive to my input and in turn it makes me want to contribute more.
>
> I feel I made two friends during the project. I knew [name1] professionally in the past and had constructive conversations related to work but I think the project changed our relationship to one where I feel I can have not only have improved working relations but an open friendship. [Name2] was a new contact. I had not known him prior to the project. Working on the project together in our face to face meetings I was able to interact with [him] and carry on the conversation post meetings. So I feel I now have two new friends.

Many of these experiences were made possible or enhanced by the opportunities group meetings afforded to spend time together, face to face, without a rigid or purely business-oriented agenda – i.e., occasions where there was freedom to act spontaneously and interact as whole people, not just co-workers. These were occasions for sharing a variety of experiences and insights ranging from institutional wisdom accumulated through years in the proverbial trenches, to strategic business thinking and professional attitudes, to noteworthy events on various parts of the grapevine, the best tech toys, and life outside the job. Humor and levity became prominent parts of how we interacted on these occasions and even sometimes carried over into our electronic communications. Having face to face interactions where humorous and other personal overtones could be interpreted in the context of nonverbal cues was also helpful in establishing the banter as playful and not socially insensitive or hurtful. Such occasions seemed

to provide the mental context for interpreting later exchanges in electronic forums as well, sustaining this more personal style of interacting beyond the purely face-to-face realm. (One participant's "crazy beard" was a running gag.)

Opportunities for being whole people around each other also meant there were opportunities to experience and express negative emotions. Humor, for instance, sometimes morphed into sarcasm or criticism – turning, as one participant put it, "teachable moments" into "a nightmare session of smash face." In private journal entries and survey responses, several participants alluded to things like wanting their opinions to be taken seriously, or the desire to demonstrate their value to the group. If inviting input and sharing knowledge are the goals, requiring individuals to sometimes expose their imperfect knowledge rather than demonstrating competence, these negative moments can be detrimental by undermining the trust, sense of safety, and other positive sentiments that are foundational to overcoming the perceived risks in such community building. Yet, the many positive remarks made by participants suggest these negative occasions did not dominate their experience but instead highlighted the authenticity of engagement and the overcoming of real barriers. On balance, it appears that most of us found at least some value in engaging in the Bace project – perhaps enough to serve as a toehold if not foundation for more firmly establishing our knowledge sharing community in the future. Practical lessons are valuable but so too, it seems, is the nurturing of personal connections between people.

Timelines, rhythms, and milestones: Structure as impediment and enabler. The figure in Appendix I summarizes notable happenings during the course of the study. Many of these are non-project events but are still noteworthy because they provide context for varying degrees of progress towards project goals throughout the study. While it may be unsurprising

that less project activity would happen during shorter workweeks, for example, the spillover of a break mentality into surrounding days and even weeks is perhaps more unexpected. On mid-day Thursday before a Monday holiday, for instance, one participant mentioned being "semi checked out for the weekend already" – an occurrence I suspect is not unusual, having engaged in it a time or two myself. Indeed, across the 12 whole-group meetings, attendance rates at meetings around Spring Break and Easter week, occasions for which employees do *not* have automatic time off, were lowest (see Appendix J). Echoing these events are journal entries containing comments like "[it] seems like my group is just losing steam," and "I feel that our small group has gone from 'full steam ahead' to more of a 'wait, what are we supposed to be doing?'" My own notes also include commentary regarding a subdued participant mood, the "deserted" feeling of campus during Spring Break, and even my own desire to withdraw somewhat from project interactions to "actually focus on some things in more depth" or otherwise "take things at a more leisurely pace." There was, in short, a noticeable slump in project activities as participants sought a break from an otherwise hectic pace.

This kind of effect did pose some challenges for a project that was completely voluntary – by definition, above and beyond usual duties. Such activities, deemed non-essential, were often shelved in order to focus on more critical tasks. As one participant put it, "I have a job to do which comes first." Another remarked that "I try to work on the project during the day, but my job often prevents me from spending as much time on it as I would like." Still another said the project activities sometimes "slip through the cracks… not from a lack of desire to participate, but simply from a lack of seconds in the day."

To one degree or another, I believe all of us experienced some difficulty in fitting in Bace activities around our official job activities. Yet, while ordinary time crunches were a challenge,

time shortages sometimes arose from opportunities taken to stretch a naturally occurring event into a longer reprieve from heavy workloads and busy schedules. It was not uncommon, for instance, for participants to take off extra days around weekends, especially those near holidays, leaving them physically absent but sometimes disengaged from the project for even longer as they mentally "checked out" or caught up with accumulated work upon their return. Sick time (quite extended in one participant's case) or other absences from work contributed to this difficulty.

However, it was not just time off that had such impact. Events like the opening of a new academic building, preparations for a new institution-wide email suite, and a commencement ceremony that included the university's first-ever visit by a sitting US President (an event most of the participants worked) were among others that also disrupted the backdrop of normal rhythms amongst which progress typically occurred. More than just using up objectively measurable chunks of time, these kinds of non-routine events created subjectively "crazy weeks" during which participants seemed disinclined to devote energy to non-essential activities like Bace that might make them crazier.

What is interesting about such disruptors, however, is that they highlight the presence of that which was disrupted. As stated earlier, one of the goals for this study was to find ways of weaving more collaborative knowledge sharing into the fabric of our regular work activities. In these regards, any success we achieved in the Bace project of necessity came from turning participants' willingness to take on yet another challenge towards exploiting and building upon some of the existing rhythms of our workplace.

For instance, besides sparing us some logistical overhead, pre-scheduling all whole-group meetings for Wednesdays helped to minimize absences due to the aforementioned "long

weekend" phenomenon: despite some dips in attendance, attendance rates were generally high at the whole group meetings (85% on average). It also avoided clashes with the beginning-of-the-week blitz of support requests that seems to occur in our environment while simultaneously allowing our three small groups the flexibility to possibly use the quieter period towards the end of the week for last-minute or loosely planned meetings involving more intensive hands-on activities. (My small group, for instance, most often met on Thursdays or Fridays.) Holding the whole-group meetings on alternating weeks also provided additional opportunities for individuals and the small groups to work on project tasks betwixt their job duties while still staying somewhat in tune with, and potentially contributing to, what others in the larger group were doing. (A bit of cross-group attendance did happen at the small group level, particularly where members from different small groups ordinarily worked in proximity to each other.) Indeed, knowing that a whole-group meeting was next week often spurred attempts to get things done during the "off week." Thus, this pattern of reliable, stable bi-weekly whole-group meetings nestled amongst the pre-existing rhythms of our environment acted as a basic skeleton with small group meetings and other interactions filling in the flesh of our activities.

While many such rhythms were based around weeks, others stemmed from another fundamental reckoner of time in our academic setting: the semester. The roughly 24 weeks of data collection for this study were somewhat longer than a standard 14-week semester, and they did not focus on academic schedules per se. Observations here are therefore necessarily tentative, being based more on years of experience in this setting than on an abundance of data. Yet many academics would likely agree that the semester also exhibits its own kind of pattern: the opening weeks are filled with energetic and sometimes chaotic activity, followed by a settling in and "getting down to work," punctuated by something of a "breathing period" at mid-

term, followed by an almost sudden realization that the final weeks of the semester are coming fast, and finally a push to wrap up final assignments, exams, and grade submissions.

As support staff, we Bacers were not driven so directly by purely academic matters such as midterms or grades, but the activities of faculty and students indirectly contributed to the boundaries and pace for our voluntary project via changing demands on our time, energy, and attention. Thus, it may not be surprising that activity on the Bace project did not proceed at a uniform pace but instead roughly paralleled this kind of semesterly trajectory, albeit a bit shifted to accommodate the workflows created by actual semesters. See again, for example, Appendix I where project milestones are shown below the horizontal timeline and major non-project events are shown above it: most Bace accomplishments seem to cluster around the gaps between those other events.

Besides needing to take advantage of the natural opportunities afforded by the rhythms of our environment, one lesson that may be gleaned from these observations is that the priority of collaborative activity in the larger scheme of things seems to be an important factor in just how much time and energy are dedicated to it on the everyday level. For us Bacers, it had become more valued and prominent, but work on our collaborative project and our outreach to each other more generally nevertheless remained secondary in the face of overriding concerns for meeting our individual job requirements. To the extent that our efforts during the study were shaped by the same factors influencing work life in our IT group more generally, this suggests that some formal, management-sanctioned reorganization of our work responsibilities and performance expectations could help make collaborative activity more sustainable: i.e., a more fundamental part of the job, not an addendum to it. Intentional inclusion of collaborative relationship building as a normal part of business process, instead of something that develops in opposition to it, may

help to reinforce and leverage collaborative-friendly values and intentions. Making human elements *part* of process could help to better integrate collaborative knowledge sharing into everyday activity instead of keeping it confined to purely voluntary efforts that can be too easily displaced by the larger patterns of our environment. Such explicit incorporation, for example, might be facilitated in part by purposefully leveraging the rhythms of the environment, perhaps complementing everyday collaboration with collaborative activities planned specially for those periods that are typically less busy.

Until now I have tried to convey some of the more salient structural (organizing) and cultural (meaning making) factors at play during the Bace experience – what may be thought of as aspects of and/or factors influencing the intermediate outcomes predicted in the embodied conjecture (see Appendix G). In the next section I will present some data summaries that may help to clarify the state(s) of our collaborative knowledge sharing habits and the accessibility of our collective knowledge in connection with such structural and cultural elements.

Knowledge Gains

Knowledge scores. Although this study's focus was primarily on understanding the social arrangements that promote knowledge sharing in the study context, a reasonable place to look for evidence of "knowledge accessibility" may very well be in the minds and skills of the people accessing said knowledge. Indeed, one of the lessons of Knowledge Building Communities is that a communal focus can confer learning benefits to individuals (Scardamalia, 2002; Scardamalia & Bereiter, 2006; Zhang et al., 2009). Focused on an ill-structured, in situ, workplace-based problem as it was, the study design did not include a well-defined curriculum of testable subject matter that might serve as a traditional yardstick with which to measure such

individual gains. However, it did include pre- and post-study knowledge scores for 10 broad IT-related skill areas (see Appendix P). Initial scores helped to inform the formation of small groups, but such scores may also serve as a basic measure of individual knowledge states. Positive changes in these states could thus be construed as indications of the kinds of individual benefits cited by others.

With the average score of all participants across the 10 categories showing an increase from 1.38 to 1.98, changes in this measure do suggest there were some knowledge gains. The dissection of these changes depends somewhat on whether the focus is put on raw increases on the 5-point scale or instead on changes in standardized averages. Considering the former first, as shown in the first table of Appendix P, Collaboration (+1.08) and Problem Solving (+0.86) were among the top three categories showing improvements. That these would bubble up makes intuitive sense given the collaborative and problem-based nature of the study's central project: we not only engaged in collaborative problem solving but also explicitly discussed these areas as topics in and of themselves. Changes in Macintosh and Visual / Graphics show the smallest changes, and this also makes some sense given that none of the products we evaluated were specifically Mac-based and that our IT group has traditionally paid more attention to function over aesthetic form.

The Windows average delta (+1.23) was the largest, which makes sense considering that most of the group uses this platform on a regular basis and would thus have spent considerable time working through technical issues in this environment. In addition, one of the products evaluated, Spiceworks, was not only Windows-based but also exhibited some particularly useful features for managing large numbers of Windows systems (an ongoing need in our environment), which may have encouraged participants to explore more advanced topics related to the platform.

Windows Management Instrumentation (WMI) stands out as one of those advanced topics, as Spiceworks seemed to leverage it quite a bit.

Still looking at increases in raw score averages, next runners up were Networking (+.73), Databases (+.56), and Web (+.47). Given that these areas are all central components of an *online* (i.e., web-based, networked) system that *stores* knowledge, it makes sense that participants would also encounter several problem-solving, potentially knowledge-increasing episodes related to these technological categories. Indeed, nearly every product we evaluated involved web-based components as well as some type of database. (Twiki stored data in flat text files rather than a relational database such as MySQL, PostgreSQL, or Microsoft SQL Server. This was noted as a deficit in the product and was a primary reason for its elimination as a candidate.) To some extent, it is surprising that their central importance to much of everyday technological life, as well as the Bace project itself, did not encourage greater gains. Perhaps these smaller gains reflect a greater technical difficulty involved in these somewhat more specialized niches: i.e., although these technologies underpin many modern systems, becoming skilled in them requires deeper, more targeted, and thus harder-to-develop knowledge. In this light, that they increased at all, even if more marginally, is still noteworthy.

Changes in *standardized* averages for each of the knowledge categories, as expressed by Cohen's *d* effect sizes and as tested through a series of paired *t*-tests ($p < .05$, 2-tailed), provide an additional vantage point for corroborating these increases while taking into account variability in the categories (see the second set of tables in Appendix P). From this view, for instance, a significant improvement was observed from pre to post in Problem Solving (Cohen's $d = 1.1895$), Collaboration (Cohen's $d = 0.8444$), and Windows (Cohen's $d = 0.9642$), the effect sizes of all three were relatively strong (>.8), and they were again the skill areas with the top

three largest effect sizes. A significant improvement was also observed for Networking (Cohen's $d = .7163$), which showed what is conventionally considered a "medium" effect size (between .5 and .8), and Databases (Cohen's $d = .4467$) just missed this cutoff and so could be considered more of a "small" (.2 to .5) effect size. Only a marginally significant improvement ($p < .10$) was observed for Web (Cohen's $d = .3770$). The skill areas with the greatest gains thus appear similar from both viewpoints. Given that the numbers of cases involved in computing such statistics is small, these calculations should not be given undue weight. However, that statistical significance was reached at all *despite* this mathematically constrained context adds credibility to the notion that there were indeed real effects.

Pivoting from knowledge categories to individual and small group performance, the raw score deltas and the raw score deltas by small group tables in Appendix P also provide insight into how these effects manifested for particular participants and small groups. Notable examples include a 3.18 point increase in Participant 5's Collaboration score and a 2.59 point increase in Participant 7's Networking score. Considering the small group context highlights that Group 1 showed an average increase of .76 points across all 10 categories, with Groups 2 and 3 following at .5 and .54 increases on average. With an abundance of shaded areas in the figure for deltas by small group, Group 1's score changes seem particularly notable when looking both across the participants and the skill areas.

Like the knowledge category analysis above, these impressions of raw initial and ending score deltas can be checked against standardized versions using Cohen's *d* effect sizes. Unfortunately, as shown in the tables for Cohen's *d* by small groups and for individuals' knowledge scores, carving up the data for this kind of analysis produces some additional mathematical constraints that make statistical significance harder to observe (the tables show

fewer blue-shaded areas). From these cases, it can be only be observed that Group1 showed significant improvements in Databases (Cohen's $d = 2.52$) and Collaboration (Cohen's $d = 1.06$) and marginally significant improvements[6] in Windows (Cohen's $d = 1.00$) and Problem Solving (Cohen's $d = 1.55$). By contrast, for example, Group 3 showed larger effect sizes in Windows (1.36) and Problem Solving (1.74), though significant gains were not observed in any of the other skill area categories. (The Windows score at least might be somewhat explained by the fact that it was Group 3 that evaluated the Windows-centric Spiceworks product.) These kinds of differences overall suggest that Group 1's members in particular most clearly experienced increases in knowledge scores.

Mathematical analysis aside, it is important to consider what has gone into these scores. As a composite of self-rating and ratings by others, the scores are perhaps less vulnerable to pure subjectivity than other self-report measures – i.e., they are at least partly *intersubjective* in nature, and purposely so to make them more robust. In the end, though, they are still basically just impressions or perceptions reported by the participants – albethey quantified and gathered systematically. As such, they might be better thought of as relative bellwethers rather than absolute or precise measurements of knowledge or changes in knowledge. That said, such impressions nevertheless reflect, by definition, the participants' view or experience. In this case, it seems they experienced a rather noticeable trend towards knowledge improvements, both overall and among the small group boundaries. If nothing else, these measures suggest the participants came to see themselves, rightly or not (or partly so), as more knowledgeable than they did previously – which borders on the entirely distinct topic of self-efficacy (Bandura, 1982;

[6] Some flexibility in the p value cutoffs for expanded consideration may be warranted given the somewhat arbitrary, conventional nature of these cutoffs and the exploratory purpose of this study.

Zimmerman, 2000) or possibly reflects a better understanding of others' skills after more interactions, but is perhaps a positive outcome in any case.

Qualitative evidence of knowledge acquisition. Despite these changing impressions, directly asking the participants what they have learned, as I did in various guises throughout the study, did not evoke a long litany of new or deepening knowledge or skills. Indeed, about halfway through the study, one participant even said quite starkly, "This project hasn't particularly exposed me to any new technical knowledge." To some extent, this may be due to a lack of conscious awareness of exactly when learning occurred: unlike lessons learned in school, which are taught and tested, with scored exams handed back to the learners for review and knowledge consolidation, the lessons we ITPs learn are often murkily defined and vetted against the (dis)functionality of a computer or system or some other broken thing demanding attention. Oftentimes the fix occurs and we move on to dousing the next "fire" with little reflection on how we applied what we already knew versus what new knowledge we attained to fix the problem. Thus, I suspect that more learning happens than can be specifically recalled in detail after the fact. (Incidentally, the average knowledge score for the originator of the above comment increased by 33.4%.)

There are, however, other indications of knowledge acquisition stemming from the collaborative project. Some of these are simple statements such as this one:

> I came across a new programming language and framework called Haskell…. I wouldn't have learned about Haskell if I hadn't installed the visual editor. Honestly, I never would have installed the visual editor if you hadn't installed it on your wiki project.

In this case, the participant was engaged in individual learning but the impetus behind it stemmed directly from the efforts of participants in a different small group.

The importance of socially induced motivation is also evident in comments like this one:

> As I mentioned in the group meeting, using a batch [file] for tunneling is new to me. I had to read a tutorial online to understand (enough) what I was looking at. Luckily for me, I can be taught and learn fairly quickly either by instruction or self taught. It is also the first time I'm using [v]Sphere. But I'm pretty sure I'll have no problems navigating around that as I am somewhat familiar with the nomenclature used through out the menu options.

This comment was made in response to a mechanism I suggested to the whole group for accessing our VMware infrastructure, which was restricted to only portions of the network. In this case, we had to "pre-collaborate" about the technical setup before we could address the matters on which we were ultimately intending to focus. The solution involved configuring IP tunneling to work around the address restrictions. Doing this with commands saved in a batch script that could be re-executed at will, rather than relying on manual configuration each time access was needed, would save time and effort and ensure that everyone could reliably get to the resources. This approach was apparently new to this participant (and probably others), as was the virtualization environment itself, and encouraged him to seek out additional understanding of the topics. Indeed, the comment suggests a desire to demonstrate both general knowledgeability and the ability to remain "on par" by acquiring more knowledge as needed.

Indirect evidence of individual knowledge gains, or least exposure to new knowledge, can also be gleaned from various interactions. Indeed, any interaction in which an individual came to others seeking input and left with a solution might be said to have exposed a variety of opportunities for learning. Whether these lessons became an integrated part of any individual's thinking is hard to say, not always having access to when similar circumstances resurfaced to

"test" that individual, but their potential to induce better knowledge seems obvious. Consider in greater depth, for example, an interaction in Slack briefly alluded to earlier, a case in which a participant leveraged his Bace connections to solve a non-Bace problem (see Appendix R). The conversation began with a simple status inquiry about network connectivity but developed into an extended exchange exposing interactants to a range of topics. These included details ranging from the location of internal resources such as the Network Status page and the addresses of different legitimate DHCP servers in the environment, to commands to identify machines by their physical addresses, and specific tools not only to locate rogue DHCP servers on a network but also to identify the manufacturer of given network devices using only their MAC address.

The exchange also demonstrated high level troubleshooting, technical reasoning, and strategizing. These exposed thinking about the way the DHCP protocol works and the relationship between network layers, such as IP addresses versus MAC addresses, physical switch ports, and bridged connections. At the same time, it modeled an investigative approach for combining technical knowledge with information about the environment, such as room numbers and drop (network jack) locations, to physically seek out and remove problematic network devices. While most of this exchange took place between a few participants, several others demonstrated interest by making small contributions or passing remarks: i.e., they were watching the exchange even though they were disinclined or unable to contribute more to it. That they were watching, however, also means a potential for learning even for those on the periphery. Thus, it seems that this single exchange provided several participants with opportunities for improving their technical prowess on multiple levels.

Similar exchanges occurred within the framework of the Bace project itself. The members of small group 1, for instance, reported great success at working out technical

challenges while co-working in lab. Combined with reports demonstrating their shared labor, this suggests that each of those participants was directly exposed to a number of technical situations with which they were unable to deal individually but were together able to overcome and learn from in the process. Sometimes this included allusions to skills, once possessed, that had atrophied over time but were rejuvenated and updated via work in the collaborative project. Participants 1 and 6, for instance, both reported satisfaction over the sharpening of their Drupal skills through their project-related efforts. I know that I personally found myself learning not just through interactions with others – e.g., as they explained the role of taxonomies in Drupal or the process for integrating plugins into Redmine. Such learning was complemented by my own efforts to build and further solidify my understanding of issues well enough to present and explain them coherently to others, and to sometimes persuade them to accept a particular direction: e.g., these include my understanding of things like Parsoid and wiki markup or markdown languages, how different namespaces in MediaWiki might be leveraged to expose some articles publicly while keeping others private, and how to build a sensible structure into the free-form space wikis expose.

These are only some examples. Throughout the 24 weeks, the collaborative process exposed learning opportunities time and again. Whole group meetings, for example, almost always included bouts of "tech talk" in which participants "picked the brains" of their colleagues on a variety of project and non-project matters, and Slack was an omnipresent mechanism allowing us to reach out at a moment's notice. What was among the most interesting developments, however, was that the learning benefits of the collaborative process were both direct and indirect, exposing individuals to their colleagues' thinking but also motivating them – e.g., via implicit comparison with others' knowledge or a desire to understand well enough to

help or influence others – to independently seek out additional knowledge to improve their own understandings.

Engagement

As a break from to the way participants interacted within the usual confines of their jobs, engagement in the novel collaborative Bace project and even the study itself can be thought of as rough indicators of collaborative engagement more generally. Thus, it may be interesting to consider participation levels and even data submission rates throughout the study as a kind of basic proxy measure for the outcomes that are of most interest here.

Whole group attendance. Attendance is perhaps the most basic level of engagement. As alluded to earlier, at an average of 85%, attendance at the 12 whole-group meetings was generally high (see again Appendix J). Apart from the marked dips in March, attendance numbers did not vary widely and so may not say much about changes in pre/post states: i.e., attendance at the first meeting did not differ much from attendance at the final meeting. With a relatively small *n* it would be statistically difficult to tease out any significance in the in-study variations even if it exists.

Still, from a design-based research perspective, it may be interesting to note that 3 of the 12 meetings saw a perfect attendance rate. While the mid-semester break may somewhat explain the 2 successive meetings with the lowest attendance rates (meeting numbers 4 and 5 with 58% and 67% attendance respectively), there are less obvious potential reasons for these instances of full attendance. Perhaps they were simply occasions when circumstances did not prevent some participants from being present. It could also be that they correspond with periods of time when less obvious progress was happening amongst the small groups and participants felt somewhat more compelled to honor their voluntary commitment to the project by being sure to attend the

whole group meeting. Throughout the study various participants did make nearly apologetic comments mentioning their lapses in participation, which bolsters this line of reasoning. However, looking at messages I sent ahead of these particular meetings, I might also suggest that the agendas for these meetings generated some extra interest – particularly meetings 7, where real product comparisons would take place, and 9, where we planned on discussing the results of the "first impressions" survey to gauge support for final product choices – what essentially became our first round of voting. Perhaps results-oriented agendas in which participants had a stake in defending or promoting their preferred product helped to boost their determination to attend.

Small group presence. There were no attendance reporting requirements for the small group meetings, and what constituted a meeting may vary somewhat at that level since many small group interactions were likely informal and perhaps spread out across relatively brief electronic exchanges. The group logs, each kept in a Sakai forum where any Bacer could see and/or comment, were intended to capture at least some of this activity and therefore provide some sense of participation levels at the small group level: what might be called "presence" if not attendance per se. However, these entries turned out to be somewhat less voluminous and richly detailed than anticipated. Figure 2 provides some summary.

My sense is that these numbers only partially represent actual participation in small group activity. For instance, considering the length of the study, members of Group 3 posted relatively few entries, and these consisted mostly of sparse outlines summarizing questions or issues yet to address. Additionally, no one in the group replied to any posts. Yet this group showed a great deal of enthusiasm, especially early in the study, and succeeded in evaluating at least 2 products, one of which eventually became our product of choice. This group seemed to use the forum

primarily as a task list or an after-the-fact trail of their activities and thought process rather than as a means of potentially interacting with each other or the other groups. Given that half of their entries were posted by the same participant but reference activities by other group members, I suspect that posting to the forum was a task assigned to an individual in the group and not something group members worked on jointly.

Figure 2: Summary of group log posting activity

	Group 1				Group 2				Group 3			
	Posts	% of total posts	# of initiating posts	# of reply posts	Posts	% of total posts	# of initiating posts	# of reply posts	Posts	% of total posts	# of initiating posts	# of reply posts
Facilitator	11	31%	0	11	12	55%	8	4	2	20%	0	2
Part1	5	14%	5	0	0	0%	0	0	0	0%	0	0
Part2	0	0%	0	0	1	5%	1	0	0	0%	0	0
Part3	3	8%	2	1	0	0%	0	0	0	0%	0	0
Part4	0	0%	0	0	0	0%	0	0	5	50%	5	0
Part5	0	0%	0	0	0	0%	0	0	2	20%	2	0
Part6	4	11%	3	1	0	0%	0	0	0	0%	0	0
Part7	13	36%	4	9	0	0%	0	0	0	0%	0	0
Part8	0	0%	0	0	4	18%	2	2	0	0%	0	0
Part9	0	0%	0	0	0	0%	0	0	0	0%	0	0
Part10	0	0%	0	0	0	0%	0	0	1	10%	1	0
Part11	0	0%	0	0	5	23%	2	3	0	0%	0	0
total	**36**	**100%**	**14**	**22**	**22**	**100%**	**13**	**9**	**10**	**100%**	**8**	**2**

Shaded cells represent posting activity for members of the given small group. For example, Participants 1 and 3 were members of small group 1 while Participants 2 and 8 were members of small group 2. Participants were encouraged to read and respond to posts from their own group as well as others but, barring facilitator activity, there were no cross-posts.

This is not too dissimilar to the way my small group (Group 2) handled the group logs: typically, we made individual comments and observations to a joint Google doc where we would gather our thoughts among our group, at least reading if not modifying one another's comments. One of us would then take a turn at posting it to Sakai for the other groups to see. We attempted to share this responsibility but, having made 55% of our posts, I (the Facilitator) clearly shouldered this duty disproportionately to the others – a disproportion that was perhaps exaggerated by a prolonged absence of one of our group members.

Group 1's use of the logs came closest to what I envisioned for this communication mechanism, with a variety of substantive content and members taking part in a more equal fashion. Perhaps factoring into their dynamics was the relatively small degree of heterogeneity in terms of workplace grade / responsibility levels in their group: i.e., Groups 2 and 3 had three Assistant Directors spread between them whereas Group 1 had none. Nor did Group 1 have the facilitator as a member. Perhaps together these group composition characteristics encouraged or allowed individual members to take more initiative.

As a data source, the group logs did provide some insight into the substance of interactions at the small group level – things I could not observe directly since I could not be a member of all three small groups. However, on the whole, it seems that these patterns in the group logs indicate less about participation at the individual or small group level and more about the relative lack of utility of using this type of mechanism (in this case, Sakai forums) for promoting interaction. With Slack already in full use, it is quite possible that participants found the forums to be something of a tacked-on exercise more akin to homework than a tool for real productivity and knowledge sharing. Given the real-time responsiveness of Slack versus the somewhat "old school" post/wait/refresh style of the forums, plus the more structurally challenging need to browse to an out-of-the-way web page to even find the forums, this should perhaps be unsurprising. Yet it may nevertheless be a lesson to remember for future attempts at promoting interactions within our environment.[7]

Individual confidences. Throughout the 24-week study, I presented the participants with 10 sets of prompts, one set about every two weeks, that probed for private responses to one

[7] Only public Slack communications were visible to me, and Slack logs were not sufficient to tease out interactions at the small group level. Otherwise, they might have been an interesting source point of comparison to consider here.

or more questions (see Appendix C). Participants could also choose to write about anything else they desired. Figure 3 shows a summary of these journal entries.

While sharing impressions with a single individual is not quite the same as sharing knowledge at a collective level, these data suggest a degree of willingness to support the collaborative goals of the study. Although two participants did not respond at all to the prompts and a third responded to only one prompt, two participants responded to all 10 prompts and several others to at least half of them. Considering that requests for these submissions occurred amidst requests for other responses as well as the actual, ongoing work required to bring our online system to fruition, the response rate seems quite high. This possibly reflects a high level of pre-existing commitment that one might expect among participants that are essentially self-selected.

Figure 3: Individual journal entry submissions

	JE01	JE02	JE03	JE04	JE05	JE06	JE07	JE08	JE09	JE10	~ total words
Part1	✓	✓	✓	✓	✓	✓	✓	✓			2089
Part2											0
Part3											0
Part4	✓	✓			✓			✓			984
Part5	✓	✓	✓	✓							983
Part6	✓	✓	✓	✓		✓	✓	✓	✓		821
Part7	✓										248
Part8	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	2755
Part9			✓								619
Part10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	3637
Part11	✓	✓	✓	✓	✓	✓					1007
										total	13143
										average	1195
										median	983

A check mark in a JE (journal entry) column means the given participant submitted a response to the prompt. Word counts come from Microsoft Word.

However, this may also be an instance where the choice of platform for running some of our Bace activities – Sakai – helped to increase engagement: the assignment module that I used to post the prompts and collect the responses also provided a Feedback mechanism that allowed me to reply to participant submissions. My replies through this mechanism totaled nearly 17,000 words across the term of the study, with relatively lengthy replies going to Participants 10, 8, 6, and 11, and an ongoing exchange with Participant 10 in particular. Thus, what could have easily remained a one-way communication of "participants submitting data to the researcher" turned into something of a two-way dialog that in some cases remained established throughout the study. As this sort of exchange is fundamental to the kind of knowledge sharing community at the heart of this study, its importance should perhaps not go without comment. To the extent that this dialog did further our efforts, it is worth underscoring the possibility that readers wanting to facilitate efforts like Bace in their own contexts may get best results when they themselves manage to model a willingness to share their own thoughts, insights, and knowledge, and to engage in collaborative dialog.

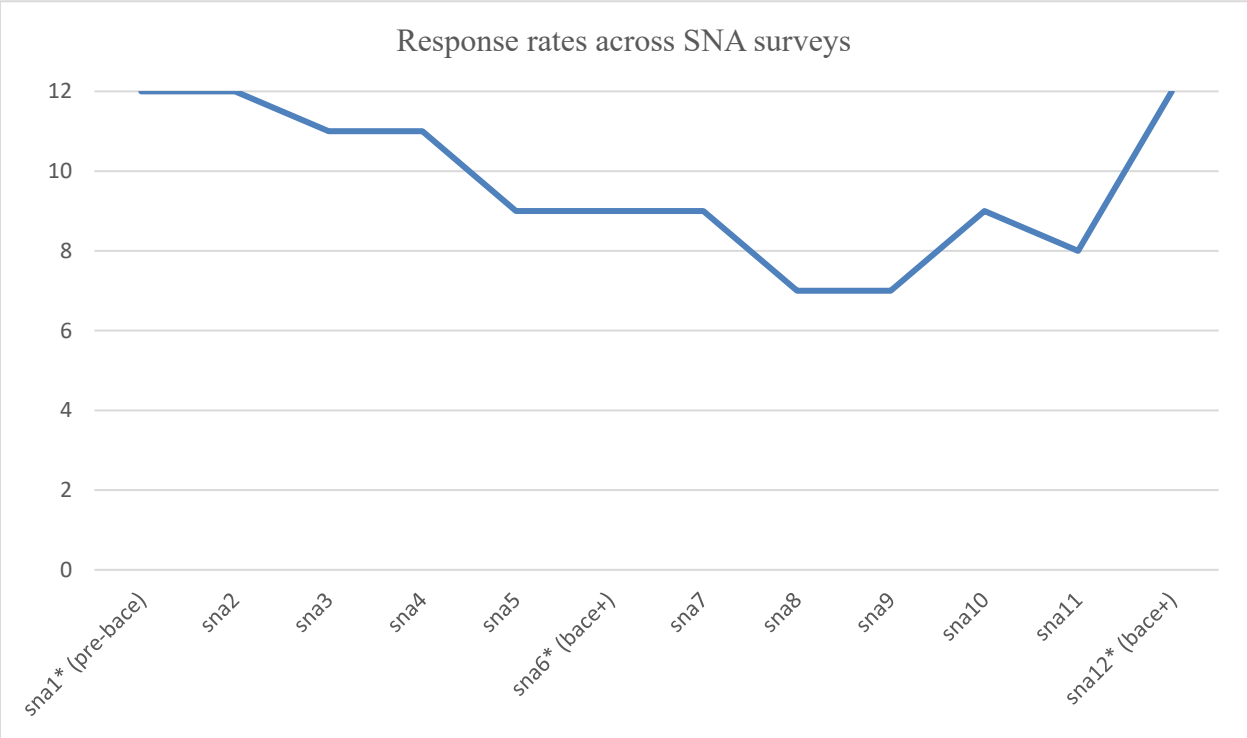
Knowledge Sharing

Whole-group relationships. Participation rates in the 12 bi-weekly social network analysis (SNA) surveys may also be worth noting, both as a proxy measure of engagement and as background for interpreting the results of the surveys themselves. Even with the relatively small number of participants in the study, obtaining perfect submission rates across the duration of the study was not possible: the mean and median number of responses per survey were 9.67 and 9, respectively, out of the possible 12 total respondents. As a full participant in the project, I expected to engage in genuine knowledge exchanges with others and saw no reason to consider

such exchanges to be invalid instances of knowledge sharing. Thus, the surveys included me as a potential giver and receiver of knowledge and these rates therefore also include my own responses to each of the surveys.

As in with other data sources, response rates on this instrument varied over time. While surveys 1,2, and 12 received perfect (12 out of 12 or 100%) response rates, surveys 8 and 9 were lowest with only 7 responses each. Figure 4 shows the trend across the 12 surveys. Considering the length of the study and the ongoing nature in which data were collected, even a response rate of 7 out of 12 arguably shows a high degree of investment in the project and its associated activities. Still, the eighth and ninth surveys are low points in something of a downward trend that only turns upward again towards the last weeks of the study.

Figure 4: Responses (n) to SNA surveys



Note: Asterisks in the survey name denote that survey responses for the given survey are expected to include knowledge exchanges between participants outside the confines of the Bace project: the first survey was distributed

before the project had gotten under way and so necessarily excludes Bace activity; for surveys 6 and 12 the respondents were asked to consider non-Bace interactions with other participants. This was intended to help gauge whether the project was having any impact on extra-project relationships. See Figures 5a and 5b, to be discussed shortly.

Juxtaposing the timing of the surveys against project events on the timeline (see Appendix K or M) shows no obvious project-related reasons for this dip in study engagement, suggesting perhaps that this merely reflects a degree of survey fatigue after months of engaging in the study and project. On the other hand, juxtaposing them against non-project events (see Appendix L or M) does show these low points following a series of somewhat non-routine end-of-semester activities. Extra-project structural factors such as convocation practice would normally introduce deviations from the usual routines, but our Obama-centric convocation practices and special concerns seem an especially likely contributor to a less-than-zealous commitment to completing yet another survey.

Regardless of the reasons or significance of the response pattern, missing data posed some difficulties for analysis. In order to reduce the blind spots introduced by such gaps, I opted to analyze the responses in a way that did not necessarily exclude knowledge exchanges with the missing respondents. This was possible because the surveys included questions about not just to whom the respondent gave knowledge but also from whom it was received. Considering that if A *gives* to B it necessarily means that B *receives* from A, asking the question in both forms means that a relationship between A and B can in theory be observed even if one of them does not respond. This is something of an optimistic way of looking at the data: it assumes one respondent's report indicates that a knowledge exchange really occurred whether or not it is corroborated by the other party. An alternative, more conservative approach would be to assume that no relationship occurred unless *both* A and B said it did, thereby perhaps giving more credibility to these self-reported, recall-based data. Thus, this optimistic approach trades off

more certainty in the observations for the possibility of noticing more knowledge exchanges – a practical choice that may be somewhat justified considering a) the exploratory nature of the study and b) the relatively large impact of missing data on an already small set of observations (see Appendix N).

From an SNA perspective, one way of evaluating changes in knowledge sharing relationships or "ties" among a given group or network of people would be to look at trends in relationship density, i.e., the proportion of relationships that occur out of all possible ones. For example, in a network that has 3 actors A, B, and C, if every person shares knowledge with every other person, that produces a total of 6 possible knowledge sharing relationships: i.e., A gives to be B, A gives to C, B gives to A, B gives to C, C gives to A, and C gives to B. If in a 3-node network only 2 such relationships occurred, the density would then be 2 out of 6, or 33.3%. Thus, if the density in a network goes from 2 of 6 (33.3%) to 3 of 6 (50%) to 4 of 6 (66.6%), this could be considered a basic indicator of an upward trend in knowledge sharing within the group. In a 12-person network, the number of possible relationships increases[8] but the basic premise remains the same: the presence of more relationships or ties between participants over time would indicate more knowledge sharing.

Figures 5a and 5b show slightly different views of the density of such ties for the whole group across the course of the study. These views represent the same exact data points, just drawn against different high and low boundaries on the vertical axis in order to look at the data from different vantage points. Unfortunately, even with the peaks and valleys illustrated more

[8] In a 12-node network, the number of total possible knowledge-giving relationships is 132. This is perhaps easiest to grasp if pictured as a grid of spreadsheet cells such as those shown in Appendix N, where participant 1 potentially gives to participants 2, 3, 4, etc.; participant 2 potentially gives to 1, 3, 4, etc. Since the matrix is square and the diagonal (where a participant row crosses its own column – i.e., where a participant would be said to "give" to him or herself) is usually discounted, the general formula is (n*n)-n.

dramatically via the zoomed in perspective of Figure 5b, neither view appears to offer any immediate or obvious conclusions to be drawn about the trend. As alluded to earlier, surveys 1, 6, and 12 also have a different emphasis in that they are expected to include non-Bace interactions between the participants, which might further complicate interpretation: the wording of survey 6 focuses only on "non-Bace interactions," while the wording for survey 12 focuses on "Bace and non-Bace interactions" (see Appendix D).

Figure 5a: Density of ties

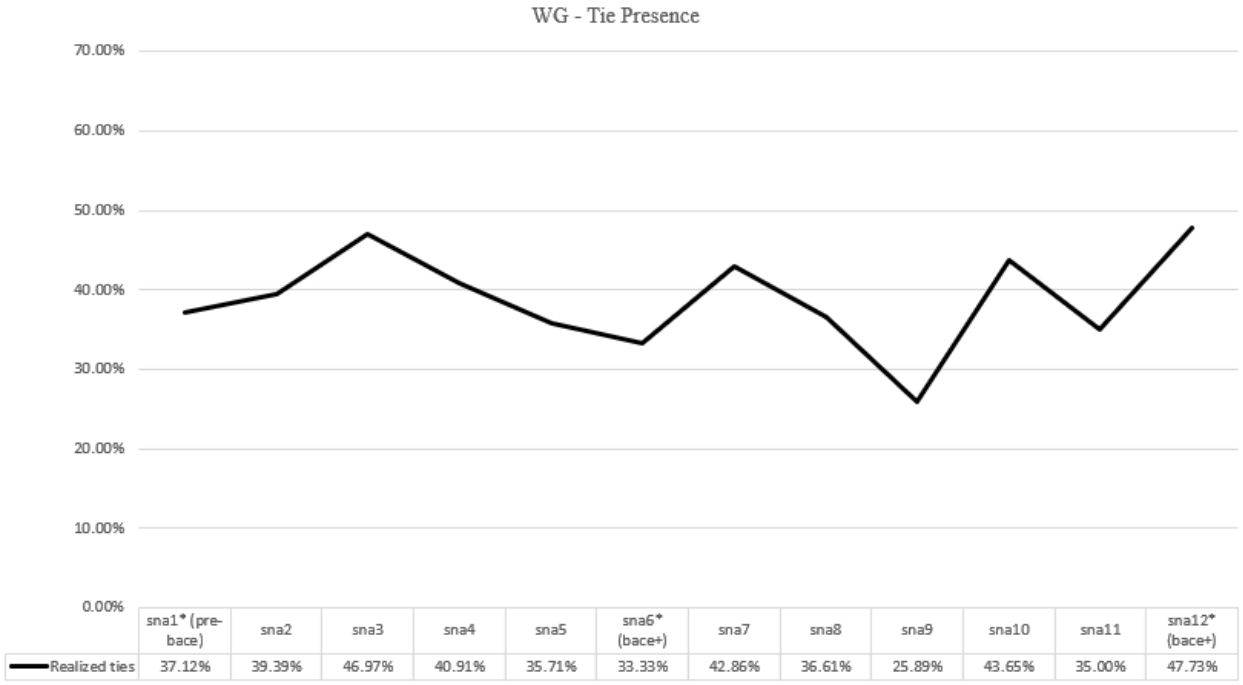
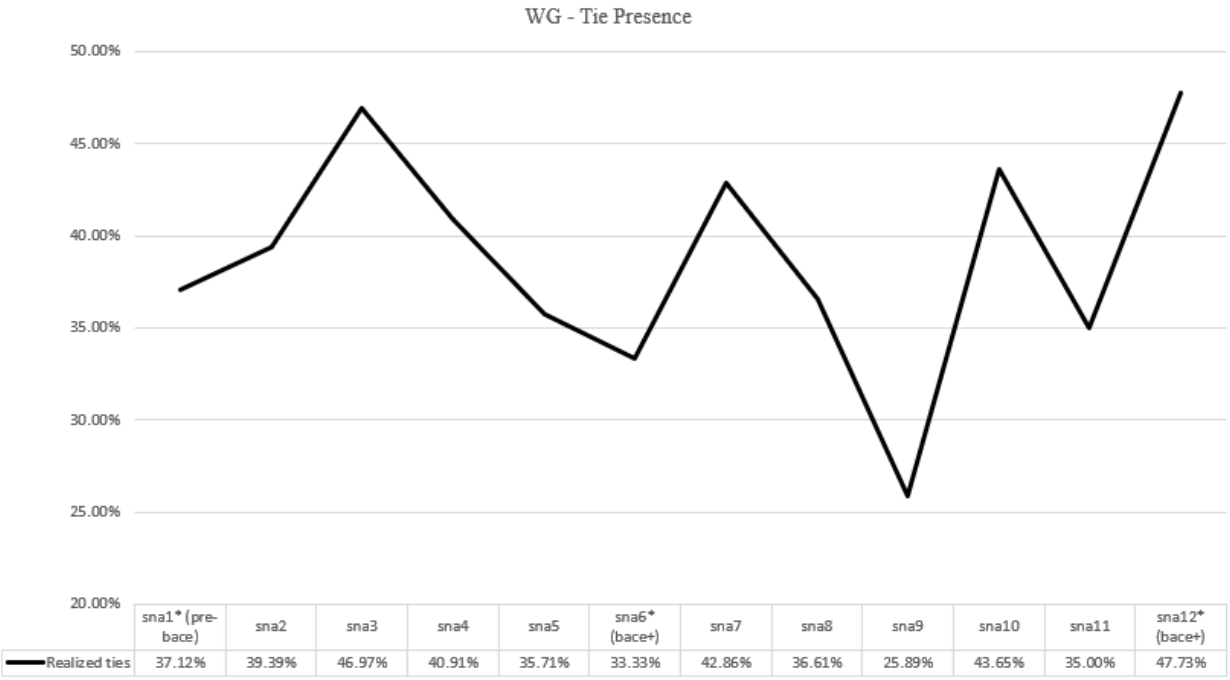


Figure 5b: Density of ties (shorter vertical axis to foreground the peaks and valleys)



	sna1* (pre-bace)	sna2	sna3	sna4	sna5	sna6* (bace+)	sna7	sna8	sna9	sna10	sna11	sna12* (bace+)
Realized ties	37.12%	39.39%	46.97%	40.91%	35.71%	33.33%	42.86%	36.61%	25.89%	43.65%	35.00%	47.73%

Note: Density values were calculated in Microsoft Excel but compared against the output of Ucinet (Borgatti et al., 2002), a well-recognized SNA program, for validation.

On a basic level, using surveys 1 and 12 to compare in a somewhat classical fashion the pre and post network density, both of which include non-Bace interactions among the participants, suggests an overall increase in relationship density – from about 37% to about 48%, a somewhat sizable increase of more than 28%.[9] However, given the variation at other points in the timeline, it is difficult to ascertain how representative or meaningful this difference is. The ending value is noticeably above the mean (38.8%) and median (38.3%) but so are the values for surveys 3, 4, 7, and 10. The mean and median are also only slightly higher than the starting value. In addition, given that survey 1 measures pre- or non-Bace exchange levels while survey 12 measures both Bace and non-Bace combined, this pre-to-post change represents not an

[9] The ending value minus the beginning value, all divided by the beginning value, yields the difference as a percentage of the beginning value: i.e., (47.73-37.12)/37.12 = 28.58%.

increase from the baseline of *Bace* activity per se but mainly an increase in *overall* exchanges between the participants, most likely due to their co-participation in the additional project. This is a desirable change, but it perhaps offers less insight into the internal workings of the intervention design.

Tabling the question of interpretation for the moment, or perhaps complicating it further, it may also be worth considering a somewhat more qualitative dimension than the simple presence or absence of relationships captured by these numbers. A binary framework does not, for instance, distinguish a knowledge sharing relationship that involved deep or iterative effort from one that happened via a brief dialog. However, although any quantitative scoring mechanism necessarily reduces such qualitative aspects, the portion of the SNA surveys that asked about "number of times" interacting with a given participant and the "overall effort" involved, does permit consideration of more than just the binary state of any potential relationship during in a survey period (see again Appendix D).

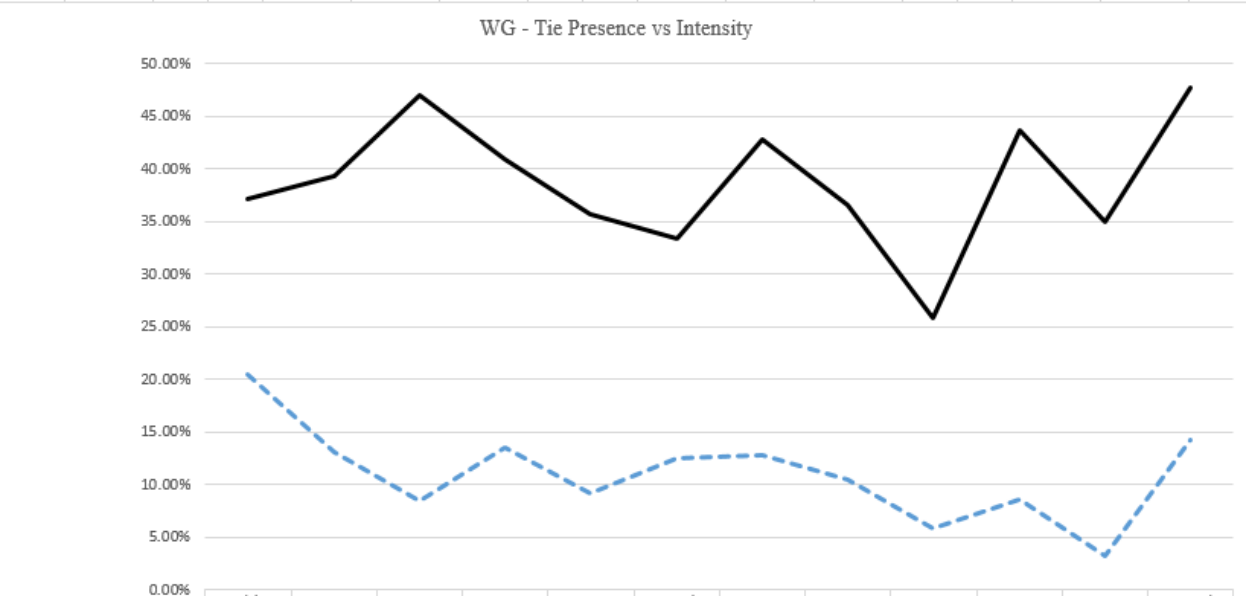
Taking the participant rankings of each of these two factors on a scale of 1 to 5 and multiplying them yields something of a composite score of relationship "intensity" that at least allows exchanges with high time and/or effort investments to be distinguished from those ranked lower on these dimensions. Such scores can also be normalized by dividing by the highest value possible (two 5-point scales=5x5=25), thus turning them into percentages much like the density scores. Although rankings such as these, particularly the effort ranking, are arguably only ordinal or possibly interval in nature and thus perhaps not strictly amenable to ratio-level operations like multiplication and division, temporarily treating them as ratio for the purposes of basic exploration and considering the results with caution – as all conclusions from designed-

based research ought to be – may provide some sense of any trends in these more qualitative aspects of the observed relationships.

Intensity values are shown in Figure 6 along-side the percentage of realized ties or relationships – i.e., the density values from Figures 5a and 5b. Like the density scores, these data show that "average" intensity (with mean and median values of about 11% and 11.5%) follows a somewhat variable path. In this case, the pre-to-post delta is about 30%[10] – similar to the roughly 28% change in density – but the trend is in a *downward* direction. To the extent that the focus remains on just pre and post states, it might be tempting to conclude that relationship density and relationship intensity are inversely related – that relationship density increased while relationship intensity decreased. Intuitively, this makes some sense: given a finite amount of time and energy, as actors engage in more relationships, they will have less time and/or energy to spend on any given relationship.

[10] The ending value minus the beginning value, all divided by the beginning value, yields the difference as a percentage of the beginning value: i.e., (20.45-14.26)/20.45 = 30.27%

Figure 6: Intensity scores of realized relationships



	sna1* (pre-bace)	sna2	sna3	sna4	sna5	sna6* (bace+)	sna7	sna8	sna9	sna10	sna11	sna12* (bace+)
Realized ties	37.12%	39.39%	46.97%	40.91%	35.71%	33.33%	42.86%	36.61%	25.89%	43.65%	35.00%	47.73%
Avg Intensity of ties	20.45%	13.04%	8.48%	13.56%	9.20%	12.52%	12.74%	10.49%	5.79%	8.55%	3.29%	14.26%

Note: the average intensity calculations in this figure exclude cases of zero intensity due to the non-existence of a relationship: i.e., they reflect the average intensity of realized relationships only. However, the individual scores from which each survey average is computed are themselves an average of the giver and receiver scores for any given relationship. Because the optimistic approach does not necessarily exclude relationships with missing respondents, this average may incorporate zeroes stemming from missing responses from either the giver or receiver. Thus, missing data may push the intensity values somewhat downward.

Whether and how that would affect the *value* of those knowledge sharing relationships is not readily discernible given the data collected but is perhaps an interesting topic for future research. It could be, for instance, that low intensity knowledge sharing relationships within a group are more productive or useful in some ways than high intensity ones – e.g., see Hansen (1999); or maybe lower intensity is an outcome or indicator of ongoing relationships that are well-honed. However, for the present study, more ties and ties with higher intensity were assumed to be better, and so a decline in intensity presents something of a puzzle. Such a decline, taken alone, possibly even suggests that the designed intervention had an undesirable impact on knowledge sharing.

To some extent, the use of a composite score for intensity probably deserves some further unpacking, as perhaps does the somewhat ambiguous notion of effort itself: e.g., relationships that participants experience as requiring "less time or effort" might be seen as easier or otherwise less costly or more desirable, and so reports that rate effort lower could potentially reflect *improvements* in terms of rapport or honing of the social skills that facilitate such interactions. Practical constraints prevent a deeper consideration of these possibilities here, but these also seem like interesting lines of thought for future explication. For now, a somewhat agnostic interpretation regarding intensity may be most prudent, especially given the extra context of observed variations over time.

Re-applying a design-based research perspective at this juncture – e.g., considering the potential structural and cultural elements at play at each of the intervals along the timeline – might help to make sense of these data. However, it may be best to complicate matters just a bit more by considering how these elements played out at the small group level.

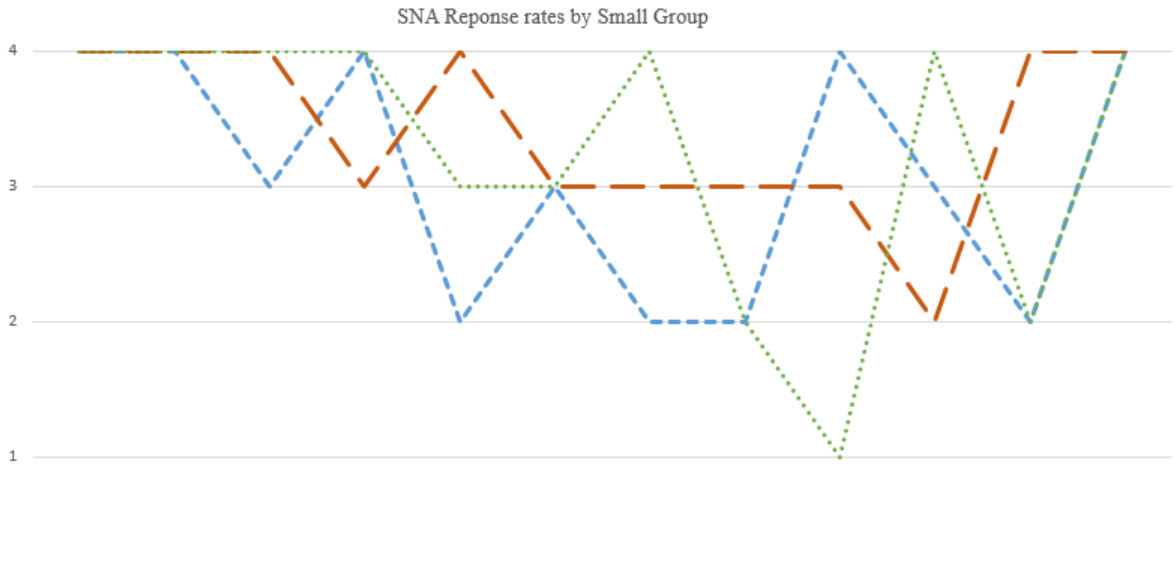
Small-group relationships. Although the sample size for this case study is relatively small, it is still possible that some of the trends noted above are somewhat diluted by opposing forces that average out when viewed purely through a whole-group lens. Including three small groups in the study design turned out to be practical in terms of dividing the work load involved in the Bace technical project. However, this multi-group design element also provides some basis for contrasting outcomes across three potentially different social "micro climates" influenced, perhaps, by some purposeful choices as well as some unanticipated variations in group composition (see Appendix Q). This may be helpful in teasing out some of the more impactful factors involved. For the sake of parity with the whole-group (WG) outcomes outlined

above, Figures 7, 8, and 9 summarize the SNA survey participation rates, density scores, and intensity scores for the three small groups SG1, SG2, and SG3.

As Figure 7 illustrates, SNA survey response rates across the three groups were not uniform throughout the study. To the extent that such rates can be taken as rough indicators of engagement, they suggest that the three groups were differently engaged at various stages, with perhaps the most overlap in engagement occurring during the initial four 2-week periods and the final weeks of the study (surveys 1, 2, 3, 4, and 12). This may simply reflect a greater degree of enthusiasm during the initial phases where volunteers' motivation and excitement over the prospects of solving the problem might normally be highest, and the last phase where the solution finally seems within reach. One possibly interesting blip occurs at survey 9, where only one member from group 3 responded. However, at 3.08, 3.42, and 3.25 for groups 1, 2, and 3 respectively, the average[11] response rates across the three groups do not seem radically different.

[11] Median values were 3, 3.5, and 4 respectively. The relatively larger gap between group 3's response mean and median as compared to those from groups 1 and 2 suggests a somewhat more skewed / less "even" distribution. This interpretation is consistent with this group's high enthusiasm and productivity early in the project and relative silence at other points – a somewhat "bursty" kind of engagement style.

Figure 7: Responses (n) to SNA surveys, by small group



	sna1* (pre-bace)	sna2	sna3	sna4	sna5	sna6* (bace+)	sna7	sna8	sna9	sna10	sna11	sna12* (bace+)
SG1	4	4	3	4	2	3	2	2	4	3	2	4
SG2	4	4	4	3	4	3	3	3	3	2	4	4
SG3	4	4	4	4	3	3	4	2	1	4	2	4

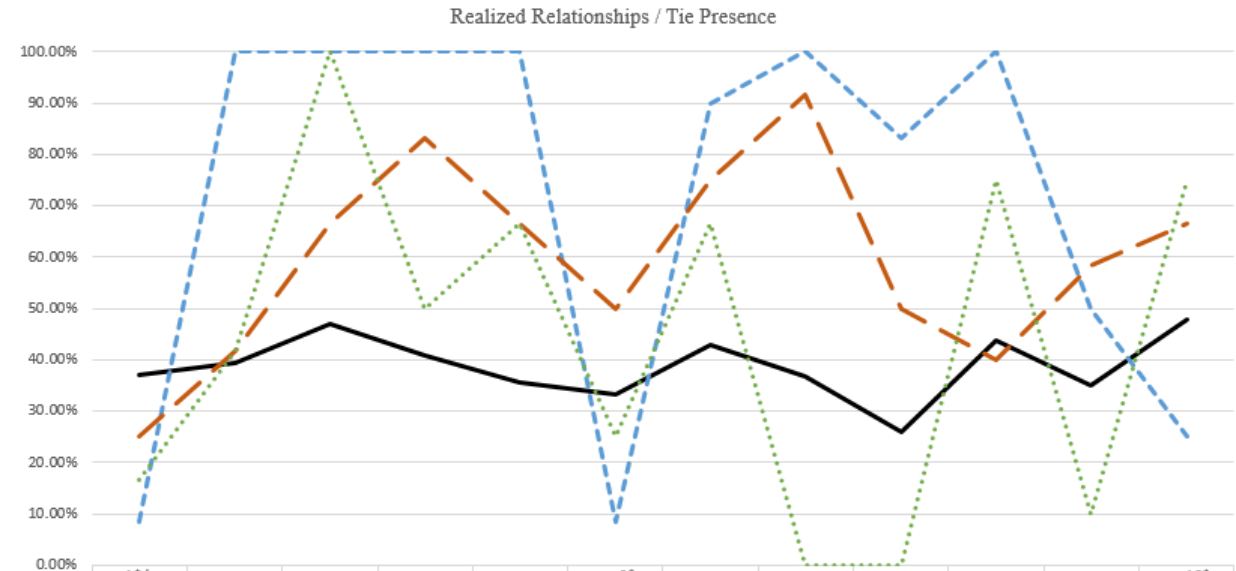
Note: Because each small group had 4 members, 4 is the highest number of responses that can be expected for any given group on any given survey.

The commonality at certain stages of the project / study combined with the groups' relative similarity in terms of average engagement may suggest that particular elements present during the initial and ending periods (where engagement, at least according to this proxy measure, was highest) hold particular value. On a basic level, it could simply be that projects that are longer term, or perhaps lacking clear shorter-term goals, are less able to sustain consistent focus or interest. Alternatively, or additionally, perhaps a key ingredient lay in cultural elements like the explicit discussions about collaborative values and vision that tended to be at the forefront of Bace discussions during these periods – motivational talk that was foundational to providing rationale for the project and, in the end stages, carrying it to the broader IT group. If so, some additional structural scaffolding that more regularly incorporated

such talk might have helped to better sustain enthusiasm and engagement. However, the variability between the groups at other points in time also suggests that interactions happening in the small group context – the one thing that definitely differed between the groups – may also have been important in creating differences in engagement.

Breaking out the density of ties by small group also suggests some inter-group differences. As Figure 8 illustrates, for instance, small group 1 showed a rather consistent trend towards knowledge sharing amongst all members: i.e., on 6 of the 12 surveys, this group showed 100% density, with several other high-ranking scores well above the values for the whole group. Small group 2 never managed 100% density but scored above the whole group level throughout a majority of the study. Finally, group 3 scored 100% on one measure but fell below the whole group at several other points. Average density scores of 72.08%, 59.58%, and 43.89% for small groups 1, 2, and 3 respectively capture a similar trend, indicating that group 1 maintained the most knowledge sharing relationships and group 3 the least. Interestingly, this corresponds somewhat with the observed trends in the Cohen's *d* score effect sizes: as mentioned earlier, group 1's knowledge scores in particular showed evidence of relatively large, significant differences. Though there is no *automatic* or *necessary* relationship between knowledge sharing and knowledge gains, their correspondence here further suggests key differences in knowledge sharing outcomes across the groups.

Figure 8: Density of ties, by small group



	sna1* (pre-bace)	sna2	sna3	sna4	sna5	sna6* (bace+)	sna7	sna8	sna9	sna10	sna11	sna12* (bace+)
WG	37.12%	39.39%	46.97%	40.91%	35.71%	33.33%	42.86%	36.61%	25.89%	43.65%	35.00%	47.73%
SG1	8.33%	100.00%	100.00%	100.00%	100.00%	8.33%	90.00%	100.00%	83.33%	100.00%	50.00%	25.00%
SG2	25.00%	41.67%	66.67%	83.33%	66.67%	50.00%	75.00%	91.67%	50.00%	40.00%	58.33%	66.67%
SG3	16.67%	41.67%	100.00%	50.00%	66.67%	25.00%	66.67%	0.00%	0.00%	75.00%	10.00%	75.00%

As was the case at the whole group level, the small group relationship intensity values seem a bit harder to interpret. For instance, group 1's survey 4 values in Figures 8 (density) and 9 (intensity) indicate that group 1 exhibited 100% density at the same time as their highest intensity score of almost 25%, which somewhat contradicts earlier speculations about the potentially inverse relationship between density and intensity.[12] However, after that point, group 1's intensity scores start trending downward while their density scores remain fairly high. Group 2's intensity scores spiked at survey 6, which corresponds with a *drop* in density, and spiked again in survey 8, which corresponds with their *highest* density score. Finally group 3's intensity spikes at surveys 4 and 7, both of which exhibit relatively robust density scores compared to

[12] Any such relationship could never be completely linear, at least not as captured in these data, because the intensity scores are computed only from realized relationships. That is, for any intensity to register, density cannot be 0; thus, intensity could never be at its absolute highest when density is at its absolute lowest.

whole group levels. In short, if there is any correspondence between intensity and density, it is not simple. Do these values, then, capture anything of interest?

Average intensity scores for groups 1, 2, and 3 respectively were 9.88%, 10.79%, and 10.69%, which does put group 1's overall intensity at the lowest. The margin looks to be small, but at a distance of .91 percentage points between group 1 and group 2's average intensity score, and .81 percentage points distance between group 1 and group 3's average, and only a .1 percentage point difference between group 2 and 3's average, group 1's lowest average intensity does seem "most different" among the three groups.[13] Given that group 1 also scored highest in terms of density, their relative differentness in terms of lower average intensity could indicate that they found more or better ways to balance their efforts across the long run, particularly after their intense, dense set of interactions around survey 4. If a lower time/effort value does mean "easier relationships," for instance, perhaps this means they managed to work out some logistical approaches early on that worked well for them, and/or that they built enough rapport or skills in interacting with each other that knowledge sharing became an easier process than what members in other small groups experienced. Considering that the product on which group 1 worked most closely throughout the project very nearly became the whole group's final choice, [14] it seems unlikely that the lower intensity scores simply reflect any kind of "slacking." Indeed, their product was not eliminated until around survey 11 (see again Appendix K), before which both groups evaluating the remaining two contending products were working hard to shore up gaps in preparation for the final face off, and yet intensity values were trending downward even then.

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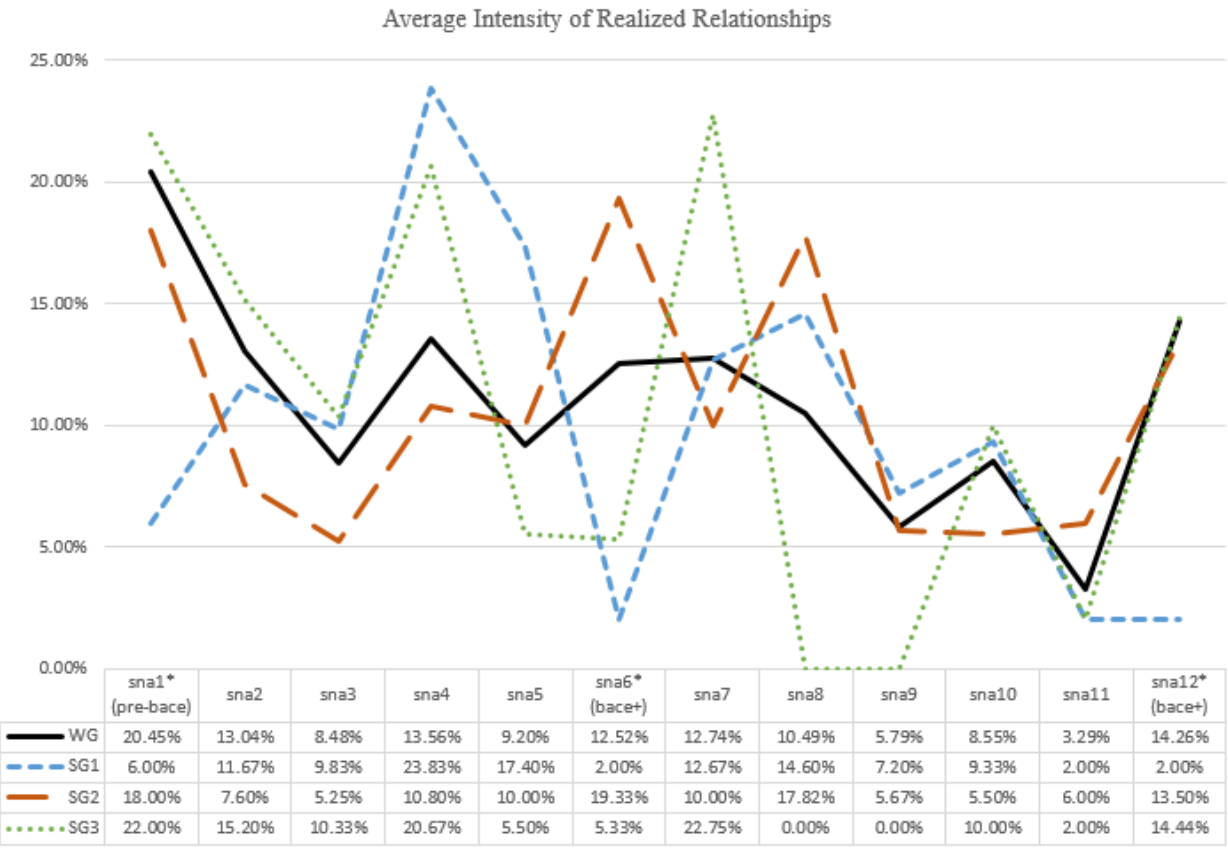
[13] Whether a .91 difference is indeed very small is difficult to say with any certainty. However, with the largest value at 10.79 and the smallest at 9.88, the gaps translate into differences of 8.4% (.91/10.79) and 9.2% (.91/9.88) – perhaps not large but maybe not unworthy of some consideration. By contrast, the .1 gap between groups 2 and 3 represents a difference of only .92% (.1/10.79) to 1.01% (.1/9.88).

[14] As mentioned earlier, group 1's chosen product, Drupal, as built out by group 1, had the most support in the first round of voting.

Perhaps, then, intensity is interesting to the extent that it must be mediated or overcome in order to maintain or increase knowledge sharing relationships not just in isolated cases but over time.

Figure 9: Intensity scores, by small group



	sna1* (pre-bace)	sna2	sna3	sna4	sna5	sna6* (bace+)	sna7	sna8	sna9	sna10	sna11	sna12* (bace+)
WG	20.45%	13.04%	8.48%	13.56%	9.20%	12.52%	12.74%	10.49%	5.79%	8.55%	3.29%	14.26%
SG1	6.00%	11.67%	9.83%	23.83%	17.40%	2.00%	12.67%	14.60%	7.20%	9.33%	2.00%	2.00%
SG2	18.00%	7.60%	5.25%	10.80%	10.00%	19.33%	10.00%	17.82%	5.67%	5.50%	6.00%	13.50%
SG3	22.00%	15.20%	10.33%	20.67%	5.50%	5.33%	22.75%	0.00%	0.00%	10.00%	2.00%	14.44%

As this line of reasoning suggests, there are several possibilities for interpreting these outcomes. For context, it might be interesting to consider any salient differences between the small groups – e.g., their makeup, practices, and experiences – particularly groups 1 and 3, as they seem to represent the most extreme cases. Before finishing this exploration of the data, then, a closer examination of the small groups may be helpful.

Small Group Closeup

As indicated in the earlier narrative, we Bacers had some difficulty bringing our project work from small group confines into a fully opportunistic model (Zhang et al., 2009) where

knowledge sharing could happen at will, as needed, among all participants involved in the project. Instead, the divide and conquer, "in parallel" approach with which we started the project held sway until a product final choice was made. Despite my suggestions that we "mix things up" by reassigning or rotating some people to different small groups, participants were reluctant to leave their group. Some of this sentiment perhaps stemmed from a degree of loyalty to or bonding with other small group members (e.g., participants in group 3 in particular made several comments indicating a somewhat competitive our-group-versus-theirs attitude; other participants spoke of friendship and other forms of attachment to their current group membership). Some reluctance was also due to concerns over potential disruptions in progress or unfairness to individuals who might have to "catch up" on work already done on a given product. In addition, by the latter stages of the project, most small group members were apparently developing a preference for the product on which they had been working and did not want to abandon it or their work on it. For several reasons, then, one's small group remained a core component of the Bace experience. To the extent that outcomes for these groups were identifiably different from each other, to what might these differences be attributed?

Group makeup. One component of the study design, driven by the literature review, was a consideration for what goes into "ideally composed" teams. To that end, I did make some purposeful choices in deciding how to assign participants to small groups. Specifically, I used ratings by self and others across 10 skillset areas, taken from the initial survey, as a rough guide for creating groups with some degree of internal skill diversity or representation in major areas of expertise – particularly in Linux and Web skills, which are somewhat rarer but quite useful for a project like Bace. Figure 10a shows the distribution of skills ratings across the three groups as computed from the survey data.

Figure 10a: Initial skill scores, by small group

	As rated by others, weighted by self rating (max=5)										
	Windows	**MacIntosh**	**Linux**	**Networking**	**Programming / Scripting**	**Visual / Graphics**	**Databases**	**Web**	**Problem Solving**	**Collaboration**	overall avg
SG1											
Part1	1.09	0.00	0.00	0.27	0.00	1.45	0.55	3.27	2.55	3.18	
Part3	2.91	0.18	0.00	1.64	0.55	0.00	0.00	0.55	2.91	1.36	
Part6	0.73	5.00	0.82	1.36	1.82	0.36	0.55	0.18	2.91	2.91	
Part7	0.00	0.00	2.73	0.91	0.00	0.00	0.36	0.00	1.45	0.91	
avg	1.18	1.30	0.89	1.05	0.59	0.45	0.36	1.00	2.45	2.09	1.14
SG2											
Facilitator	--	--	--	--	--	--	--	--	--	--	
Part2	0.27	0.55	2.18	0.36	1.82	0.73	1.09	1.09	2.27	0.18	
Part8	2.27	0.36	0.00	0.91	0.18	0.36	0.00	0.27	2.73	3.18	
Part11	2.55	0.00	0.18	2.55	0.18	0.00	0.09	0.18	3.64	2.18	
avg	1.70	0.30	0.79	1.27	0.73	0.36	0.39	0.52	2.88	1.85	1.08
SG3											
Part4	2.91	0.00	0.55	2.73	0.09	0.00	0.09	0.73	3.64	4.55	
Part5	1.82	0.00	0.09	0.36	0.00	0.00	0.00	0.00	2.27	1.82	
Part9	2.55	2.91	0.27	1.64	1.45	0.18	0.27	0.36	4.09	4.09	
Part10	1.36	0.00	2.27	1.82	3.64	1.09	4.09	3.18	3.64	3.27	
avg	2.16	0.73	0.80	1.64	1.30	0.32	1.11	1.07	3.41	3.43	1.60

Scores in these areas were computed by taking the participant's self-rating on a scale of 1 to 5 (with 5 meaning "very strong") and adjusting / weighting it by the percentage of participants who ranked a given participant as "better than average" in the given skill area. For example, if participant A gave himself a rating of 5 in Linux but only 4 of the 11 participants (~ 36%) ranked participant A as better than average in Linux, his score for Linux would be adjusted to 1.82 (5*(4/11)). If everyone rated a person as better than average in a skill area and that person ranked himself very strong, his score would remain the highest possible 5. This approach may be thought of as correcting an overreliance on self-reporting by incorporating others' opinions while still including the individual's (arguably most accurate) knowledge of self.

In order to reduce my own biases in the assignment process and also to minimize the appearance that I might be critically judging the participants' knowledge, I made it known to the participants that I would not contribute to these rankings and thus did not answer this portion of the survey myself. This made the divisor in the scoring formula 11 instead of 12. I did, however, include myself as a target for others to rank so as not to appear to be shielding myself from being rated like everyone else. Still, without my own self-ratings, the Facilitator scores could not be computed and are therefore excluded from Figure 10a. Given an apparent trend in

others' ratings for me, however, it seemed that these could potentially make an impact in interpreting intergroup differences. Figure 10b therefore includes these scores based on *estimates* (made at the time of this writing) of what my self-ratings would have been at the time of the initial survey. Made so long after the fact, such estimates must be treated cautiously but may still offer additional insight.

Based on Figure 10a, for instance, group 3 looks to be somewhat "more different" than the other groups in terms of overall score: i.e., it is .46 points and .52 points away from the average scores for groups 1 and 2 respectively, while groups 1 and 2 differ from each other by only .06 points. The numbers tell a slightly different story with inclusion of the Facilitator estimates. Group 3 still scores highest on average but now appears most different only from group 1: i.e., group 2's average skills score falls nearly at the midpoint between groups 1 and 3, creating the most noticeable contrast between these latter groups. The difference looks not staggeringly large, but it is potentially interesting in that it corresponds with the contrast noted in these groups' density scores. Perhaps most interesting is that, in both figures, group 3 scored noticeably *higher* in terms of Collaboration skills even as they scored *lowest* in terms of knowledge sharing density. It would seem there is again a potentially unanticipated inverse relationship: one might reasonably expect knowledge sharing relationships to increase with higher skills ratings (e.g., "more skills" equals "more knowledge to share" [15]), particularly when collaboration skills are relatively high. Yet, in this case, the opposite appears to be true. How can this be?

[15] Another possibility is that teams with individuals possessing more knowledge in particular areas creates less "positive interdependence" (Johnson & Johnson, 1992) between team members, less *need* to share knowledge, and therefore promotes less knowledge sharing. I attempted to minimize this effect by distributing participants with strengths in two key areas: Linux and Web.

Figure 10b: Initial skill scores, by small group, with Facilitator estimated

	As rated by others, weighted by self rating (max=5)										
	Windows	**MacIntosh**	**Linux**	**Networking**	**Programming / Scripting**	**Visual / Graphics**	**Databases**	**Web**	**Problem Solving**	**Collaboration**	overall avg
SG1											
Part1	1.09	0.00	0.00	0.27	0.00	1.45	0.55	3.27	2.55	3.18	
Part3	2.91	0.18	0.00	1.64	0.55	0.00	0.00	0.55	2.91	1.36	
Part6	0.73	5.00	0.82	1.36	1.82	0.36	0.55	0.18	2.91	2.91	
Part7	0.00	0.00	2.73	0.91	0.00	0.00	0.36	0.00	1.45	0.91	
avg	1.18	1.30	0.89	1.05	0.59	0.45	0.36	1.00	2.45	2.09	1.14
SG2											
Facilitator	*4.00*	*0.27*	*4.00*	*3.64*	*3.00*	*0.00*	*1.64*	*1.09*	*4.00*	*2.73*	
Part2	0.27	0.55	2.18	0.36	1.82	0.73	1.09	1.09	2.27	0.18	
Part8	2.27	0.36	0.00	0.91	0.18	0.36	0.00	0.27	2.73	3.18	
Part11	2.55	0.00	0.18	2.55	0.18	0.00	0.09	0.18	3.64	2.18	
avg	2.27	0.30	1.59	1.86	1.30	0.27	0.70	0.66	3.16	2.07	1.42
SG3											
Part4	2.91	0.00	0.55	2.73	0.09	0.00	0.09	0.73	3.64	4.55	
Part5	1.82	0.00	0.09	0.36	0.00	0.00	0.00	0.00	2.27	1.82	
Part9	2.55	2.91	0.27	1.64	1.45	0.18	0.27	0.36	4.09	4.09	
Part10	1.36	0.00	2.27	1.82	3.64	1.09	4.09	3.18	3.64	3.27	
avg	2.16	0.73	0.80	1.64	1.30	0.32	1.11	1.07	3.41	3.43	1.60

Facilitator estimates are based on post-hoc self-ratings on the same scale (1 to 5) multiplied by the percentage of participants who rated the Facilitator's skills in a given area as "above average."

The explanation may partly lie in what goes into the scores. What gets counted as collaboration skills, for instance, surely depends on the interpretations of specific participants and also on each participant's familiarity with coworkers' strength in this area, but it is possible that this dimension is influenced by or related to a couple of other factors that could cast a different light on the composition of the groups. The first of these is a preference for working independently. One of the Likert questions in the initial and ending survey asked respondents to rate their agreement with the statement "I prefer to work independently" (1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree). As Bace was a fundamentally collaborative project, I used the responses from the initial survey to spread out the four participants who agreed that they preferred to work independently. Only two participants

disagreed with the statement – not enough to spread across all the groups – and so I opted instead to group these *together* (in group 3), in conjunction with consideration for skillsets, to see if perhaps some concentration of this less common individual preference might manifest a particular impact.

While I did not compute average scores at the time of the assignment, after the fact analysis shows that these choices resulted in group 1's average for this trait falling just slightly above the middle or neutral mark, group 2's average falling closest to a preference for working independently, and group 3's average falling closest to a preference for *not* working independently (see Figure 11). With half their members preferring not to work independently, group 3 might be said to be the most inclined towards collaboration, which could account somewhat for the higher pre-study collaboration score of their group: e.g., their preference to work with others (not independently) may mean they get more practice at collaborating and/or, furthermore, that other participants have seen them working with others and thus ranked them higher in this area.

Given the other outcomes noted so far, however, these observations should also suggest that having members with a collaborative predisposition – at least insofar as this one question taps into it – did not automatically translate into better knowledge sharing at the group level; nor was having members with a strong inclination towards collaboration a necessary precondition for successful knowledge sharing, as even group 2's preference for working independently did not prevent a relatively solid knowledge sharing performance vis-à-vis whole-group levels. Indeed, given group 1's relative neutrality on this point and their higher knowledge sharing density, it is possible that some kind of balanced perspective or flexibility in attitude towards how one works in relation to others was more important than a preference one way or the other.

Figure 11: Preference for working independently[16]

prefer to work independently (2=disagree, 3=neither, 4=agree)														
	SG1					SG2					SG3			
Part1	Part3	Part6	Part7	avg	Facilitator	Part2	Part8	Part11	avg	Part4	Part5	Part9	Part10	avg
3.00	3.00	4.00	3.00	3.25	--	4.00	3.00	4.00	3.67	2.00	2.00	4.00	3.00	2.75

Besides preference for working independently, a second factor that might explain or have influenced initial collaboration scores for members of group 3, as well as knowledge sharing outcomes more generally, is one that I did not very carefully factor into group composition: pre-existing status in the larger IT group. Conceptually, this could consist of somewhat concrete traits like job title or paygrade, or fuzzier components such as authority, influence, or social capital.

Although my experience in the study setting gives me some informal understanding of such factors in that context, no measures were geared towards explicitly gauging them and so any suggestions here must be even more speculative than those already made. Nevertheless, it is perhaps interesting or important to note that small-group makeup seems to have varied somewhat along aspects of this dimension. For instance, while I generally attempted to avoid grouping together participants with official reporting relationships to each other, group 3 did have one such relationship. In addition, as briefly alluded to earlier, both groups 2 and 3 included what might be considered authority figures based on their title of Assistant Director. Such figures tend to be in charge of many activities in the normal, non-Bace work environment, and may thus be or be seen as collaborative in that they coordinate many work-related efforts and thereby interact with many people. Despite the Bace goal of all participants having an equal voice during the

[16] I answered only the SNA section of the survey, and thus did not respond to this particular question. However, despite being the author of this rather pro-collaboration paper, I probably would have answered 4 – an agreement that I tend to prefer working independently, particularly at the beginning of the study. If counted, this would raise small group 2's average preference towards independent work from 3.67 to 3.75.

project, it is possible that these differences introduced a dimension of power or deference, or maybe just interactional habit, into small-group dynamics in some cases. (This, for example, could account for – or is at least consistent with – earlier mentions of efforts seeming to stall when the usual leaders held back for some reason.)

The fact that group 1 had no such members while group 3 had two (half the group), as well as an official reporting relationship, seems like a potentially notable mention: the group that was most homogeneous in terms of this status element engaged in the most knowledge sharing while the group that was most mixed engaged in the least. Group 2 had only one such member and was middle of the pack in terms of knowledge sharing density. The small numbers of participants involved (*n*) mean this seeming correspondence could simply be coincidental, due largely to the specifics of individual personalities or other hard-to-summarize vagaries, but it hints at the possibility that knowledge sharing is more likely to occur within groups where differences in pre-existing power, influence, or status are minimal – where members are on more even footing from a hierarchical, organizational, or "social location" point of view.

Mirroring this apparent pattern is a potentially interesting trend across the small groups in terms of their average years of service to the university (YOSU) overall versus average years of service to our particular IT unit (YOSI): group 1 had the highest YOSU but the lowest YOSI, while group 3 had the highest YOSI and the lowest YOSU. In other words, group 1 had the most experience at the university but significantly less experience in our particular IT unit compared to group 3. (YOSU for groups 1, 2, and 3 respectively were 15.5, 12.67, and 10.25. YOSI values were 7.0, 8.67, and 9.5.[17]) Perhaps having less influence or authority vis-à-vis not just job title

[17] It should be noted that group 2's middle-of-the-pack status is made less stark when including the Facilitator's years of service values in the YOSI score: doing so increases group 2's YOSI score from 8.67 to 10.25, making group 2's YOSI highest. This does not change the relationship between the YOSI values of groups 1 and 3, however: group 3's YOSI value is still about 36% higher than group 1's.

but also *seniority* in the group, or maybe being experienced but less steeped or stuck in our IT unit's pre-existing patterns, somehow made a difference in group 1's tendency to share knowledge more widely amongst its group members. One overall lesson in this case, however, may be that attempts to foster knowledge sharing would do well to remain sensitive to such elements rather than trusting too much in obvious or traditional predictors of success such as tenure in the group or even the apparent collaborative skills of specific individuals.

Group compositional traits like these are social structural factors in that they do potentially organize or influence patterns of interaction. Like other structural factors, they are also "social facts" – characteristics of the social environment that are not readily amenable to the direct influence of single individuals (even though understanding or at least awareness of their existence may help those attempting to engineer better knowledge sharing). But were there other, perhaps more purposeful or dynamically evolving structural elements – e.g., interactional strategies, tendencies, or practices in which the groups engaged differently – that were important? And what of cultural elements: did the groups make meaning in different ways or adopt different values?

Unfortunately, there are perhaps fewer data that speak clearly to these questions because such elements would have transpired within the confines of small groups in ways that I could not always observe. As suggested earlier, the group logs were intended to shine light on these kinds of questions but were not as robust as initially anticipated. Yet between those logs and the individual journal submissions (and a little help from Slack entries), read with small group membership as the backdrop, some potential themes do stand out (see Appendix O for excepts supporting the following observations).

Structural dynamics. There was probably a number of subtle habits and practices that differed between the groups, but those that were most salient among the available data concern interaction format and/or venue. While all three groups interacted both face-to-face and electronically, there appears to be some differences in the extent to which each group relied on these formats, especially for their weekly small group "meeting."

Group 1, for instance, appears to have favored meeting in-person over electronic channels. As teased out of the group logs, they met via a Google Hangouts video chat on at least three occasions. However, comments about these occasions highlight the difficulties involved in trying to meet electronically, particularly when they needed to work on a technical problem. For solving difficult technical problems (they mentioned again at least three different occasions), they liked the experience of meeting in a computer lab where they could interact with each other and the problem unencumbered by communication difficulties. For general discussions, they also met over lunch on at least three occasions and otherwise face-to-face on two other occasions. It is possible that not every meeting is captured in the data, and surely many ongoing communications that did not quite constitute a meeting were by necessity conducted electronically. However, that said, the estimated distribution of face-to-face meetings versus electronic meetings was 8 to 3.

In the matter of physical versus virtual meetings, group 2 (my group) again appears to have been "middle of the road." Taking a cue from group 1, we did meet in a lab setting one time and thought the experience was productive and "fun." Otherwise our face-to-face encounters consisted of meeting over lunch to engage in general discussion and planning. On at least five occasions we used Google Hangouts to meet. We generally found this mechanism to work best for demonstrations and other one-to-many kinds of interactions, but sometimes we

really did just "hang out" and discuss issues, plans, or other next steps. One week's meeting around Spring Break was dubbed asynchronous, where we "traded Slack messages, notes on the Forum, and spent some one-on-one time where we could." In other words, we did not formally meet that week, although we did interact. Group 2's estimated distribution of face-to-face versus electronic meetings was an even split: 6 to 6.

Group 3's engagement of these mechanisms is harder to discern but they appear to have relied more heavily on electronic channels than the other groups. As one group 3 member retrospectively put it, "We met mostly electronically through an online meeting but a few times in person over lunch meetings." Minimal details about physical meeting venues were included in public communications. Given the frequent citing of time conflicts and other scheduling difficulties, it seems likely that this group most often met through virtual means. They were, for instance, early proponents of Slack and may have relied on that tool's private channels or direct messages (both publicly invisible) to conduct most of their interactions either synchronously or asynchronously. This deduction is corroborated by a journal entry made by one group 3 member: "Most of our interactions are now quick exchanges via slack (still mostly in the private channel, not sure why)…." Thus, the distribution of face-to-face versus electronic meetings is not computable in the same way as the others'. However, assuming that "a few" lunch meetings means three – there were indeed exactly three entries in their group logs labeled as "meetings" – and assuming the other groups' meeting frequency applies, it might be estimated at 3 to 8 or 3 to 9 – the inverse of group 1's 8 to 3 ratio.

This line of thought prompts a couple of additional observations. First, small groups were instructed to meet weekly for at least an hour whenever possible. The fact that none of the groups mentions meeting more than 11 or 12 times in a 24-week study may therefore seem

curious. Recall, however, that whole group meetings were also happening every other week. It seems that this schedule did impinge on the small groups' ability or willingness to meet on their own. However, it also highlights the likelihood that many interactions happened outside of the "meeting" rubric: i.e., to some extent, all the groups probably relied on asynchronous or ad hoc communications in order to keep the project moving forward. However, second, even given this reality it seems important to note that there does seem to be a correspondence in the data between meeting face-to-face and knowledge sharing: at 73% of their meetings, group 1 relied on in-person meetings the most and engaged in the most knowledge sharing while group 3 relied on it the least (27% of their meetings) and engaged in the least knowledge sharing, at least as measured here.

Cultural emergence. Recall that Figure 2 shows some metrics regarding participation in the group forums that constituted the group logs. One thing that is not explicitly included in that figure is the ratio of responses to initial posts. Numerically speaking, higher ratios would indicate more responses, or perhaps more "responsiveness," per initial post for a given topic. [18] Again, the numbers involved are small and thus inconclusive, but this ratio is somewhat interesting in that it follows a now-familiar trend across the groups: for groups 1, 2, and 3 respectively, the ratios were 1.57, 0.69, and 0.25. Thus, while group 1's more robust use of this mechanism suggests a greater degree of engagement of some kind (at the very least, more willingness to use the assigned tool for submitting group logs), it also suggests a degree of willingness to engage in two-way communication or *dialog* in this venue. The distributions of initial entries per group member (5, 2, 3, and 4 in group 1; versus 8, 1, 2, and 2 in group 2; versus 5, 2, 0, and 1 in group 3 – see again Figure 2) furthermore suggest that group 1 favored a

[18] The ratio was computed by dividing the total count of initial posts (top level entries) in a group's forum by its total count of responses (nested entries).

relatively *fair division of labor*, a more evenly distributed shouldering of this particular responsibility. The content of group 1's log entries often reflected this value: e.g., most entries lay out exactly who did what in their evaluation efforts, suggesting that sharing the load, giving credit, and *inclusion* of all group members were relatively important values held by the group. By posting this level of detail to the public forums where the other groups could see, group 1 also demonstrated a willingness to engage in cross-group *transparency*, which stands out even more when considered in contrast to group 3's tendency to favor non-public communication channels. Interesting mentions include use of the word "fun" to characterize at least one meeting and it being "nice" or "enjoyable" to interact with group mates.

Knowing all of the participants, I suspect that the members of group 3 would not disparage or necessarily disagree with these values, but their interactions appear to have emphasized somewhat different guiding principles as most significant or meaningful. Whereas much of the data from group 1 members highlighted aspects of the interactions between group members, group 3 data focused mostly on the products under consideration: their strengths and weaknesses, work still needing to be done on them, questions about functionality yet to be answered, etcetera. That is, while group 1's processes and commentary were relatively people-centric, group 3's appears to have been more heavily *process-centric*: somewhat sparse but focused on project activities and less so on who was doing them, perhaps coinciding with uneven workloads in some cases. There was also an emphasis on *efficiency*, as highlighted by concerns over disruptions to project efforts caused by time conflicts, neglection of duties, personal traits or challenges that needed to be overcome or improved upon in order to meet project goals. Stances on their particular product of choice were defended in terms of "superiority" or *effectiveness* in complementing the workflow and addressing the challenges and needs of the larger IT group.

Such commentary, sprinkled through various communications, also exhibited some *competitiveness* vis-à-vis other groups' products and contributions to the overall effort. In sum, group 3 seemed to focus most on being best and on finding the best solution. Indeed, their emphasis on *practicality* contributed greatly to a practical outcome: it was group 3's product of choice that was ultimately selected as the most optimal solution to the problem we Bacers were trying to solve.

Group 2's cultural style is not as easily distilled. While neither group 1 nor group 3 was culturally pure or exclusive of the values emphasized by the other, group 2's style might be best characterized as a slightly people-centric hybrid of the elements emphasized by the other groups. Such hybridization may be due in part to the Facilitator's presence in the group: i.e., as Facilitator, I was purposefully attempting, perhaps more than my group mates, to stay informed of the other groups' activities and may have been influenced by their attitudes and approaches – an impact which I perhaps then carried to my own small group to varying degrees. As researcher, I also had a vested interest in balancing viewpoints and exploring different arrangements as well as staying attuned to the "big picture," all which may have combined with my group mates' own inclinations. Thus, in the group 2 data, there is often mention of people-oriented factors such as who did what, attributions of credit for particular achievements, strategies for *dividing labor fairly*, etcetera. Our forum entries, having started as a joint Google doc that flowed directly from our interactive meetings, do not reflect a lot of responsiveness per se but do contain sections of commentary from each group member, which highlights the importance of *equal input* and as well as *transparency* for the benefit of the other groups. Additionally, there was talk of *friendship* and *fun* as key benefits to the Bace experience, as well as the potential personal and social risks of expressing opinions that differ from others' views.

Yet, group 2 also focused to a significant degree on optimizing our view of possible solutions by evaluating multiple products (group 2 evaluated more products than either groups 1 or 3), *being thorough* (e.g., we submitted the longest log entries by far), analyzing our meeting strategies after-the-fact for *effectiveness*, *efficiency,* and *task-appropriateness*, and considering the pragmatic requirements of securing buy-in from the larger IT group.

Just as most social scientists would agree that no culture is innately better than any other, the cultural styles of the three small groups also cannot be ranked in terms of their inherent value. However, it is a different question to ask whether a particular style better promotes collaborative knowledge sharing, and it is perhaps still another to ask what *other* outcomes different styles promote: to the extent that any conclusions can be drawn from the above analysis, it may be important to note that knowledge sharing and practical achievements are not necessarily one and the same thing. For instance, while it does appear that people-centric values corresponded with more knowledge sharing in the Bace project, process- or efficiency-centric ones likely contributed significantly to group 3's pragmatic success in identifying and championing the chosen solution. Does that mean that knowledge sharing and, by extension, group 1's cultural style were unimportant to achieving the project goal? If group 2's "middle of the pack" performance in knowledge sharing and early elimination of its most deeply investigated product coincide with a hybrid cultural style, does that further suggest that diluting a practical, efficiency-minded outlook with people-centric concerns detracts from practical achievement, or that knowledge sharing must come at the expense of efficiency and practicality?

The reader may draw her own conclusions, but the relationships are probably more complex than these questions imply. For one thing, the measurements employed here are surely imperfect in both design and execution: even if they perfectly captured what they were designed

to capture (an especially difficult task in situ), they can still only tap into limited aspects of the phenomenon of interest. It may be, for instance, that some *types* of knowledge sharing lend themselves better to achieving particular types of goals, that knowledge sharing as a practice can be done with more or less depth or *skill*, which could change with experience, and that the dynamics of knowledge sharing may vary with other factors such as time, pressure, resources, and other constraints. All of these possibilities may have gone unnoticed or understated in the collection and analysis of the data. If these could be factored in, for instance, various styles might illustrate a variety of benefits in different scenarios. It does seem somewhat less than coincidental, however, that the difficulties expressed in the earlier narrative – our seemingly constant struggle to balance democracy and efficiency, to build relationships into and around business-driven structures, to address human elements in addition to practical concerns – are personified so neatly as differences between these small group portraits. Perhaps they may serve as useful guides, not necessarily as end states to strive for but as illustrations of the types of forces that can impact the development of knowledge sharing community and *other* desirable outcomes.

Chapter 5: Discussion

Given that the previous chapter was something of a tortuous journey[19] that co-mingled presentation of the data with narrative and interpretation, it seems prudent to recap, summarize, and perhaps add to some of the key points made along the way. Doing so may serve the dual purposes of highlighting potential take-aways for practitioners interested in fostering knowledge sharing in their own environments as well as explicating directions for future research – one of the stated benefits of design-based research. Such summary, done within the framework of embodied conjecture at the center of this study, will also help to gauge how well this model held up against empirical reality (see again Appendix G). To the extent that it performed well, it might be used as a kind of starting point or blueprint for practitioners while offering researchers hints into which relationships to investigate in greater depth or under more classically controlled conditions; to the extent that it failed in its predictions, it might suggest areas for scholarly practitioners to avoid, downplay, or otherwise approach differently, ultimately adding to productive outcomes and thus possibly greater theoretical understanding of the core components of robust knowledge sharing communities.

What, then, are these key points and how do they relate to the problem of practice that started this endeavor? How, furthermore, did the embodied conjecture perform as a predictive model?

Recap

To summarize, the last chapter started with a look into the Bace experience as told from my participant observer perspective. There I tried to highlight the various tensions and constraints the participants experienced throughout the project. As a purely voluntary effort

[19] Tortuous but hopefully not too *torturous*.

done around and between ongoing job requirements, success in the Bace project required exploiting the natural rhythms of our environment. Along the way, all together or within in our small groups, we learned various lessons about the timing, frequency, and format of meetings. For solving nitty-gritty technical problems, for instance, some of us found that meeting in a lab worked best. Others thought that electronic meetings sufficed and saved logistical effort, particularly for one-to-many demonstrations or light discussions among a handful of people. Whole group meetings pre-scheduled for every other week, particularly mid-week, seemed to be a good skeleton for keeping participants engaged while allowing the small groups some ad-hoc, if logistically burdensome, flexibility to do the core evaluative work – though the fact that small groups did not often meet in the weeks of whole-group meetings suggests there may be call for some adjustment there. As an overarching organizer, the idea of problem-solving inherent to the PBL framework seemed to resonate with the participants. It allowed me as facilitator to somewhat naturally introduce the research component to these problem-solving ITPs and even leverage it to realize opportunities for reflection, communication, and meaning-making.

We Bacers did struggle, however. For example, the ideals of distributed leadership and equal input that stemmed from notions of collective responsibility and the voluntary nature of the project were often at odds with our desire to progress efficiently. Attending to collaborative relationships *and* remaining efficient within the broader realities of the environment proved to be difficult to achieve and sustain solely through individuals' above-and-beyond voluntary efforts. Within the small groups, some of these tensions manifested different outcomes, and it is these differences that offer the best insights into the structural and cultural factors that promote knowledge sharing in the study context.

To recall the specifics, the most distinct differences emerged between small groups 1 and 3. Group 1 maintained the highest density of knowledge sharing relationships and showed notable increases in knowledge scores. The pattern in group 1's intensity scores also suggests that they perhaps found ways to hone their skills over time and collaborate with less effort. By contrast, while it was ultimately group 3's product-of-choice that became the whole group's chosen solution, group 3 showed the lowest density of knowledge sharing relationships and fewer significant increases in knowledge scores.

At the same time, the groups showed noticeable differences in several other ways. For instance, group 1 relied most heavily on face-to-face interactions, communicated transparently through public channels, and appeared responsive and willing to engage in dialog, share workloads, and attribute credit to individual group members for their efforts. By contrast, group 3 relied most heavily on electronic interactions, communicated opaquely more often through private channels, emphasized efficiency and superiority, and indicated less attention to shared load and individual contributions in favor of attending to outstanding practical matters and next steps. Dubbing these contrasting structural-cultural styles people-centrism versus process-centrism, I thus suggested that a people-centric style is more closely associated with knowledge sharing and its potential benefit in knowledge gains even though being process-oriented still offers obvious practical benefits. Given that groups 1 and 3 differed in terms of seniority in our IT unit, stated preference for working independently, and members' relative authority, influence, or status within the group, I furthermore suggested that these factors may contribute to the dynamics influencing the emergence of such styles. More specifically, relative homogeneity in status complemented by a mix of critical skills may be better predictors of a group's

collaborative knowledge sharing success than common sense assumptions regarding more seniority or a clear preference for working collaboratively.

The primary components of the Bace design experiment were implemented to directly challenge the barriers to collaborative knowledge sharing identified early in this paper. While our IT group has traditionally been geographically and mentally divided, Bacers focused on coming together to work on a common problem. While the larger group has long valued self-sufficiency, Bacers sought to elevate the value of input and rely more heavily on each other. While learning from and with each other has traditionally been treated as expendable and secondary, Bacers made its more robust achievement a primary goal, both for ourselves and our colleagues. And although the demands on our IT group continue to increase our ranks and responsibilities, we Bacers sought to reaffirm our connections to one another as ITPs and as whole people. The contrasts and struggles outlined above highlight the incomplete nature of the success, but the lessons of our experience, accomplishments in knowledge sharing and increases in knowledge scores, and the continuing presence of Grokbox and Slack as tools available to the entire IT group indicate that the efforts were fruitful nonetheless.

With this summary in mind, then, how did the embodied conjecture at the center of the study fare?

Intervention Outcomes

The simplest point to consider may very well be the ultimate outcomes of the design experiment, the last boxes in the embodied conjecture (EC). I started the previous chapter by essentially calling Bace a qualified success story, and I have echoed these sentiments in the summary above. It was qualified in the sense that the whole group never fully achieved the kind of opportunistic collaboration demonstrated in the now much-cited Zhang et al. (2009) piece, and

much of the observed changes in knowledge sharing averaged out at the whole group level. To be sure, some degree of whole group success is indicated by an increase in relationship density and average knowledge scores from pre- to post-study, and the very existence of our multifaceted online knowledge sharing system – Grokbox, in which the number of articles is still increasing, and Slack, which has become an integral collaborative mechanism in our everyday work lives – is testament to the reification and greater accessibility of the collective knowledge of Bacers and now our colleagues from the larger IT group as well. Yet, our struggles and varying knowledge-related outcomes highlight that our success was not unfettered. Thus, collaborative knowledge sharing did become more regular and normal but not uniformly so – not during the Bace experience itself, at least. This is somewhat unsurprising: it seems unlikely that a 6-month intervention would completely change in so short a time structural and cultural factors that have evolved over years. Yet the project was successful in several ways, and the extent to which our Bace-initiated efforts will flourish and take root among all Bacers as well as members of the larger group is still unfolding.

Intermediate Outcomes

The connections between the middle portions of the EC are where many of the most interesting details and remaining questions lie, and these ultimately determine the extent to which the intervention design worked. Still working backwards, then, the EC next shows a variety of intervening factors or variables that represent the inner gears of the heretofore "black box" containing the so-called secrets of successful collaborative relationship building at the heart of knowledge sharing community.

The "increase in perceived value of collaboration" seems a somewhat easy point to address. For example, the block quotes near the beginning of the previous chapter illustrating

"collaborative sensibilities" indicate an overall positive attitude about the collaborative experience we called Bace. In addition, although participation rates varied, the fact that no one walked away from the project mid-stream but instead persisted in the face of numerous challenges, time conflicts, and additional workload also suggests a level of commitment that likely stems from a growing appreciation for the project's collaborative goals.

On the other hand, the importance of a "Growing awareness of others' knowledge and role of one's own knowledge" is questionable, although some re-evaluation of knowledge did seem to occur. For instance, besides suggesting changes in actual knowledge, the increases in knowledge scores could indicate a change in this "knowledge of knowledge" factor, even possibly including a better understanding or evaluation of one's own knowledge and how it complements the knowledge of others in the group. That is, the scores might have increased in part because participants got to better know the strengths of their colleagues and adjusted them accordingly. However, as a theme, this topic did not surface very often. When specifically prompted about it, for instance, one participant said, "I'm not sure I've discovered that anyone has skills and knowledge that I wasn't aware of." Another said, "I feel like I came into this project with a pretty good understanding of where others were technically, so I haven't felt I've learned anything new about other group member's knowledge yet." Furthermore, despite my encouragement to include a kind of knowledge Profiles component in our online system – a somewhat formalized directory of who knows what – that never came to fruition. Perhaps this element would be more significant among participants who have not worked together for so many years, but among Bacers it seems to have been relatively unimportant.

The next two composites – "rapport; sense of connectedness or 'team-ness'; feelings that one's input matters" and "honing of collaborative skills and mechanisms" – appear to be among

the most critical components in the model. In their abstract form, they perhaps do not add all that much to a precise understanding of the black box. However, placed in the context of structural factors such as face-to-face versus virtual meeting formats, or cultural factors such as values that are predominantly people- versus process-centric, they begin to gain more clarity. In retrospect, their importance seems almost obvious: as fostering the growth of *community* around the practice of collaborative knowledge *sharing* is a fundamentally social endeavor, indeed literally measured in this case in terms of *relationships*, it only makes sense that elements like comfort and skill in interacting are at the center of things. Given the possible importance of relative social statuses in a group, I would also suggest that power, authority, and influence are also important ingredients that may in some ways mediate these elements.

Here the two key findings – that face-to-face interaction and people-centric values corresponded most with knowledge sharing relationships – may be especially important to IT people, as our profession so often demands that we focus on all things virtual, and on processes that create and even *define* efficiency in the workplace. In a way, enabling of such efficiencies and effectiveness via electronic mechanisms is the very definition of our roles, the reason we are employed. Yet, to the extent that we value or need collaborative knowledge sharing to meet the challenges we face, it appears that we cannot escape the fact that we must nurture our connections to each other if we wish to maximize our success. Just as an operating system needs a bit of outside help to bootstrap itself into operation, we IT people cannot rely solely on technology to be great technologists. If the natural pressures of our jobs pull us away from collaboration, we need to make a concerted effort to focus more intentionally on them. However, these efforts cannot be left up to individuals alone: their greatest chance of success

lies not in swimming upstream against these forces but in implementing structural and cultural supports that make the currents easier to navigate.

Perhaps a critical distinction to make here is that there is indeed a conceptual and possibly empirical difference between knowledge sharing and the achievement of other outcomes. In this, an educational study, one of those outcomes may indeed involve acquisition of knowledge and understanding, and yet even that topic was somewhat secondary to uncovering the social foundations of better collaboration. For IT people, practical outcomes such as getting something to work or finishing a project by a deadline are also important outcomes that can compete with the logically separate goal of working more collaboratively. Given the premises underlying papers like this one and the assumptions of collaborative learning schools of thought in general, we might not expect such outcomes to be at odds, but they very well may be – especially at first. The cost of working in a collaborative fashion can indeed be high; sometimes it may simply be easier, more effective or efficient, or at least more expedient, to move ahead independently. Indeed, carrying inclusion and equal input to something of an extreme – what I earlier called democratic inefficiency – bogged us Bacers down quite a lot during our efforts to choose a product on which to build our knowledge sharing system. An executive decision would surely have kept things moving where they otherwise stalled. Moreover, it was often too costly in time for Bacers to meet in person during the project. Insisting that all interactions happen face-to-face would have greatly diminished progress toward our technological goals.

However, we should not confuse the startup costs of moving to a more collaborative model with its true, ongoing costs, and we should also not confuse short term or expedient outcomes with long term or quality outcomes. As was mentioned in the context of intensity values earlier, for instance, it could be that costs in time and effort are higher during the earlier

phases of knowledge sharing efforts. As people hone their interactional skills, learn how to include others as a matter of habit, come to derive meaning and even comfort from human elements like remaining connected to one another as whole people, and learn to exploit the natural opportunities presented by the rhythms and resources of their environment, these costs may diminish while leaving in place a vaster array of input and talent with which to achieve desirable, higher quality outcomes. In short, knowledge sharing can ultimately lead to better outcomes in multiple arenas even if it does not do so immediately. It may just require an upfront investment of extra time and effort.

Intervention Design

Stepping backwards in the EC one more time brings the focus to the intervention elements themselves, and ultimately to the research questions and the very problem that started this endeavor. The four major barriers to collaborative knowledge sharing that I listed early in this document take on a somewhat different pallor when viewed through the lens of the above analysis. For instance, our IT group's strategies for dividing employees into separate areas, our admiration of self-sufficiency, the supremacy of productivity over connectivity through learning with others, and the ongoing changes in organizational structure that further dilute our connections to one another, all appear to be manifestations of the basic dialectical tension between people-centric versus process-centric social forces. More specifically, these barriers are all process-centric: focused on addressing practical needs in the most efficient ways possible.

In this light, the components listed as structural and cultural supports more clearly look like people-centric ones. Group goals, face-to-face interactions, and transparent communication are all elements that emphasize things like reliance on and inclusion of others, whole-person interactions, willingness to engage in dialog, and an undergirding trust that others will see their

colleagues as equally uninformed rather than deficient. Ongoing exposure or voicing of people-centric values through discussion, "prompts," or other devices help to make these values outwardly known or socially real, and then are again reinforced through interactions that call upon behavioral traits consistent with such values. Thus, structure and culture reinforce one another.

Stated more simply, the research questions essentially ask what kinds of structural and cultural factors promote collaborative knowledge sharing. Based on the preceding line of reasoning, my educated guess can only be this: people-centric ones. That is the theory, at least, but it appears to have been borne out at least in part in the Bace experience. The realities of modern organizational life surely prevent the wholesale adoption of people-centrism, so does that mean it is pointless to think in these terms? The broader implication, I think, is not to cast the possibilities in terms of all or nothing but rather to continue being sensitive to and offsetting the extremes where and when they arise.

Suggestions for Further Research

I posed or implied several questions throughout the previous chapter, and I may also have raised a few here. As an exploratory study, my efforts could not focus as precisely or as in depth as a more advanced or targeted study might. Thus, there are surely ways in which the ideas presented here can be expanded or improved. Some possibilities are as follows.

a) What would a Bace 2.0 look like? If honing of collaborative skills and rapport with others were indeed the most significant intermediate outcomes, in what ways might the intervention design be changed to more directly target these? Would it make sense, for instance, to engage participants in more formal interactional training instead of relying on open-ended problem-solving challenges to help participants improve their interactions with one another?

Would team building exercises be well received or off-putting? The PBL framework afforded several opportunities to fit the designed intervention somewhat naturally into the work life of these participants. However, are there any other approaches that might work as well or better – possibly ones that could be done repeatedly or in a shorter time frame?

b) What is the relationship between knowledge sharing density and intensity of interactions? Would clarifying the meaning or role of effort offer any insight into the mechanics of building better collaborative knowledge sharing relationships? Does more effort indicate more commitment or less collaborative skill? The answers might suggest whether this factor could help to gauge the state or stage of knowledge sharing development in any given environment and possibly offer ideas for more effective intervention.

c) In attempts to foster knowledge sharing, what is the role of perceptions of structural or cultural factors versus the impact of the realities that may differ from those perceptions? For example, does actual efficiency or equality change the possibilities for knowledge sharing, or do they only matter as ideals? Changing realities versus changing perceptions have different implications for possible intervention strategies.

d) If collaborative knowledge sharing does not necessarily have an impact on individual learning, how might attempts to foster knowledge sharing be adapted to promote the most learning? In what ways can individuals get better at sharing knowledge so as to maximize peer learning?

e) Are different types of knowledge sharing worth fostering in favor of others? Are some types better for achieving different outcomes? For instance, Bace highlighted possibilities for knowledge sharing of various kinds. In addition to technical knowledge, other types might

include organizational wisdom or insight, professional understanding of strategy and risk, knowledge of interactional or political dynamics, etcetera.

The possibilities are many. I hope my efforts here have contributed positively to the endeavor of understanding and promoting knowledge sharing community.

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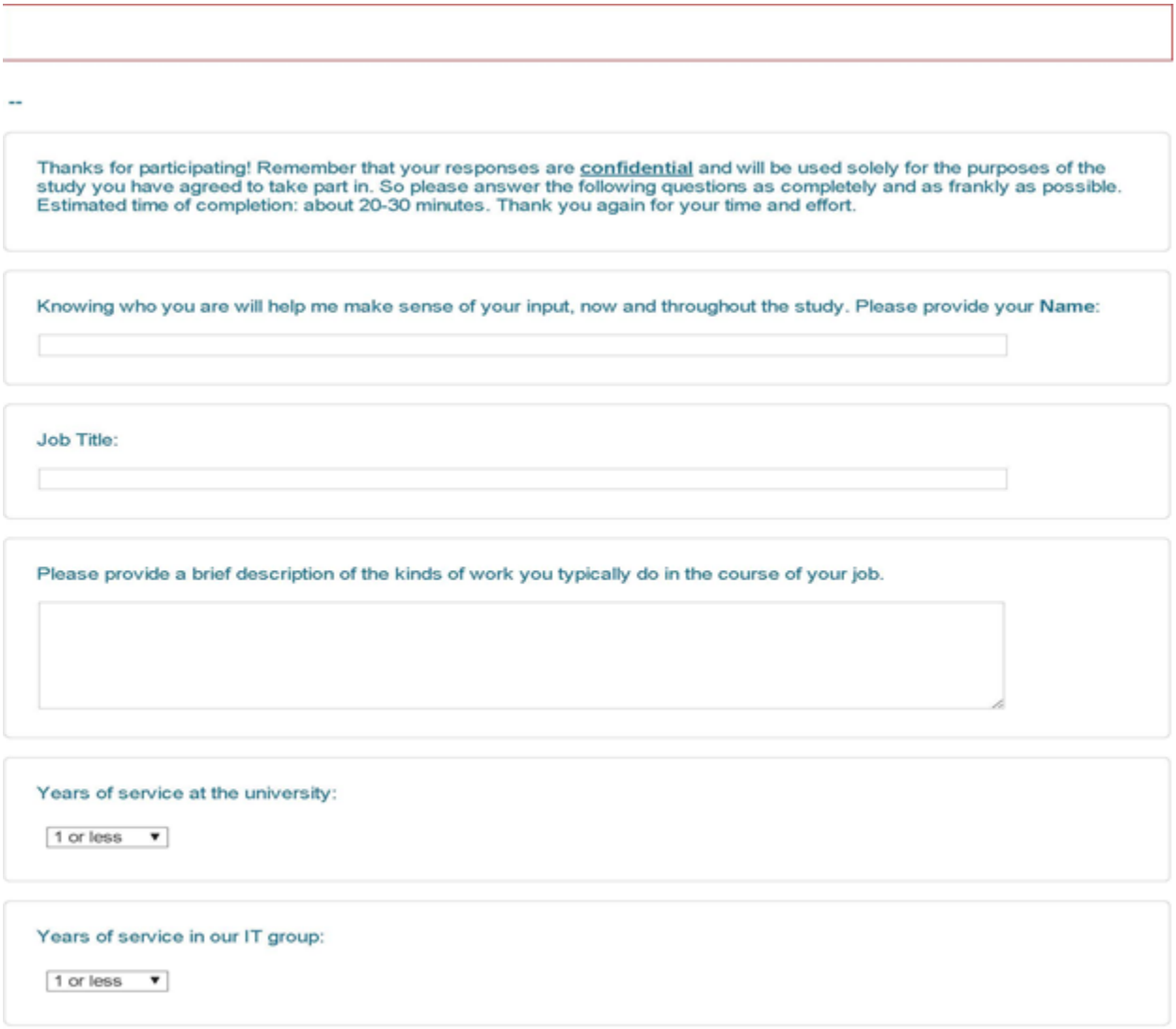
Appendix A

Initial / Ending Survey

This survey, designed to capture a variety of relevant closed- and open-ended responses, was administered at the beginning and end of the study (with minor modifications). This view retains most, though not all, of the formatting as participants saw it in the Qualtrics survey response interface.



It's impossible for anyone to know everything, but sometimes knowing others' strong suits helps people get the input they need. To help me understand how familiar you are with other people's expertise, please indicate the people that you think have **better-than-average** knowledge / skills in each of the **10** categories shown. Note that you may select multiple people per skill area.

	Facilitator	Part1	Part2	Part3	Part4	Part5	Part6	Part7	Part8	Part9	Part10	Part11
Windows administration	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Macintosh administration	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Linux administration	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Network troubleshooting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Programming / scripting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Visual layout, graphics creation / editing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SQL / databases	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
HTML / CSS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Technical problem solving	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Collaboration / working with others	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

On a scale of 1 to 5, how do you rate the strength of your own knowledge / skills in each of these areas? (5=very strong)

	1	2	3	4	5
Windows administration	○	○	○	○	○
Macintosh administration	○	○	○	○	○
Linux administration	○	○	○	○	○
Network troubleshooting	○	○	○	○	○
Programming / scripting	○	○	○	○	○
Visual layout, graphics creation / editing	○	○	○	○	○
SQL / databases	○	○	○	○	○
HTML / CSS	○	○	○	○	○
Technical problem solving	○	○	○	○	○
Collaboration / working with others	○	○	○	○	○

Are there other areas you are good at, or particular areas where you'd like to learn more? Elaborate as much as you'd like.

Please indicate how much you disagree or agree with the following statements about our IT group and/or your experiences as a member of this group.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
We work well together.	○	○	○	○	○
We communicate well.	○	○	○	○	○
The way we do things makes it easy to work together.	○	○	○	○	○
Interactions are usually comfortable and tension-free.	○	○	○	○	○
I am "in the know" about most important events and happenings in our group.	○	○	○	○	○
Most of us work independently most of the time.	○	○	○	○	○
We should work together regularly.	○	○	○	○	○
	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
We work together enough.	○	○	○	○	○
We should exchange knowledge regularly.	○	○	○	○	○
We share knowledge with each other enough.	○	○	○	○	○
The way we do things makes it easy to share knowledge with each other.	○	○	○	○	○
We have enough opportunities to work together and/or share knowledge.	○	○	○	○	○
We know each other well enough.	○	○	○	○	○
I prefer to work independently.	○	○	○	○	○
	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I feel like I am part of a team.	○	○	○	○	○
I know who to ask for technical advice on most issues.	○	○	○	○	○
I seek technical input from others in the group when I need it.	○	○	○	○	○
I worry about what others will think if I ask for input.	○	○	○	○	○
Others in the group know what my technical strengths are.	○	○	○	○	○
My technical input matters to others in the group.	○	○	○	○	○
I would like to contribute my input and insights more frequently.	○	○	○	○	○
	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Others in the group ask me for my technical input.	○	○	○	○	○

I can rely on others in the group to help me solve problems.	○	○	○	○	○
Others are OK with me asking them questions or seeking their advice.	○	○	○	○	○
Others will judge me negatively if they think I don't know something.	○	○	○	○	○
I like to share my technical knowledge with others in the group.	○	○	○	○	○

Collaboration can be seen as the process of people solving problems together, through combined efforts or in a joint fashion. Knowledge sharing can be seen as part of the collaborative process – where people explain what they know in order to help others solve problems or meet objectives.

With these ideas in mind, please respond to the following questions regarding our IT group and your experiences within it. Use as many words as you need. The details of your experiences are important! Wherever possible, please use examples from your experience to clarify what you mean.

Think for a moment about the kinds of work we typically do and the standards we try to meet. To what extent do you think we should or need to engage in collaboration and knowledge sharing with each other? Do you see any particular pros or cons to sharing knowledge or working collaboratively?

In your experience, how good or bad are we at collaboration and knowledge sharing now? Why do you think that's the case?

From your point of view, are there particular factors that help or hinder us in collaborating and sharing knowledge with each other? What things, if any, have helped or hindered you from collaborating or sharing knowledge with others?

What changes, if any, would you make to the way we do things in order to improve our ability to collaborate and share knowledge with each other? How could technology help or hurt? How could non-technological factors help or hurt?

You know what it's like working in our group day to day. If you were designing an online knowledge sharing system for our group to use, what kinds of features (broadly speaking) would you want it to have and why? For instance, would you want it have a searchable database where technical notes could be stored, built-in mechanisms for communicating with others in the group, etc.? What else? What should it *not* be like?

Appendix B

Subgroup Log Template

For the weekly subgroup log entries, participants were advised to include elements such as the following:

- Issues investigated
- Technical challenges solved
- How tasks were divided (e.g., whether they were done together or by individuals and why)
- Channels through which the group interacted (e.g., email, instant messaging, sms, phone, face-to-face, etcetera)
- Interactional channel that worked best
- Interactional channels that worked least well
- Barriers to progress, things that helped
- Plans / next steps
- Any other comments or observations

Appendix C

Prompts for Individual Journal Entries

The 10 journal entries (JEs) were an opportunity for participants to think about and share their own experiences independently of other participants. The following prompts were a means of providing some direction to these reflections. One prompt set was provided roughly every two weeks in the order shown below.

JE1

We are still in the early stages, but take some time to think about your experiences as part of this project / study in these first two weeks. Comment on anything that seems noteworthy to you regarding particular successes or failures, challenges or obstacles to collaboration and/or knowledge sharing that you've noticed or thought about as we've begun ramping up our attempt to collaboratively build this collaborative online environment of ours. Fair game is anything you think might be significant or relevant to our IT group's ability to learn from each other, including your opinions or reactions to particular events, ways of doing things, etc. You can write as much as you want, but please try to write a minimum of 100 words (about the length of this paragraph).

If you're not sure what to write about, you might consider responding to one or more of the following questions:

1. Is there anything particular that you hope to get out of this process or the product we ultimately create?
2. Think of some of the challenges you've had on the job recently. Is there something we could incorporate into our process/product that could help?

3. Are you worried or otherwise concerned about anything particular?

4. Is there something positive you've experienced as a result of participating in the project so far?

Your insights are critical! I appreciate your time and thoughtfulness.

- Dave

JE2

As I've mentioned before, you may use these journal entries as a way to think about your experiences as a participant and communicate anything you think is notable. I'm interested in a variety of things -- pleasant surprises or interactions, difficulties or concerns, opportunities you see for improvements, your ideas for facilitating better collaboration and knowledge sharing, etc.

If you're looking for ideas, consider these questions: Have your experiences in the project so far helped you learn anything about yourself or your colleagues? Have you learned anything technical? Can you provide details or an example or two to illustrate what you mean?

JE3

As always, feel free to write about any of your impressions, thoughts, suggestions, etc. Here are some questions to consider:

1. Have our project activities inspired you to learn or consider learning something new? like what?

2. Do you notice any spillover effect of our activities -- e.g., do you find yourself interacting any differently with colleagues who are not participating in this study?

3. How has the workload been? Is participating in the study/project getting in the way of your "real" work? Have job responsibilities made it hard for you to give as much energy and focus to the study/project? If so, what can be done to help keep things balanced?

4. Do you have any suggestions for better organizing our interactions / communications at this point?

JE4

As always, feel free to write about any of your impressions, thoughts, suggestions, etc. Here are some questions to consider:

1. Pretend for a moment that you haven't been part of this study / project and now your co-workers are approaching you with a "knowledge sharing system" they want you to use. What could they do (or avoid doing) to motivate you to use the system? What system features would draw you in or turn you off?

2. Think about a knowledge-sharing interaction you've had with one of your fellow participants. What was it that went right about that interaction? Did you overcome or avoid any particular obstacles to make it happen? For example, was there something about the way you interacted (the communication channel or the tone of the communication) that made it easier or was particularly helpful? Conversely, did you have an unpleasant or uneasy interaction that may shed light on things to minimize or avoid?

3. Think about your experiences in this project so far. How important is it to have face-to-face (f2f) interactions with your colleagues? Do f2f interactions make it easier to share knowledge? to get things done?

4. Is there something we (participants in this project) know now as a group that we didn't know before? How so?

JE5

You are always free to use these journal entries to write about any of your impressions, thoughts, suggestions, etc., For this entry, though, I'd like you to focus especially on the things you've been learning and on any knowledge sharing that's been happening as you've worked on our project. So please consider answering one or more of these questions about your experiences in the project so far:

1. What kinds of new technical knowledge have you acquired or been exposed to? (Remember that "learning" does not necessarily mean you have to be an expert -- it just means you know more than you did before.) Provide an example or two if you can.

2. Did the direct or indirect influence of your colleagues make a difference in what you learned? For instance, could you or would you have learned all that you have learned completely on your own? What have you learned from others?

3. What have you learned about your colleagues' skills and knowledge? For instance, has anyone shared knowledge you didn't know they had?

4. Has the extra coordination / interaction "overhead" involved in working more collaboratively been worth the benefits?

JE6

Ideas for this week's entry are below. Pick and choose, mix and match, write about what you want. Any insights into your experiences in this project are fair game. I am especially interested in knowledge sharing that is happening within or across the small groups even as we work on our own knowledge sharing system.

1. Many of us have mentioned how regular job duties have impacted the amount of time or effort we've been able to dedicate to this project. This might suggest that a collaborative project like

this one could potentially fare better if were better incorporated into our regular responsibilities. That is, rather than it being an “extra” thing we'd have to do on top of our “regular” job, if our duties were shifted or reorganized to accommodate this kind of activity, in theory we might be able to engage in this kind of collaborative project more easily and/or with faster or better progress. On the other hand, perhaps our progress so far -- in spite of all the competing demands -- is due to the very kind of dedication that volunteers (almost by definition) bring to a project like this. Do you think this kind of collaboration would work as well as if it were a more “regular” occurrence or even a job expectation? Would it promote better knowledge sharing among our IT group? Would you be in favor or against more-regular participation in some kind of collaborative (perhaps smaller-scale) project if the rest of your duties were adjusted to accommodate it?

2. Describe a recent experience where you shared knowledge with a fellow “bacer” or received input or assistance from one. What influenced you to seek or provide input? What made the exchange possible -- e.g., friendship, familiarity, ease of access, the right communication tool? Alternatively, describe a recent experience where you felt like you could use some help or input but did not seek it out. What stopped you?

JE7

As usual, please use this as an opportunity to share any insights you might have about our project, things that have made it easy or difficult to work collaboratively or participate in the study, processes or skills you think we could improve, etc. In general, if you have suggestions for how to use our time more effectively or efficiently, please let me know. This project belongs to all of us.

For some ideas, consider answering one or more of these:

1. Do you think we've gotten any better (or worse) at working collaboratively since the project began? Can you give an example or two? Where do we still need to improve?

2. Have any of your knowledge-sharing or overall relationships with colleagues improved (or worsened) as a result of participating in the project / study? How so?

3. As we move on to making a final choice for our product and fully developing / populating it, what should we do to maintain or improve our enthusiasm and collaborative activities? For instance, maybe instead of three separate weekly small-group meetings, should we have one or two anybody-can-attend meetings? Should we call for volunteers to facilitate whole-group meetings, suggest a theme, or otherwise direct our focus? Schedule a semi-standing Google Hangout? Try to schedule a semi-regular optional lunch together?

JE8

Here are some questions you might consider thinking / writing about this week. Remember that you can share anything you want -- you don't necessarily have to answer any or all of these questions.

1. Has my feedback on these journal entries been useful? If so, in what ways? Is there a way I could make it more useful? Would it be better for me to refrain from making comments / providing “feedback”?

2. What can each individual Bacer do to keep our project on track both a) now and b) beyond the end of the study? Is there something particular that you can see yourself doing along these lines?

3. In the past I've brought up the ideas of “openness” and “transparency” as things we might want to try to emulate or incorporate into our ways of doing things. What do these things mean to you? Have we been sufficiently open and transparent in our project? Does it matter? (If

you're up for a little philosophical thinking, you might revisit my post to the General -> What's on your Mind? forum area. On Feb 26, I posted something about Open Source.)

JE9

As always, feel free to use this venue as an opportunity to reflect on anything that seems important or noteworthy to you: e.g., any impacts this project has had on your expectations or attitudes or actions (positive or negative), any changes you've noticed in the way others in the project interact with you or each other and what aspects of our project activities might account for those changes, etc. These kinds of observations are valuable because they might help us to purposely incorporate or downplay particular things in order to improve everyone's experience in the project and on the job.

Some specific questions to consider, if you prefer:

1. We Bacers have been pursuing a fairly democratic process -- doing polls, taking votes, making decisions as a group, etc. In a voluntary project like ours, that might seem like a natural way to do things. In the world of "real work" life, where we all have a boss and there is something of a "chain-of-command," that might be harder to do. Can you think of any ways for us to maintain at least some of our democratic sensibilities and/or practices even beyond the end of the study? What would each of us have to do to help that happen?

2. We all have different strengths and comfort zones but we can all be leaders in our own ways. In what ways do you think you have been a leader in our project? (Take credit!) In what ways can you continue to lead or otherwise contribute positively to the direction we take in the final stages of our project and beyond?

3. If forced to make a choice, what would you say is the single most important factor that will affect how well we continue to share knowledge with each other through the end of the study and

beyond? For instance, is it something practical like “we need to continue meeting in some form, on some kind of regular basis”? Or is it something more basic like “we need to maintain a collaborative spirit” or “we need to give and take freely, without judgement” or....? What do you think? How come?

JE10

As always, feel free to use this venue as an opportunity to reflect on anything that seems important or noteworthy to you. Here are some possibilities to think about:

1. We have not yet instituted our official “knowledge sharing system” but we have been working collaboratively throughout this project. Do you think that working on the project itself has increased or improved knowledge sharing with your fellow Bacers or even other SAS IT staff? If so, can you recall an example or two? What might have improved the experience?
2. What has been the most difficult aspect of working on this project? What's been the most positive aspect?
3. Have we gotten any better at working together? What still needs improvement?

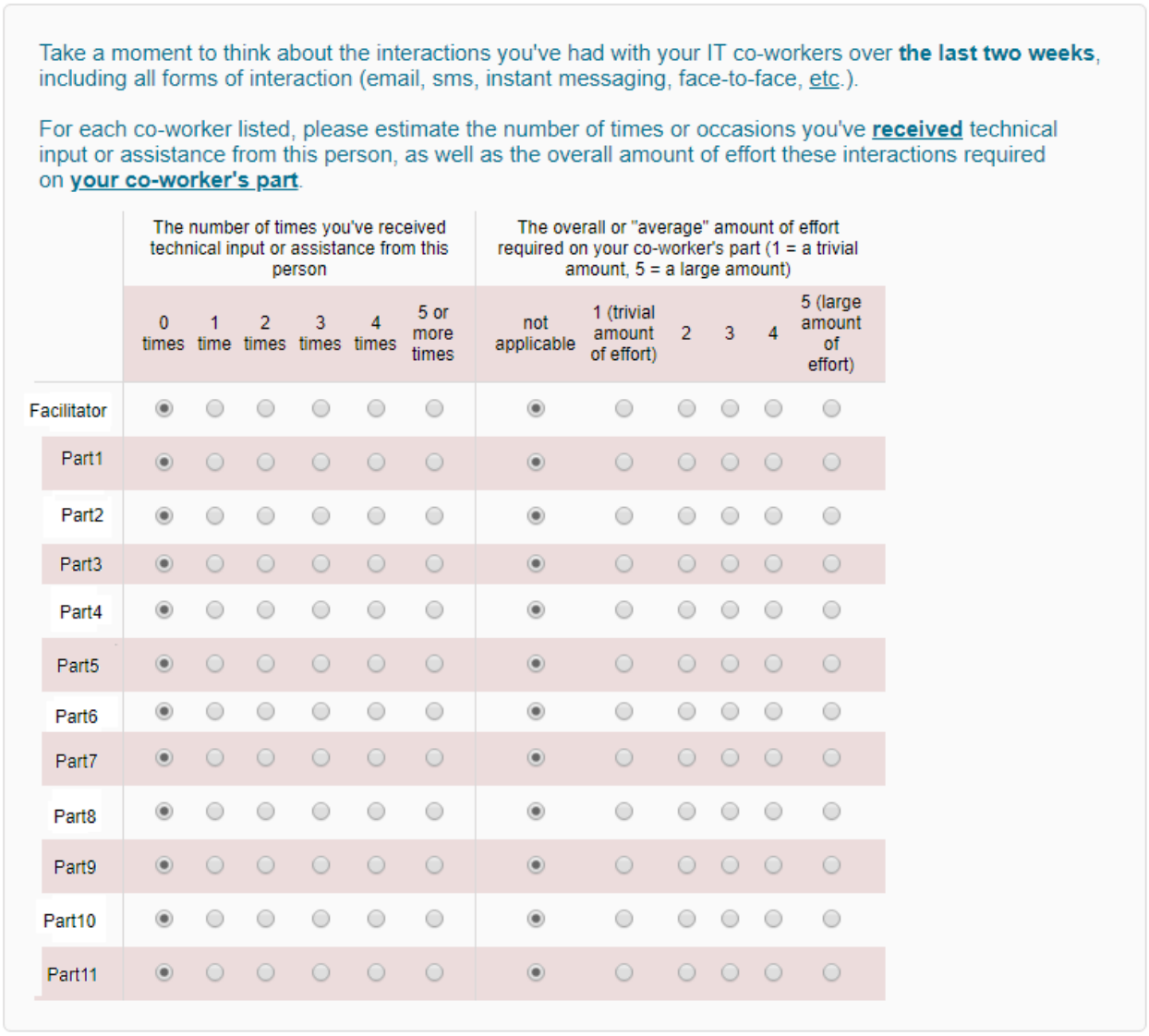
Appendix D

Social Network Analysis (SNA) Survey Questions

These questions (anonymized here) attempt to gauge the interactions of every participant with every other participant in the network, which in this case is defined in terms of the participant pool. In addition to indicating whether there was sharing of knowledge reported, this Likert-style format also allows for the possibility of gauging the frequency of knowledge exchange as well as the estimated effort involved in the exchange. These are details that may not factor directly into the summary measures but could provide additional context when interpreting the numbers, or may indeed be used to build a composite score that incorporates both interactional frequency and "strength." Note that asking both forms of the question from all participants allows the computation of scores from both the initiator and receiver's points of view. If everyone remembered and interpreted interactions identically, these two points of view would be identical. Thus using both forms allows for consensual validation as well as the potential to uncover possibly interesting discrepancies in perception.

For each co-worker listed, please estimate the number of times or occasions you've **given** technical input or assistance to this person, as well as the overall amount of effort these interactions required on **your part**.

	The number of times you've given this person technical input or assistance						The overall or "average" amount of effort required on your part (1 = a trivial amount, 5 = a large amount)					
	0 times	1 time	2 times	3 times	4 times	5 or more times	not applicable	1 (trivial amount of effort)	2	3	4	5 (large amount of effort)
Facilitator	◉	○	○	○	○	○	◉	○	○	○	○	○
Part1	◉	○	○	○	○	○	◉	○	○	○	○	○
Part2	◉	○	○	○	○	○	◉	○	○	○	○	○
Part3	◉	○	○	○	○	○	◉	○	○	○	○	○
Part4	◉	○	○	○	○	○	○	◉	○	○	○	○
Part5	◉	○	○	○	○	○	◉	○	○	○	○	○
Part6	◉	○	○	○	○	○	◉	○	○	○	○	○
Part7	◉	○	○	○	○	○	◉	○	○	○	○	○
Part8	◉	○	○	○	○	○	◉	○	○	○	○	○
Part9	◉	○	○	○	○	○	◉	○	○	○	○	○
Part10	◉	○	○	○	○	○	◉	○	○	○	○	○
Part11	◉	○	○	○	○	○	◉	○	○	○	○	○



Take a moment to think about the interactions you've had with your IT co-workers over **the last two weeks**, including all forms of interaction (email, sms, instant messaging, face-to-face, etc.).

For each co-worker listed, please estimate the number of times or occasions you've **received** technical input or assistance from this person, as well as the overall amount of effort these interactions required on **your co-worker's part**.

	The number of times you've received technical input or assistance from this person						The overall or "average" amount of effort required on your co-worker's part (1 = a trivial amount, 5 = a large amount)					
	0 times	1 time	2 times	3 times	4 times	5 or more times	not applicable	1 (trivial amount of effort)	2	3	4	5 (large amount of effort)
Facilitator	◉	○	○	○	○	○	◉	○	○	○	○	○
Part1	◉	○	○	○	○	○	◉	○	○	○	○	○
Part2	◉	○	○	○	○	○	◉	○	○	○	○	○
Part3	◉	○	○	○	○	○	◉	○	○	○	○	○
Part4	◉	○	○	○	○	○	◉	○	○	○	○	○
Part5	◉	○	○	○	○	○	◉	○	○	○	○	○
Part6	◉	○	○	○	○	○	◉	○	○	○	○	○
Part7	◉	○	○	○	○	○	◉	○	○	○	○	○
Part8	◉	○	○	○	○	○	◉	○	○	○	○	○
Part9	◉	○	○	○	○	○	◉	○	○	○	○	○
Part10	◉	○	○	○	○	○	◉	○	○	○	○	○
Part11	◉	○	○	○	○	○	◉	○	○	○	○	○

The wording of these questions was slightly modified after the initial survey in order to focus attention on project-related activities. Specifically, the phrase "interactions you've had with your IT co-workers" was changed to "the Bace-related interactions you've had with your IT co-workers." On survey 6, which was intended to look beyond the project confines, the wording was changed to "the NON-Bace-related interactions you've had with your IT co-workers." Finally, on survey 12, it was changed to "the Bace and NON-Bace-related interactions you've had with your IT co-workers." While it would be interesting to also ask about interactions that

happen between participants and non-participants – for example, to observe any transfer effects of the intervention – the logistics of doing this (e.g., the incomplete picture that stems from the impossibility of obtaining input from non-participants, the need to ask respondents to make distictions between participants and non-participants) make it somewhat unwieldy to manage.

Appendix E

Data Collection / Activity Timeline

Week # / Week of	1 Feb 1	2 Feb 8	3 Feb 15	4 Feb 22	5 Feb 29	6 Ma 7	7 Ma 14	8 Ma 21	9 Ma 28	10 Apr 4	11 Apr 11	12 Apr 18	13 Apr 25	14 My 2	15 My 9	16 My 16	17 My 23	18 My 30	19 Jun 6	20 Jun 13	21 Jun 20	22 Jun 27	23 Jul 4	24 Jul 11
Project activities / data collection:																								
Initial / Ending Survey	x																							x
Whole-group meeting (audio recording)	x		x		x		x		x		x		x		x		x		x		x			x
Subgroup meetings (group log entries expected)		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Individual journal prompts posted			x		x		x		x		x		x		x		x		x		x			
Facilitator journal entry	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
SNA survey	x		x		x		x		x		x		x		x		x		x		x			x
PBL stages (approximate):																								
Prepare the Learners	x	x	x																					

Meet the problem	x	x	x																					
Identify knowledge and knowledge needs			x	x	x	x	x	x	x	x														
Gather and share information					x	x	x	x	x	x	x	x	x											
Generate possible solutions (design)						x	x	x	x	x	x	x	x	x	x	x								
Determine optimal solutions (design / develop)													x	x	x	x	x	x	x	x				
Present / Implement the solution																					x	x		
Debrief / review / improve																							x	x
Week Week of	1 Feb 1	2 Feb 8	3 Feb 15	4 Feb 22	5 Feb 29	6 Mar 7	7 Ma 14	8 Ma 21	9 Ma 28	10 Apr 4	11 Apr 11	12 Apr 18	13 Apr 25	14 My 2	15 My 9	16 My 16	17 My 23	18 My 30	19 Jun 6	20 Jun 13	21 Jun 20	22 Jun 27	23 Jul 4	24 Jul 11

Appendix F

Sample Whole-Group Meeting Agenda

Each whole-group lasted approximately 90 minutes. Agendas varied according to what was most logical at any given time. However, they generally adhered to a format similar to the following:

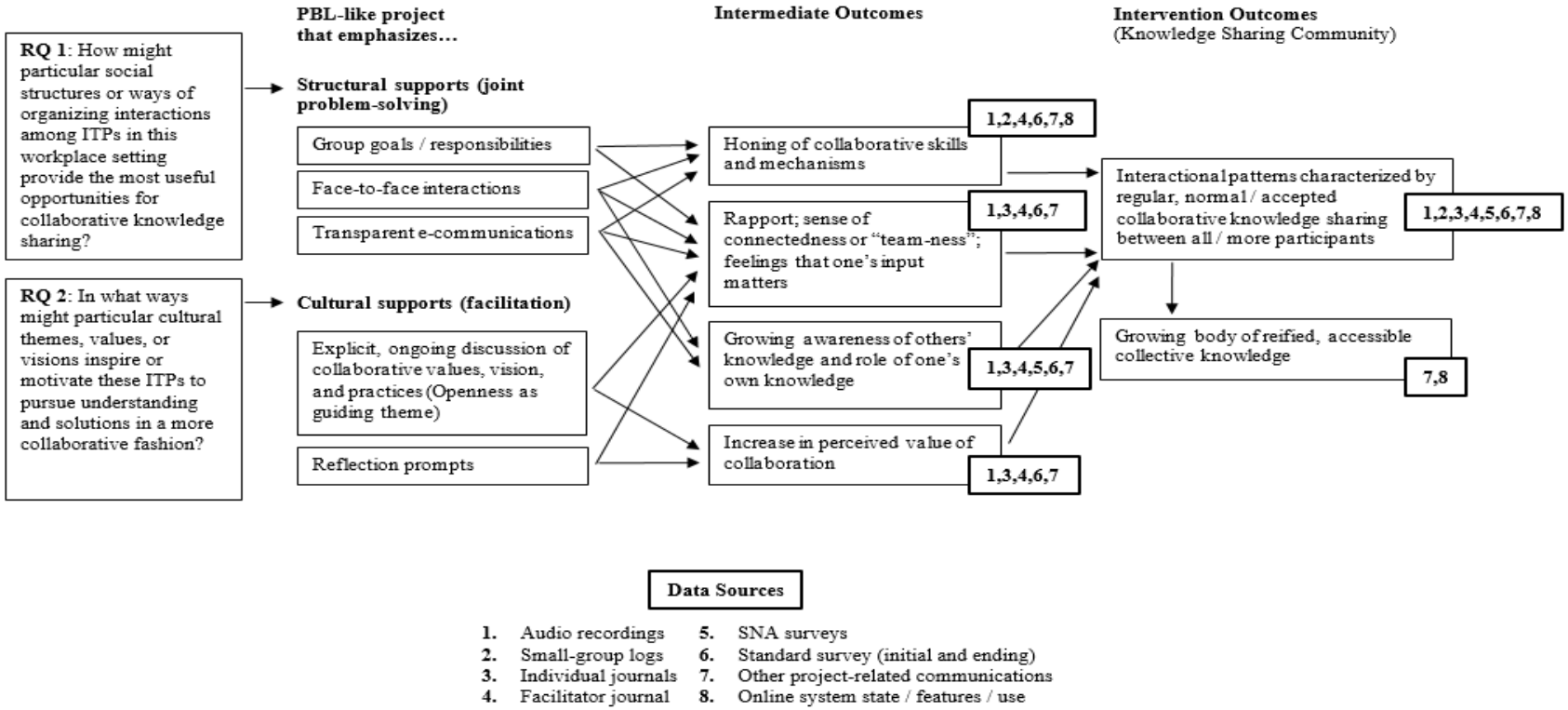
- Opening remarks / old business (~ 10-15 minutes)
- Subgroup check-in / status updates (~ 30-60 minutes): Members from each subgroup provide status updates on the issues they investigated, significant findings, difficulties or obstacles, etcetera. This should include some insight sharing, troubleshooting advice, and general commentary from the whole group. The dynamics of these discussions provide an opportunity to directly observe the state of relationships between all participants.
- Discussion of next steps (~ 10-20 minutes)
- Facilitator observations (~ 10-20 minutes), especially summarizing or highlighting aspects of the collaborative process that seem to be going well, or suggesting / soliciting adjustments in cases where things are not progressing so well. This may be an opportunity to broker discussion of collaborative ideals and values.

Attendance at these meetings was noted. Generally speaking, besides addressing the practical aspects of the technical project, the main goals of these meetings were to allow interaction, especially knowledge exchanges, to happen between all participants. I attempted to facilitate this throughout the proceedings.

Appendix G

Design Alignments

This figure shows a mapping between the various elements of the overall study design, including the research questions, embodied conjecture, and data sources intended to gauge intermediate and final outcomes predicted by the conjecture.



Appendix H

Rubric for Product Evaluations

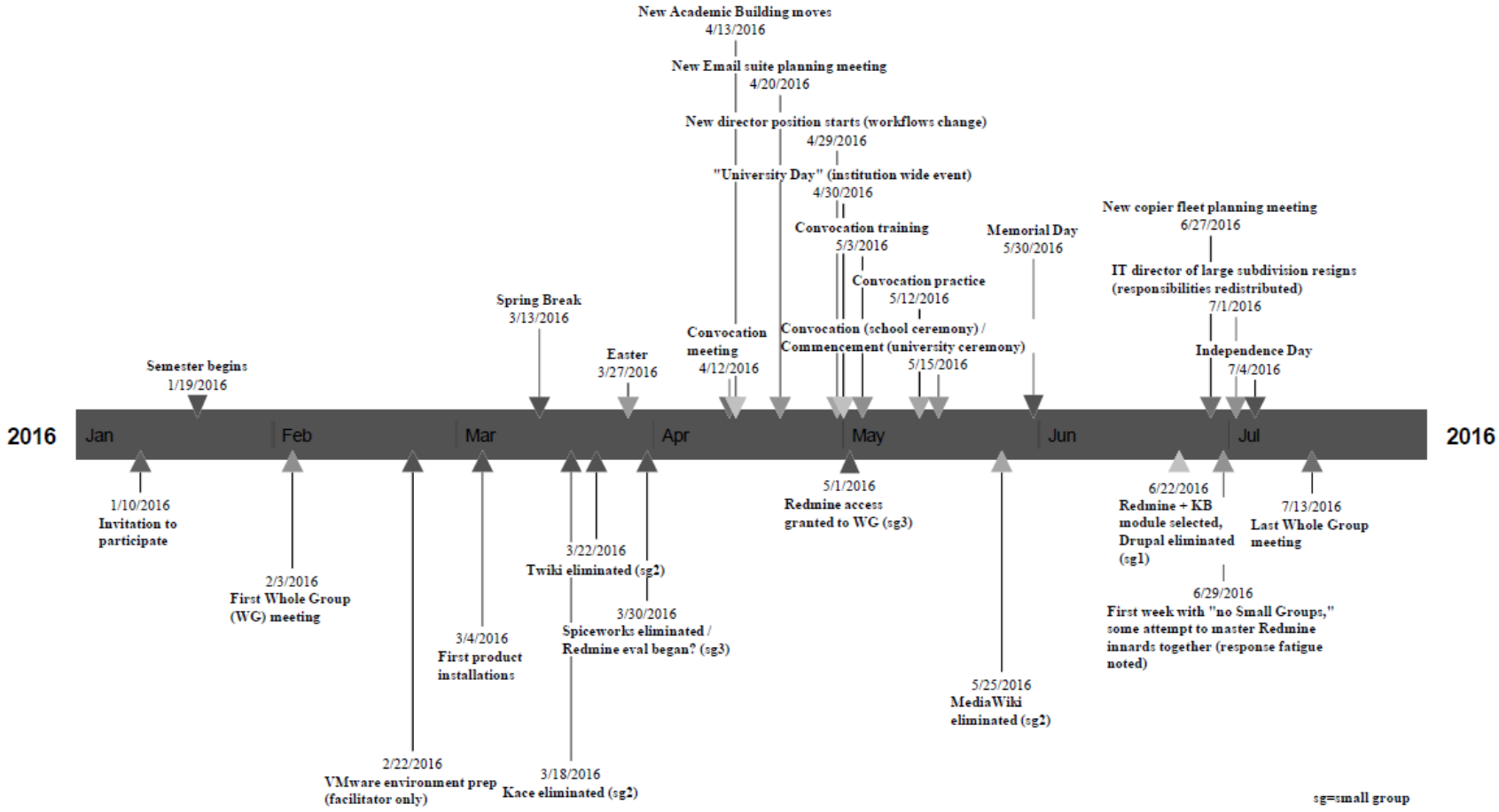
Shown here is the list of features Bacers co-constructed along with per-participant (Part1, Part2, etc.) scores for importance and the evaluating small group's score for the product on that feature. These formed the basis for a weighted score for each product.

C4 =AVERAGE(D4:N4)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	***Feature weightings / importance***			As rated by...											Primary group's rating/commentary	*** For complete fairness, we might want to compute scores based on everyone's rat**				
2	**Features**	**Median Computed Importance (-1 = don't want, 0 = don't care, 1 = low, 2 = medium, 3 = high)**	**Average Computed Importance (-1 = don't want, 0 = don't care, 1 = low, 2 = medium, 3 = high)**	**Part1**	**Part2**	**Part3**	**Part4**	**Part5**	**Part6**	**Part7**	**Part8**	**Part9**	**Part10**	**Part11**	**Drupal**	**Drupal Score***	**MediaWiki (MW)**	**MW score***	**Redmine**	**Redmine score***
3	Robust, easy-to-use knowledge base	3.00	3.00	3	3	3	3	3	3	3	3	3	3	3	yes	3	yes	3	yes	3
4	Pretty / well-formatted KB docs	3.00	2.73	3	3	2	2	3	3	3	3	3	3	2	yes	3	yes	3	yes	3
5	Easy maintainability (security-wise as well as content)	3.00	2.73	3	2	3	3	3	3	3	3	2	3	2	yes for modules and content, manual updates for core system	3	yes	3	yes	3
6	No phoning home / offsite data leakage	3.00	2.55	2	3	2	3	3	2	2	3	2	3	3	yes	3	yes	3	yes	3
7	Ldap / CAS support	3.00	2.73	2	3	3	3	3	2	3	3	3	2	3	yes with module	2	yes with extension	2	yes	3
8	Permissioning system (different content / editing for different audiences)	3.00	3.00	3	3	3	3	3	3	3	3	3	3	3	yes	3	yes	3	yes	3
9	Tagging solutions as "helpful" or "worked" / thumbs up	2.00	2.09	3	1	2	1	2	2	3	3	2	3	1	yes with module	2	yes with extension (commentary via Talk pages possible)	2	yes	3
10	Integrated helpdesk / ticketing system with anonymous submissions possible	2.00	2.00	1	2	1	2	3	2	3	1	2	3	2	yes with module and custom programming	1	no	0	yes	3
11	In-system communication (e.g., group chat, forums, ability to comment on submissions)	2.00	2.18	3	2	2	2	2	2	2	2	2	2	3	yes with module	2	yes, commentary via Talk pages and with extension	2	yes	3
12	On-premises data storage (local install)	2.00	2.36	1	3	2	3	3	2	3	2	2	3	2	yes	3	yes	3	yes	3
13	Integration support (ability to link to other products)	2.00	2.00	1	2	2	2	1	2	2	3	2	3	2	yes with module and custom programming	1	maybe with extension or custom coding	1	yes	3
14	Simple infrastructure requirements (e.g., runs on one box)	2.00	2.18	2	2	2	2	3	2	3	3	2	2	1	yes	3	yes	3	yes	3
15	File storage (e.g., scripts, reg files, video/audio, other resources)	2.00	2.36	2	2	2	2	2	3	3	3	2	2	3	yes with module	2	yes, with mime type jiggering	2	yes	3
16	Reminders to update old docs	2.00	1.82	0	2	2	3	1	1	2	2	2	3	2	yes with module	2	maybe with extension (watch feature present)	1	yes, with plugin	2
17	Ability to selectively push / publish content for public consumption	2.00	1.91	3	2	2	-1	2	3	3	2	2	1	2	yes with module	2	yes	3	yes, depends on how we configure authentication	2
18	Integrated inventory system	1.00	1.36	1	0	0	0	3	0	2	2	1	3	3	yes with module and custom programming	1	no	0	yes, with plugin	1
19	Systems monitoring / status page	1.00	1.45	0	2	3	0	1	1	1	3	1	1	3	yes with module	2	no	0	no	0
20	In-system or easy-addon video call / screen sharing (like /hangout in Slack)	1.00	1.18	1	1	2	0	1	1	1	2	0	1	3	yes with module	2	no	0	yes, with plugin	2
21	User profiles (ability to describe one's skills, interests, etc.)	1.00	1.18	2	2	1	-1	1	2	2	2	1	1	0	yes	3	yes, each user gets own wiki page	3	yes, with plugin	2
22																				
23	straight average															2.26		1.95		2.53
24	weighted average															1.63		1.49		1.88
25	weighted score (sum of primary group's rating times median computed importance)															93		85		107
26																				

Appendix I

Timeline of Notable Events



Appendix J

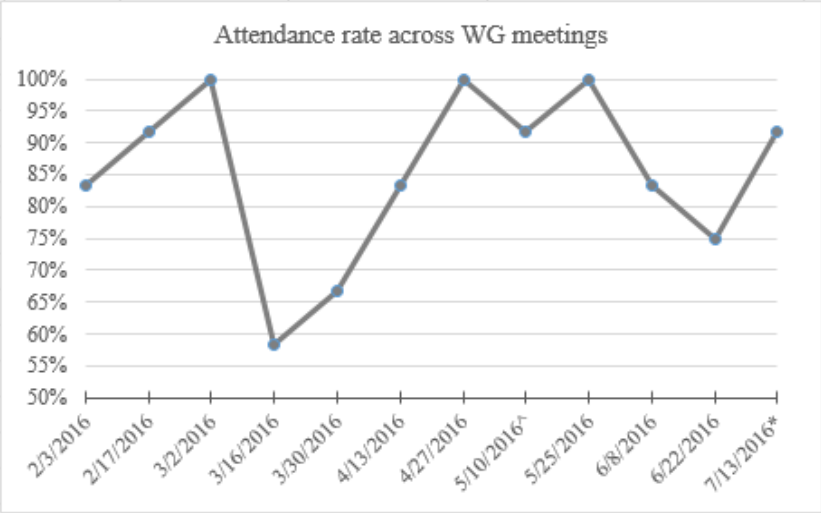
Attendance / Participation at Whole Group Meetings

This figure shows attendance as well as basic participation (speaking) at whole group meetings. The average number of speakers was computed by counting the number of unique speakers per 5 minute segment and averaging across all the segments. Some values are highlighted in relation to their average.

Date	Meeting#	Attendance	Attendance rate	Avg no of speakers per mtg	Avg speaker counts as % of attendance
2/3/2016	1	10	83%	2.86	29%
2/17/2016	2	11	92%	4.39	40%
3/2/2016	3	12	100%	4.12	34%
3/16/2016	4	7	58%	4.70	67%
3/30/2016	5	8	67%	3.68	46%
4/13/2016	6	10	83%	5.06	51%
4/27/2016	7	12	100%	4.15	35%
5/10/2016^	8	11	92%	4.21	38%
5/25/2016	9	12	100%	4.47	37%
6/8/2016	10	10	83%	6.63	66%
6/22/2016	11	9	75%	5.59	62%
7/13/2016*	12	11	92%	4.85	44%
	avg	10.25	85%	4.56	45.76%
	avg %	85%			

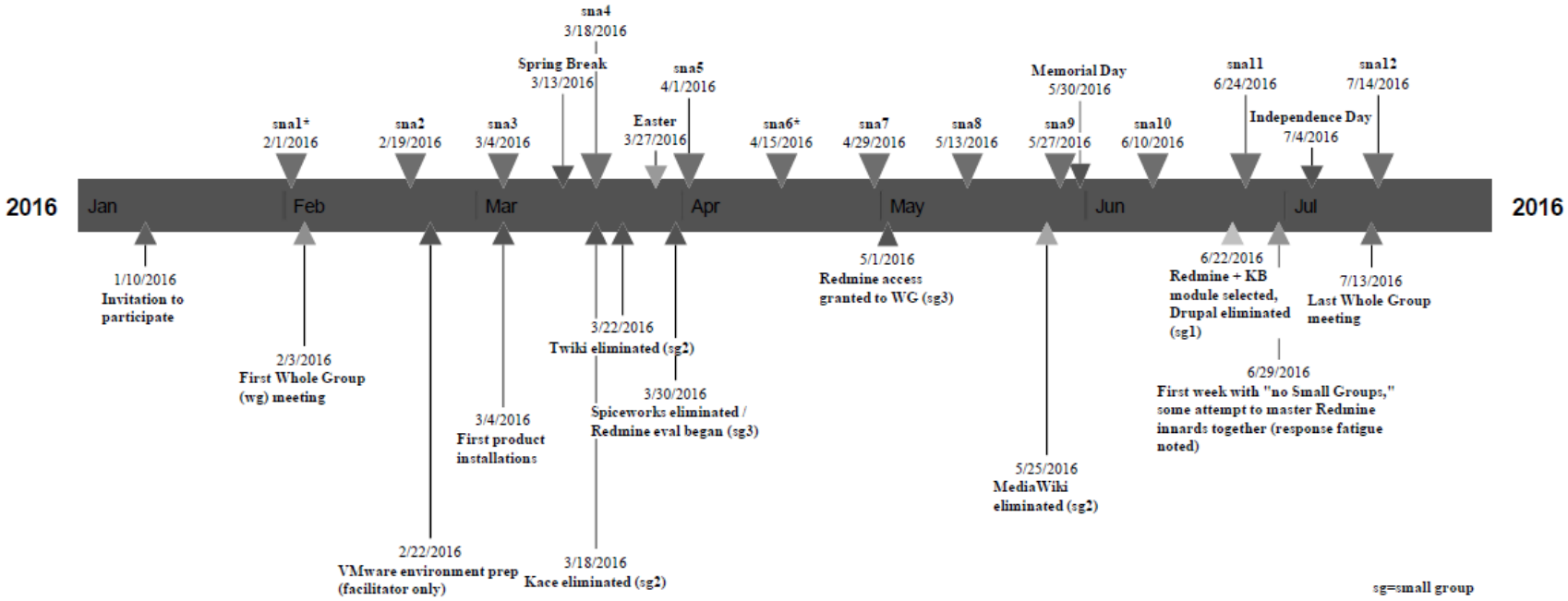
^ This meeting was moved to Tues in anticipation of possible convocation practice.

* This meeting was originally scheduled for Wed 7/6 but was delayed a week due to director resignation.



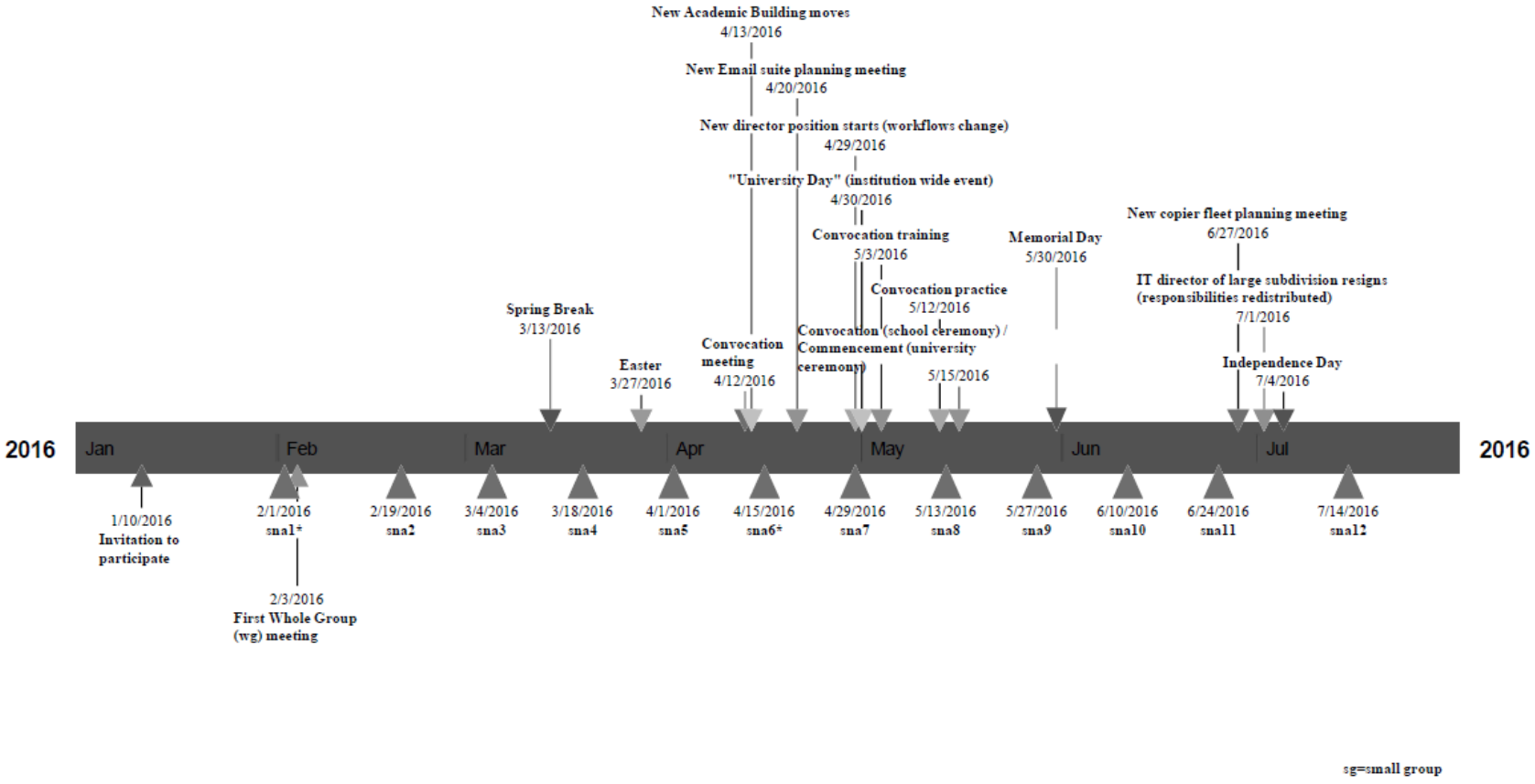
Appendix K

SNA survey timing juxtaposed against project events



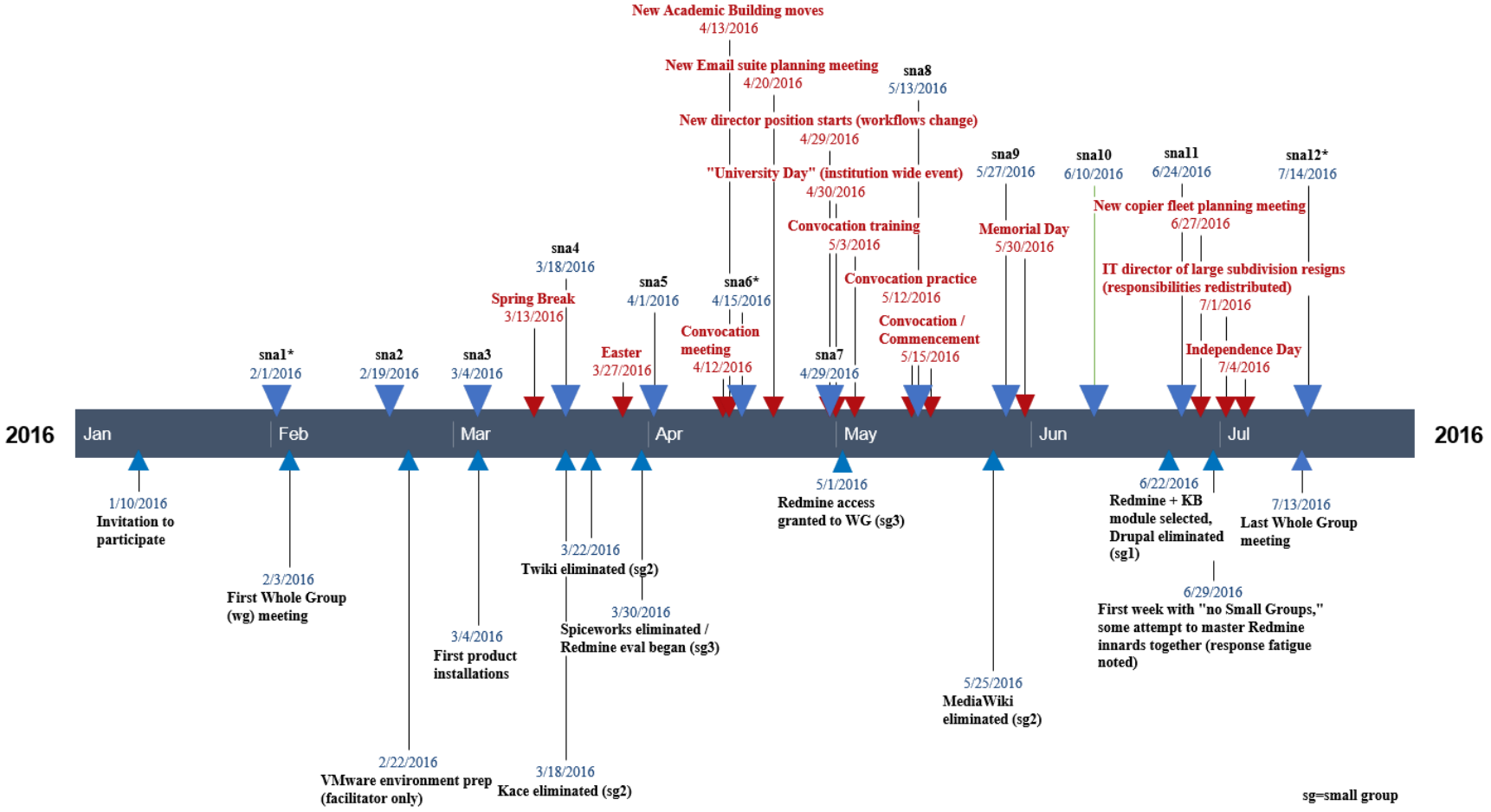
Appendix L

SNA survey timing juxtaposed against non-project events



Appendix M

SNA survey timing juxtaposed against project and non-project events



Appendix N

Conservative versus optimistic approaches to counting relationships: Example impact using SNA survey 8 data

Conservative approach: count only corroborated relationships

	Facilitato	Part1	Part2	Part3	Part4	Part5	Part6	Part7	Part8	Part9	Part10	Part11
Facilitato	0	1	1	1	0	0	0	0	1	0	1	0
Part1	0	0	0	1	0	0	0	0	0	0	0	0
Part2	1	0	0	0	0	0	0	0	0	0	0	0
Part3	0	1	0	0	0	0	0	0	0	0	0	0
Part4	0	0	0	0	0	0	0	0	0	0	0	0
Part5	0	0	0	0	0	0	0	0	0	0	0	0
Part6	0	0	0	0	0	0	0	0	0	0	0	0
Part7	0	0	0	0	0	0	0	0	0	0	0	0
Part8	1	0	1	0	0	0	0	0	0	0	0	0
Part9	0	0	0	0	0	0	0	0	0	0	0	0
Part10	0	0	0	0	0	0	0	0	0	0	0	0
Part11	0	0	0	0	0	0	0	0	0	0	0	0

Participants 5, 6, 7, 9, and 11 (bold row headings) did not respond to this survey. Requiring that a reported relationship be corroborated by the other party in order to "count" means that all potential relationships with the missing respondents (those indicated by the 90 shaded cells shown above) will be treated as "no relationship" (0s) because corroboration is impossible with missing respondents. (A note on reading such matrixes: participant X is indicated as having given

knowledge to participant Y when the cell where X's row intersects Y's column has a 1 in it. For instance, the cell intersecting row Part8 and column Part2 has a 1, so Participant 8 is said to have given knowledge to Participant 2.)

Optimistic approach: count corroborated and uncorroborated relationships

	Facilitato	Part1	Part2	Part3	Part4	Part5	Part6	Part7	Part8	Part9	Part10	Part11
Facilitator	0	1	1	1	0	0	1	1	1	0	1	1
Part1	1	0	0	1	0	0	1	1	0	0	0	0
Part2	1	0	0	0	0	1	0	1	1	0	1	0
Part3	1	1	0	0	0	0	1	1	1	0	0	0
Part4	1	0	0	0	0	0	0	0	0	0	0	0
Part5	0	0	0	0	0	0	0	0	0	0	0	0
Part6	0	1	0	1	0	0	0	0	0	0	0	0
Part7	1	1	0	1	0	0	0	0	0	0	0	0
Part8	1	0	1	0	0	0	0	0	0	1	1	1
Part9	1	0	0	0	0	0	0	0	1	0	0	0
Part10	1	0	0	0	0	0	0	0	1	0	0	0
Part11	1	0	1	0	0	0	0	0	1	0	1	0

Using the same survey data, the optimistic approach – counting relationships reported by *either* party – automatically treats as "no relationship" only those potential relationships for which there can be *no* data: i.e., those between the missing respondents (the 20 shaded cells versus the 90 automatically excluded in the conservative approach). In this case, for instance, missing respondent Participant 6 is shown as having given knowledge to Participants 1 and 3 whereas these relationships remain unidentified from the conservative viewpoint. However, it should be noted that systematically relaxing the standard like this means that uncorroborated relationships between responding participants will also be counted. For instance, in this optimistic view, Participant 1 is shown as having given knowledge to the Facilitator, as indicated by the 1 listed where row Part1 intersects column Facilitator. Referring back to the original response data (not shown here) reveals that only the Facilitator reported this exchange, a lack of corroboration that explains why its presence is noticed here but not from the conservative viewpoint.

Appendix O

Excerpts Highlighting Themes Discussed in the Text

COMMENTS FROM GROUP 1 MEMBERS

Themes: face-to-face versus virtual meetings, honing of collaborative skills

"[F]or this meeting we used Google hangouts. I don't recommend trying to do this on a phone..."

"[Google Hangouts is] fine for trying to get together for lunch or something, but no so much for resolving things clearly."

"We attempted a meeting via google hangouts today which, I don't think really worked out well. I find face to face meetings much more productive."

"We made some real progress with our drupal install and I think its largely do to have face to face interactions in a computer lab. It let's us all do a little collaborative hacking at the same. The one meeting we attempted in google hangouts didn't really produce to much and was a bit difficult to follow…. working in this manner [in a lab] definitely seems to get everyone on the same page and produce some real results in moving forward on this project."

"This [lab work] has allowed for some really productive collaboration and problem solving having everyone present with access to a computer…. [W]e were able to work out bugs and issues that may have taken much more time individually. We configured a ticket system last week but tried troubleshooting that over a hangout meeting and I don't think we got as far."

"Based on back-to-back meetings in the last two weeks – one virtual, one in person – I do believe it's important to have face-to-face interactions. Although technology does make virtual meetings possible, there are still barriers that slow down the free flow of ideas. For example, during our virtual meeting, we all needed to individually monitor a Google Hangouts feed, the VM console, and the Drupal website. A lot of brain cycles were required to navigate the various windows, which might have been better spent on brainstorming. By comparison, the following week we met in a lab, we were able to collectively monitor the VM console, the Drupal site, and an SSH session established with the VM's OS. It was fairly easy to move from one system to another and trade ideas on the fly, since we didn't need to spend a lot of effort just getting on the

same page. (One advantage of the virtual session is that it was much easier to review the conversation afterwards, simply by viewing the chat log.)"

"I feel that there is a multiplier effect when working in the small group sessions. One person will ask a question or share some information, and the others will immediately follow up and pursue the line of inquiry further, sometimes in different directions, and with unexpected results. There is definitely a synergy that emerges when working collaboratively."

"In the beginning, our group approached the project a little tentatively, and our meetings were not quite as productive as they are now. As we progressed, I sensed that the group members were finding their roles and accomplishing more during our lab sessions. I found that when someone raised a question or mentioned a problem, we brainstormed quickly and were able to test and implement various solutions."

Themes: inclusion, attributions of credit, fairness / shared labor (people-centrism)

"An example of a successful knowledge interaction occurred during our meeting in a computer lab. Our goal was to set up automated backups of our Drupal database. One group member was familiar with the VM infrastructure and was able to observe changes to the VM's filesystem. Another member was fluent at the command line and created the directory where backups were stored. A third person knew enough Drupal to configure the backups, and the fourth person was familiar with cron and configured it to run at a specified time. The meeting was a classic example of everyone sharing their knowledge to achieve a desired outcome."

"As I learn new things for our project, I find myself communicating more effectively with my colleagues, who know a lot more about Drupal, CSS and HTML than I do. I can let them know what I'm learning and ask their advice when needed."

"We discussed the suggested platform of Spiceworks…. [Part7] noted that it only runs on Windows servers. [Part3] said that other platforms should be able to access Spiceworks through a web browser…. [Part6] noted that reliance on data entry to maintain the serial number could be a failure point…. [Part2] noted that the implementation of Redmine…."

Theme: enjoyment, rapport (more people-centrism)

"I am really enjoying getting to know the guys in my group and what things they are working on and the things that are important to them."

"So far, I have enjoyed meeting my colleagues… in person on a more regular basis, and I look forward to further collaboration within the group…. I'm looking forward to the more technical aspects of the project, and the opportunity to collaborate with group members and acquire new knowledge."

"As our trusty scribe, [Part1], was out this week, we decided to regroup on Monday to discuss tasks, direction, goals, etc. It was a no-brainer to have [Part6] install our drupal 7 (since it is still widely supported and he has much experience) vs drupal 8 and that our install would run on Sles 12. [Part7] installed the vm at end of day (with new mysql) and passed info to [Part3] and [Part6]."

COMMENTS FROM GROUP 3 MEMBERS

Theme: (obstacles to) effectiveness and efficiency

"I have found that I have lost my once second nature ability to complete course-like assignments in a timely matter. When I was more accustomed with having to constantly monitor multiple courses announcements as well as their assignments I could easily manage my time effectively. Now, I find that this is so far from my routine that I am struggling to get into a rhythm of completing the easy work that is required… [T]his project has shown me that I need to learn how to be productive and reliable in situations where I don't necessarily feel comfortable. It has also shown me that pushing myself into uncomfortable positions can be beneficial…."

"I find that the people within the project are using Slack effectively and it is a reliable tool that we have pretty much adopted across the board. Having the ability to share quick help links through an embedding chat or easily bring multiple people in on a question is incredibly beneficial. I find myself upset at the fact that I use GChat with other colleagues because of how much better I find my productivity to be while using [Slack]."

“The problem is more on my own lack of ability to do things in a timely matter that is causing my problems. The workload is more than I anticipated but not more than I can handle. I just need to practice those skills to a higher level.”

“Considering we weren't able to come to together this week, I would say that we weren't able to overcome our challenges.”

“…I think it's crucial for our solution to have an asset tracking component…. Whether it be hardware or software, this could drastically improve our level of service…. Product notes and work order history would reduce the delays caused by variances in configurations and procedures between the different departments.”

“Redmine Benefits: [several points that highlight breadth of features, pre-existence of product components already in use in the immediate environment, presence of existing users and admins on staff….]”

“I really think we're on to something good here and we're moving forward effectively. Perhaps though, not as efficiently as it would if this project was an actual part of our daily responsibilities. When judging outcome, I think that is a major factor. Being a side project, this may not be getting the priority it rightfully deserves.”

“I initiated a meeting for tomorrow in order to discuss our current standings. I feel as if we are going stagnant and I'm not quite sure where the break down is occurring. Hopefully we'll be able to get back on track after our next meeting.”

“Personally, I haven't had much time to devote to the project this week. It also seems like my group is just losing steam. Honestly, not quite sure where we currently stand…. I highly doubt our lag has anything to do with lack of interest but more so over commitment to our job functions…. I am going to try and personally recommit a determinant amount of time to this project (ie.. my lunch hour every day or a single day a week) to see if that makes for better time management.”

“I continue to be impressed by the utility of the Slack tool in our group. As we all discussed this past week in the larger meeting, the example of how [Part3] was able to quickly reach out for

help on the problem of the rouge router was really a shining example of how a real time group chat tool would serve [our IT group]."

Theme: task-, product-, or process-centrism

"Interested in an integrated solution… Combine help desk, knowledgebase, inventory, forum/real time communications, etc.; Benefit of having worldwide community support – many outlets to get support with the product; New employees could already have experience with product… Discussed: [bullet points of several products and their key features]…. Regardless of solution, we need: [more bullet points]"

"Last week we installed Windows Server 2012 and Spiceworks. This week we spent some time together touring our Spiceworks install, looking through the apps (inventory, knowledgebase, ticketing) and available options. We decided that we would like to investigate Spiceworks further…."

"My group moved on from SpiceWorks for a number of different reasons while I was out of the office on vacation. While I did like the product, there were a number of things that just were not going to work for us. My biggest issue was with the ads. While they were IT related and not overly obtrusive, they still were ads and took away from the experience… The other big downside was the lack of a rich text editor."

"Something I've noticed already is how effective the Slack tool has been at connecting us. I've only really been using it for a few days and I can already tell you that I feel more connected to the members of this project than I did before using it."

"I think that the quicker we evaluate the remaining solutions and pick something, the better. I think people (at least my group) are starting to feel a bit disengaged because we've setup our proposed solution (Redmine) and are kind of in wait and see what happens next mode."

Themes: competitiveness, being / promoting the "best"

"Review of other group's proposals: no ability to like others' posts; no training videos…; no RTC… requires high amount of customization…"

"Speaking of contributing more, I think you can thank our group and our contributions for stimulating the others. Although they may have had good conversations and ideas, I believe by us bringing actual products to the table and even going further and evaluating those products and being able to adequately introduce them to the group, we have set a high bar. You will get more meaningful dialog as a result."

"I think there is real value in adopting Redmine in bace vs. Drupal because we are already using Redmine in three areas of [our IT group]…. Do any of us really want to add yet another system to our daily workflow? I think this is something that we should consider carefully."

Part9: "Should this Redmine how-to article be nested under any specific category or should Redmine be a category of its own?"
Part10: "File it under 'Awesome'…."
Part5: "Lol. Is it an unfair advantage that searching for this article is going to be extremely easy considering it will show at the top of the 'Recent Articles' list?"
Part9: "No. We rule."

Part10: "Group3 channel is where it's at"

COMMENTS FROM GROUP 2 MEMBERS

Themes: face-to-face versus virtual meetings, honing of collaborative skills

"Guys, for next time…. I wish one of us had taken notes in the meeting. I did it last time and totally spaced and forgot about it today. I felt like we had a pretty rich discussion and that some of it is probably missing from this write up above. Maybe next time we should designate a note taker (nothing too elaborate required). We might even just put the notes right into a Forum post. (Initially I was thinking we would be writing this doc in a synthetic way -- like massaging each other's words. If this format is working for us, though, I don't see any reason why we can't just put some stuff right in the Forums. But let's think about that.)"

"This week it was difficult for us to meet face-to-face. I ([the Facilitator]) think we got off to a disadvantaged start at the beginning of the whole study in that we could not meet that first week

until late in the week. It feels like that sort of set the rhythm for when our group meets -- e.g., meeting late one week makes it less likely that we will want to meet early the next. And the big group meeting this week also robbed of us Wednesday and also contributed to the sense of "well, we just talked," so no one was chomping at the bit to make another meeting happen. Top that off with [Part11] having appointments and the rest of us busy in our own ways and we just couldn't make the f2f thing happen. But instead of fighting that, we recognized we'd be better off doing a video call to meet up, especially since the plan was to go through a practice / demo session of how to import an OVF / VM appliance into VMware…."

"Today we met in a lab in order to work on stuff together and be able to discuss things while we worked. This seemed to work well…."

"It feels like we're on the verge of something. From what I can tell I think we have all been positive and mostly productive. I would like to know how others in the group feel."

Themes: inclusion, attributions of credit, fairness / shared labor (people-centrism)

"We missed [Part11] but I thought we still had a good meeting today. [Part8] said he'd create a Google doc and share it with us all so we can write up our thing for this week. My scribblings regarding needs and features might be useful in that regard:…"

"In this week's meeting, all were in attendance, and we were able to cover a lot of the topics and systems represented in the large group meeting on Wednesday, which I had missed…."

"I asked about the possibility of soliciting some opinions from [non-Bace colleagues] outside the study in order to get some more feedback about the usefulness of our system…."

"Also discussed was how to assign the different products to each group to evaluate further. We talked a bit about having each groups evaluate a product they aren't as familiar with. This would eliminate the tendency to favor products they have used in the past."

"[The Facilitator] is looking at WikiMedia's MediaWiki…. [Part11] is going to check out possibilities for a local Kace install. While that's happening, [the Facilitator], [Part2], and [Part8] will browse the Appliances scene and keep on the lookout for additional possibilities. Then we can all jump into Kace when we have next steps there."

“[Part8] hooked us up with the steps necessary to make it happen with zero thought on our side, and I did a screen sharing session where everyone could see my desktop to view the process. I also used screen capture software to record the steps so that we could turn our video meeting into a kind of tutorial or walk through to benefit others in the group…. [Part8] is going to combine those and I will post to Sakai for the whole group to see.)”

“The initial group test was 1 on 1 with [Part11] testing integration and functionality. Secondary test was 2-1 with [Part8], [Part11] and [Part2]. After successful testing we connected with [the Facilitator] for a preliminary conference and group demo 4-1. Here we explained how to connect, launch the display screen portion of the app and toggle which items to show on the screen or to display the entire screen.”

“[Part11] and [the Facilitator] met over [Google Hangouts] to discuss the state of our evaluations and think about next steps. For instance, is there anything else about MediaWiki (MW) that we want to evaluate, or should we move on to evaluating something else? [Part11] is interested to see what Redmine has to offer, and we also want [Part2] and [Part8] to provide input as to any specific products they may want to evaluate. We think we have enough to time to consider one or maybe two other products, depending on how much time we want to spend on them.”

“Still To do:
- can we lock individual pages (prevent some people from editing) – [Part11]
- can we limit access by role (edit only some pages / namespaces) – [Part2]
- are there extensions that would let us say "yes" to some of the "no's" or blanks in the rubric under MW – [the Facilitator] and [Part8]”

“In the meanwhile we tried to rollback our site to a previous state based on some backups [the Facilitator] had set up…. Then we realized that [the Facilitator] had mistakenly ‘sourced’ the wrong database-dump file into our mediawiki db. [Part2] also picked up on this, though he also indicated he used alternate ways of directing the dump file…. After restoring the db from the right source, functionality was back to normal.”

Themes: enjoyment, rapport, or lack thereof (more people-centric valuation)

"I think we had a good meeting, and it was great to sit down at a table and talk with other members of the group, and to have a voice in the discussion. I got to spend a little bit of extra time before and after the meeting talking with [Part8] and getting to know him better, which is one of the most important and worthwhile qualities of group interaction such as this…"

"It's tough to keep momentum going for this long of a project, especially in the midst of a busy semester for most of us. I wasn't sure how much I would enjoy this kind of collaboration when this started, but I find it very useful."

"The tone of our interaction I feel as been consistently positive. It's obvious (and inevitable) that some people will participate more than others, but in general I feel like everyone is trying to contribute."

"I think that working collaboratively is almost always beneficial from both a technical and social perspective. It's most definitely helped to integrate our new colleagues from [a new department] into our environment. It's been a chance for them to learn more about our computing environment, as well as us to find out how they currently run their operation."

"A challenge to collaboration for me, is fear of being rejected or discounted…. This is often a deterrent for me personally…. Personally, I feel recommending something [different] is dangerous and will cause me to be devalued and snubbed…. This week I was pleasantly surprised to hear that [Part10] and I had common view points and concerns."

"I thought it was fun and productive and we also made jokes at the same time."

"I think I have developed a new working friendship with one of our my team members…. the project changed our relationship to one where I feel I can have not only have improved working relations but an open friendship.…"

Theme: task-, product-, or process-centrism

"We said that we would like some kind of profile section wherein….We also discussed the advantage such a profile system would have…. We wanted to see a feature that promotes or suggests problems from our database of articles that are relevant and might be helpful…"

"Guys, Just as group 3 is homing in on testing Spiceworks, I think it would be good for us to consider what our group would like to test as part of this process. Kace may be an easy one since we already have an instance running in our environment, yet we have never really investigated its use from a CKS point of view. Thoughts?"

"We noted that there currently seems to be three classes of systems that the WG is considering: 1) integrated IT one-stop-shop solutions (like Spiceworks and Kace), 2) content management systems (like Drupal; we also mentioned Joomla and Wordpress in this context), and 3) wiki-style solutions that focus squarely on document creation and sharing…. Everyone seems to like the features of Spiceworks…. Kace is a disappointment in the KB category as well…. Our group decided that we will now turn our attention to the wiki products we have running: MediaWiki and Twiki…."

"For the most part we focused on our MediaWiki project. Actually, the bulk of the focus was spent on a new instance that [the Facilitator] installed from scratch. Relying on the bitnami VM kind of obscured some of the possibilities because we were not exposed to all the potential options available during the installation process. Doing a manual install allowed us to choose to install the Advanced editor, for instance, which seems to add some significant functionality to the WYSIWYG editing toolbar. [The Faciliator] also spent some time playing with skins to enhance the aesthetic experience and investigating strategies for organizing content (namely namespaces and category pages)."

"I think at this point it would helpful to start eliminating some options (like KACE) and start to focus on 2-3 'finalists.' I was also thinking it might be good to start trying to mold something specific. For example, decide exactly what we want Drupal to look like and be able to do, and see if the group working on it can make it happen, as a way to test how easy it will be to adapt it to our needs."

“Things like ratings, gold stars, etc. to me are completely useless and even counter-productive. The more time spent on these kinds of window dressing items, the less time and resources there are to devote to the core functionality.”

Theme: (obstacles to) effectiveness and efficiency, venue / task appropriateness

“So in many ways I think we turned our challenges into a pretty good session. No one had to travel, no sitting around a crowded desk was required, and everyone was able to hear and see each other (and my screen) and interact. On top of that, we did lay some foundations for further progress in evaluating Kace. These are just my impressions, of course, but I thought it went pretty well. This definitely seems like a viable alternative to meeting f2f on those occasions where it just can’t happen, or when time is better spent on the video call than in finding parking.”

“I saw this meeting as not only as a means for our group to get together electronically, but also as a way to see if this kind of remote screen sharing/webchat concept would be beneficial to integrate into our final BACE project. I think it could be very helpful on an ad hoc basis, i.e. when asking questions of a colleague, they could quickly and easily share their screen as a means for explaining something.”

“I am liking the Hangouts approach for things like this -- i.e., screensharing and walk throughs are nice. I am wondering if this will continue to be sufficient as we get into nitty grittier territory. This could be a real challenge. Working on very technical issues ‘together’ can be beneficial I think but I’m not sure how we can integrate that into our flow without causing too many hardships or disruptions time-wise. I think we should try to come up with some possibilities.”

“[The Facilitator] suggested that there may be a tradeoff between complexity and aesthetic flexibility versus the immediacy a system with less complexity may have. For instance, MW will not out-of-the-box provide a lot of control over visual elements other than by swapping out skins. Systems like Drupal and Joomla also use ‘templates’ that perform a similar function, but there seems to be more emphasis on visual flexibility in the CMS world. By contrast, MW seems to emphasize content more than form. Though there are some skins available, only two of these appear to be compatible as-is with the VisualEditor in MW. We’d have to hack up any others to get it to work, which could take real development time….”

“F2F interaction is essential, at least for some of the meetings. I actually think it's more essential for the large group meetings, since you can talk with people outside your own small group. For small groups, I'm not so sure that it's significantly better than video chat.”

Appendix P

Pre and Post Knowledge Scores

Scores in 10 skill areas were computed by taking the participant's self-rating on a scale of 1 to 5 (with 5 meaning "very strong") and weighting (multiplying) it by the percentage of participants who ranked a given participant as "better than average" in the given area. Facilitator scores (italicized) are based on post-hoc self-ratings weighted by actual "better than average" ratings of other participants.

Raw knowledge score deltas (ending minus initial values)

deltas (post minus pre)											
	As rated by others, weighted by self rating (max=5)										
	with Facilitator estimated										
	Windows	**MacIntosh**	**Linux**	**Networking**	**Programming**	**Visual /**	**Databases**	**Web**	**Problem**	**Collaboration**	overall
Facilitator	*0.00*	*0.03*	*0.00*	*0.36*	*0.00*	*0.00*	*0.76*	*0.11*	*0.00*	*1.27*	*0.25*
Part1	0.41	0.00	0.00	0.63	0.40	0.35	0.65	0.33	0.25	0.82	0.38
Part2	0.93	0.65	2.82	0.14	1.18	-0.33	0.91	2.41	1.73	0.52	1.10
Part3	1.59	-0.18	0.40	1.16	0.65	0.20	0.80	0.05	1.09	1.34	0.71
Part4	2.09	0.00	-0.25	0.07	0.01	0.00	0.11	-0.13	0.86	0.45	0.32
Part5	0.58	0.30	0.01	1.64	0.00	0.00	0.00	0.00	1.73	3.18	0.74
Part6	0.87	-0.50	-0.42	0.64	-0.02	1.24	0.95	0.62	0.69	1.09	0.52
Part7	2.40	0.30	1.77	2.59	0.90	0.00	1.64	1.60	1.75	1.19	1.41
Part8	0.93	-0.06	0.00	0.69	0.22	0.04	0.00	0.13	0.47	0.42	0.28
Part9	1.05	0.69	-0.27	0.46	0.95	0.12	0.33	0.24	0.91	0.41	0.49
Part10	1.44	0.30	1.23	0.18	0.36	-0.19	0.41	0.32	0.86	1.23	0.61
Part11	2.45	0.00	-0.08	0.25	0.12	0.00	0.11	0.02	-0.04	1.02	0.39
avg	1.23	0.13	0.43	0.73	0.40	0.12	0.56	0.47	0.86	1.08	0.60
sdev	0.78	0.34	0.99	0.74	0.42	0.39	0.49	0.76	0.63	0.75	0.35

Initial and ending knowledge scores with Cohen's d knowledge category effect sizes

	As rated by others, weighted by self rating (max=5)										
	with Facilitator estimated										
	(p values derived from 2-tailed paired t-tests)										
	Windows	**MacIntosh**	**Linux**	**Networking**	**Programming / Scripting**	**Visual / Graphics**	**Databases**	**Web**	**Problem Solving**	**Collaboration**	**overall avg**
WG (pre)											
Facilitator	*4.00*	*0.27*	*4.00*	*3.64*	*3.00*	*0.00*	*1.64*	*1.09*	*4.00*	*2.73*	*2.44*
Part1	1.09	0.00	0.00	0.27	0.00	1.45	0.55	3.27	2.55	3.18	1.24
Part2	0.27	0.55	2.18	0.36	1.82	0.73	1.09	1.09	2.27	0.18	1.05
Part3	2.91	0.18	0.00	1.64	0.55	0.00	0.00	0.55	2.91	1.36	1.01
Part4	2.91	0.00	0.55	2.73	0.09	0.00	0.09	0.73	3.64	4.55	1.53
Part5	1.82	0.00	0.09	0.36	0.00	0.00	0.00	0.00	2.27	1.82	0.64
Part6	0.73	5.00	0.82	1.36	1.82	0.36	0.55	0.18	2.91	2.91	1.66
Part7	0.00	0.00	2.73	0.91	0.00	0.00	0.36	0.00	1.45	0.91	0.64
Part8	2.27	0.36	0.00	0.91	0.18	0.36	0.00	0.27	2.73	3.18	1.03
Part9	2.55	2.91	0.27	1.64	1.45	0.18	0.27	0.36	4.09	4.09	1.78
Part10	1.36	0.00	2.27	1.82	3.64	1.09	4.09	3.18	3.64	3.27	2.44
Part11	2.55	0.00	0.18	2.55	0.18	0.00	0.09	0.18	3.64	2.18	1.15
avg	1.87	0.77	1.09	1.52	1.06	0.35	0.73	0.91	3.01	2.53	1.38
sdev	1.21	1.56	1.35	1.05	1.27	0.49	1.17	1.14	0.81	1.29	0.61

	Windows	**MacIntosh**	**Linux**	**Networking**	**Programming / Scripting**	**Visual / Graphics**	**Databases**	**Web**	**Problem Solving**	**Collaboration**	**overall avg**
WG (post)											
Facilitator	*4.00*	*0.30*	*4.00*	*4.00*	*3.00*	*0.00*	*2.40*	*1.20*	*4.00*	*4.00*	*2.69*
Part1	1.50	0.00	0.00	0.90	0.40	1.80	1.20	3.60	2.80	4.00	1.62
Part2	1.20	1.20	5.00	0.50	3.00	0.40	2.00	3.50	4.00	0.70	2.15
Part3	4.50	0.00	0.40	2.80	1.20	0.20	0.80	0.60	4.00	2.70	1.72
Part4	5.00	0.00	0.30	2.80	0.10	0.00	0.20	0.60	4.50	5.00	1.85
Part5	2.40	0.30	0.10	2.00	0.00	0.00	0.00	0.00	4.00	5.00	1.38
Part6	1.60	4.50	0.40	2.00	1.80	1.60	1.50	0.80	3.60	4.00	2.18
Part7	2.40	0.30	4.50	3.50	0.90	0.00	2.00	1.60	3.20	2.10	2.05
Part8	3.20	0.30	0.00	1.60	0.40	0.40	0.00	0.40	3.20	3.60	1.31
Part9	3.60	3.60	0.00	2.10	2.40	0.30	0.60	0.60	5.00	4.50	2.27
Part10	2.80	0.30	3.50	2.00	4.00	0.90	4.50	3.50	4.50	4.50	3.05
Part11	5.00	0.00	0.10	2.80	0.30	0.00	0.20	0.20	3.60	3.20	1.54
avg	3.10	0.90	1.53	2.25	1.46	0.47	1.28	1.38	3.87	3.61	1.98
sdev	1.34	1.52	2.05	1.00	1.35	0.64	1.31	1.36	0.63	1.27	0.52

	Windows	**MacIntosh**	**Linux**	**Networking**	**Programming / Scripting**	**Visual / Graphics**	**Databases**	**Web**	**Problem Solving**	**Collaboration**	**overall avg**
WG (pre to post contrast)											
p values	0.0002	0.2209	0.1574	0.0055	0.0078	0.3172	0.0024	0.0536	0.0007	0.0004	0.0001
cohen's d	0.9642	0.0826	0.2503	0.7163	0.3027	0.2077	0.4467	0.3770	1.1895	0.8444	1.0603

Raw knowledge score deltas by small group (ending minus initial values)

deltas (post minus pre)											
	As rated by others, weighted by self rating (max=5)										
	Windows	**MacIntosh**	**Linux**	**Networking**	**Programming / Scripting**	**Visual / Graphics**	**Databases**	**Web**	**Problem Solving**	**Collaboration**	overall avg
SG1											
Part1	0.41	0.00	0.00	0.63	0.40	0.35	0.65	0.33	0.25	0.82	0.38
Part3	1.59	-0.18	0.40	1.16	0.65	0.20	0.80	0.05	1.09	1.34	0.71
Part6	0.87	-0.50	-0.42	0.64	-0.02	1.24	0.95	0.62	0.69	1.09	0.52
Part7	2.40	0.30	1.77	2.59	0.90	0.00	1.64	1.60	1.75	1.19	1.41
avg	1.32	-0.10	0.44	1.25	0.48	0.45	1.01	0.65	0.95	1.11	0.76
SG2											
Facilitator	*0.00*	*0.03*	*0.00*	*0.36*	*0.00*	*0.00*	*0.76*	*0.11*	*0.00*	*1.27*	*0.25*
Part2	0.93	0.65	2.82	0.14	1.18	-0.33	0.91	2.41	1.73	0.52	1.10
Part8	0.93	-0.06	0.00	0.69	0.22	0.04	0.00	0.13	0.47	0.42	0.28
Part11	2.45	0.00	-0.08	0.25	0.12	0.00	0.11	0.02	-0.04	1.02	0.39
avg	1.08	0.15	0.68	0.36	0.38	-0.07	0.45	0.67	0.54	0.81	0.50
SG3											
Part4	2.09	0.00	-0.25	0.07	0.01	0.00	0.11	-0.13	0.86	0.45	0.32
Part5	0.58	0.30	0.01	1.64	0.00	0.00	0.00	0.00	1.73	3.18	0.74
Part9	1.05	0.69	-0.27	0.46	0.95	0.12	0.33	0.24	0.91	0.41	0.49
Part10	1.44	0.30	1.23	0.18	0.36	-0.19	0.41	0.32	0.86	1.23	0.61
avg	1.29	0.32	0.18	0.59	0.33	-0.02	0.21	0.11	1.09	1.32	0.54

Initial and ending knowledge scores with Cohen's d effect sizes, by small groups (SG)

	By small groups with Facilitator estimated										
	Windows	**MacIntosh**	**Linux**	**Networking**	**Programming / Scripting**	**Visual / Graphics**	**Databases**	**Web**	**Problem Solving**	**Collaboration**	overall avg
SG1 (pre)											
Part1	1.09	0.00	0.00	0.27	0.00	1.45	0.55	3.27	2.55	3.18	1.24
Part3	2.91	0.18	0.00	1.64	0.55	0.00	0.00	0.55	2.91	1.36	1.01
Part6	0.73	5.00	0.82	1.36	1.82	0.36	0.55	0.18	2.91	2.91	1.66
Part7	0.00	0.00	2.73	0.91	0.00	0.00	0.36	0.00	1.45	0.91	0.64
avg	1.18	1.30	0.89	1.05	0.59	0.45	0.36	1.00	2.45	2.09	1.14
sdev	1.24	2.47	1.29	0.60	0.86	0.69	0.26	1.53	0.69	1.12	0.43
SG1 (post)											
Part1	1.50	0.00	0.00	0.90	0.40	1.80	1.20	3.60	2.80	4.00	1.62
Part3	4.50	0.00	0.40	2.80	1.20	0.20	0.80	0.60	4.00	2.70	1.72
Part6	1.60	4.50	0.40	2.00	1.80	1.60	1.50	0.80	3.60	4.00	2.18
Part7	2.40	0.30	4.50	3.50	0.90	0.00	2.00	1.60	3.20	2.10	2.05
avg	2.50	1.20	1.33	2.30	1.08	0.90	1.38	1.65	3.40	3.20	1.89
sdev	1.39	2.20	2.13	1.12	0.59	0.93	0.51	1.37	0.52	0.96	0.27
p values	0.0563	0.6086	0.4239	0.0731	0.0902	0.2012	0.0187	0.1493	0.0583	0.0020	0.0458
cohen's d	1.0005	-0.0408	0.2497	1.4017	0.6594	0.5441	2.5207	0.4473	1.5538	1.0635	2.1167

	Windows	MacIntosh	Linux	Networking	Programming / Scripting	Visual / Graphics	Databases	Web	Problem Solving	Collaboration	overall avg
SG2 (pre)											
Facilitator	*4.00*	*0.27*	*4.00*	*3.64*	*3.00*	*0.00*	*1.64*	*1.09*	*4.00*	*2.73*	*2.44*
Part2	0.27	0.55	2.18	0.36	1.82	0.73	1.09	1.09	2.27	0.18	1.05
Part8	2.27	0.36	0.00	0.91	0.18	0.36	0.00	0.27	2.73	3.18	1.03
Part11	2.55	0.00	0.18	2.55	0.18	0.00	0.09	0.18	3.64	2.18	1.15
avg	2.27	0.30	1.59	1.86	1.30	0.27	0.70	0.66	3.16	2.07	1.42
sdev	1.53	0.23	1.89	1.50	1.37	0.35	0.79	0.50	0.80	1.32	0.68
SG2 (post)											
Facilitator	*4.00*	*0.30*	*4.00*	*4.00*	*3.00*	*0.00*	*2.40*	*1.20*	*4.00*	*4.00*	*2.69*
Part2	1.20	1.20	5.00	0.50	3.00	0.40	2.00	3.50	4.00	0.70	2.15
Part8	3.20	0.30	0.00	1.60	0.40	0.40	0.00	0.40	3.20	3.60	1.31
Part11	5.00	0.00	0.10	2.80	0.30	0.00	0.20	0.20	3.60	3.20	1.54
avg	3.35	0.45	2.28	2.23	1.68	0.20	1.15	1.33	3.70	2.88	1.92
sdev	1.61	0.52	2.60	1.51	1.53	0.23	1.23	1.51	0.38	1.49	0.62
p values	0.1243	0.4249	0.4073	0.0563	0.2560	0.4564	0.1466	0.3353	0.2807	0.0286	0.0852
cohen's d	0.6848	0.3854	0.3011	0.2399	0.2610	-0.2462	0.4313	0.5910	0.8649	0.5735	0.7731

	Windows	MacIntosh	Linux	Networking	Programming / Scripting	Visual / Graphics	Databases	Web	Problem Solving	Collaboration	overall avg
SG3 (pre)											
Part4	2.91	0.00	0.55	2.73	0.09	0.00	0.09	0.73	3.64	4.55	1.53
Part5	1.82	0.00	0.09	0.36	0.00	0.00	0.00	0.00	2.27	1.82	0.64
Part9	2.55	2.91	0.27	1.64	1.45	0.18	0.27	0.36	4.09	4.09	1.78
Part10	1.36	0.00	2.27	1.82	3.64	1.09	4.09	3.18	3.64	3.27	2.44
avg	2.16	0.73	0.80	1.64	1.30	0.32	1.11	1.07	3.41	3.43	1.60
sdev	0.70	1.45	1.00	0.97	1.70	0.52	1.99	1.44	0.79	1.20	0.75
SG3 (post)											
Part4	5.00	0.00	0.30	2.80	0.10	0.00	0.20	0.60	4.50	5.00	1.85
Part5	2.40	0.30	0.10	2.00	0.00	0.00	0.00	0.00	4.00	5.00	1.38
Part9	3.60	3.60	0.00	2.10	2.40	0.30	0.60	0.60	5.00	4.50	2.27
Part10	2.80	0.30	3.50	2.00	4.00	0.90	4.50	3.50	4.50	4.50	3.05
avg	3.45	1.05	0.98	2.23	1.63	0.30	1.33	1.18	4.50	4.75	2.14
sdev	1.15	1.71	1.69	0.39	1.93	0.42	2.13	1.58	0.41	0.29	0.71
p values	0.0271	0.1071	0.6478	0.1994	0.2345	0.7947	0.1118	0.3765	0.0143	0.1352	0.0091
cohen's d	1.3594	0.2036	0.1293	0.7949	0.1812	-0.0382	0.1026	0.0708	1.7396	1.5131	0.7454

Summary of Cohen's d knowledge category effect sizes for whole group (WG) and small groups (SG)

	effect sizes (Cohen's d) = (avg2-avg1)/(squareroot of ((stdDev1Squared+stdDev2Squared)/2))									
	Windows	**MacIntosh**	**Linux**	**Networking**	**Programming / Scripting**	**Visual / Graphics**	**Databases**	**Web**	**Problem Solving**	**Collaboration**
WG	0.9642	0.0826	0.2503	0.7163	0.3027	0.2077	0.4467	0.3770	1.1895	0.8444
SG1	1.0005	-0.0408	0.2497	1.4017	0.6594	0.5441	2.5207	0.4473	1.5538	1.0635
SG2	0.6848	0.3854	0.3011	0.2399	0.2610	-0.2462	0.4313	0.5910	0.8649	0.5735
SG3	1.3594	0.2036	0.1293	0.7949	0.1812	-0.0382	0.1026	0.0708	1.7396	1.5131
	effect sizes having p values <= .05 highlighted									
WG	0.9642	0.0826	0.2503	0.7163	0.3027	0.2077	0.4467	0.3770	1.1895	0.8444
SG1	1.0005	-0.0408	0.2497	1.4017	0.6594	0.5441	2.5207	0.4473	1.5538	1.0635
SG2	0.6848	0.3854	0.3011	0.2399	0.2610	-0.2462	0.4313	0.5910	0.8649	0.5735
SG3	1.3594	0.2036	0.1293	0.7949	0.1812	-0.0382	0.1026	0.0708	1.7396	1.5131

Appendix Q

Participant Small-group Characteristics

SG1		SG2			SG3	
Members:	Part1	Members:	Part2		Members:	Part4
	Part3		Part8			Part5
	Part6		Part11			Part9
	Part7		*Fac*			Part10
ADs	0	ADs	*1*		ADs	2
YOSI	7.00	YOSI	8.67	*10.25*	YOSI	9.50
YOSU	15.50	YOSU	12.67	*13.25*	YOSU	10.25
PWI	3.25	PWI	3.67	*3.75*	PWI	2.75

ADs	= Number of Assistant Directors
Fac	= Facilitator
Part	= Participant label / name replacement
PWI	= Agreement with "I prefer to work independently" (mean)
SG	= Small group number
YOSI	= Years of service in IT unit (mean)
YOSU	= Years of Service at University (mean)
Italic	= values include Facilitator

Appendix R

A Slack Exchange Demonstrating Several Learning Opportunities

Part3 [10:23 AM] Anyone having internet issues at the moment? <Department> is apparently not able to access the internet.

Part10 [10:24 AM] everything appears to be working here

Part9 [10:24 AM] I am fine in <Building name 1>

Part2 [10:25 AM] We were ok in <Building name 2>

Part8 [10:28 AM] check the network status if your connected to one of those routers <network status URL>

Part3 [10:28 AM] Actually seems like it might be a DNS issue. Machines are up and I'm able to connect, but when viewing the IP information the DNS came up as 192.168.1.1 I renewed and it picked up <University DNS / DHCP Server IP>, but just now lost it again

Facilitator [10:29 AM] can you ping <University DNS / DHCP Server IP>?

Part10 [10:29 AM] Are you able to check which DHCP server is providing that DNS data?

Part3 [10:31 AM] yes i can ping and it's responding.

Facilitator [10:31 AM] dhcp puke

Part3 [10:32 AM] and it's our dhcp server, <School's DHCP Server IP>

renewing doesn't fix it

Facilitator [10:32 AM] doh give me a mac address of an affected machine. I'll look.

Part3 [10:32 AM] xx-xx-xx-xx-xx-xx currently getting <a private IP>

Facilitator [10:36 AM] subnet is set to use the ... anycast address. Given that you're seeing 192.x.x.x almost seems like there's a rogue device on your net. does arp -a show you anything?

Part3 [10:38 AM] <arp dump>

Part8 [10:42 AM] Are there any hops between you and the 192.x.x.x address. If not, try dropping the host address, flushing DNS info and renewing the host address with, 'ipconfig/release & ipconfig/flushdns & ipconfig/renew'

Facilitator [10:42 AM] 192 is not routed on our network.

Part8 [10:43 AM] I know. I think someone may have plugged in a device to his network.

Part3 [10:43 AM] If I renew it picks up <University DNS / DHCP Server IP> as the DNS. But then after a short while it changes to 192.168.1.1

Part8 [10:44 AM] Are there multiple host getting this info and are there any new devices on the network?

Part3 [10:46 AM] They were having widespread but short internet issues earlier this morning. For most people the internet access seemed to come back up, but some are still having issues. I just tried the release, flush, renew, and got this: An error occurred while

renewing interface Local Area Connection 2 : The name specified in the network control block (NCB) is in use on a remote adapter. The NCB is the data.

Part8 [10:49 AM] Is the host statically defined in DHCP?

Part3 [10:50 AM] The affected people are not all on the same switch either. This person (<a private IP>) is on <switch name>. Someone else reporting issues is on <switch name> Yes it's assigned in DHCP. No issues picking up the right IP address

Part8 [10:53 AM] If Facilitator doesn't have an idea you might need to reach out to the NOC.

Part3 [10:54 AM] Yeah I'm trying to at least narrow the issue down if I can.

Part8 [10:55 AM] manually cofig the host and see if name resolution is clean or OK.

Part3 [10:56 AM] yeah i'm trying manually configuring just the DNS and seeing what happens. fwiw my computer in <Department>, on public IP, is not having any issues.

things seem fine with DNS manually set Facilitator, think we should try restarting our DHCP server?

Facilitator [11:15 AM] Got sidetracked. I restarted dhcp, though I doubt that will help if you have a rogue device somewhere. http://<a different private IP> what is that?

Part3 [11:17 AM] podium in the library that's the av receiver i think

Facilitator [11:17 AM] there is also .42.

Part3 [11:18 AM] sorry, .41 is iboot, .42 is the receiver

Facilitator [11:19 AM] did you say this was the only IP subnet affected?

Part3 [11:20 AM] seems to be. my machine on public IP is fine. Not sure about the private IP space used by the lab, haven't checked yet.

Facilitator [11:20 AM] <yet another private IP> has ssh open. Know what that is?

Part3 [11:21 AM] Also part of the podium, that's the iMac.

Facilitator [11:22 AM] looking at dhcp log...

Part3 [11:26 AM] don't seem to be any issues with the private IP used by the lab computers

Facilitator [11:30 AM] same net or different?

Part3 [11:30 AM] lab computers are on a different subnet i tried renewing one of the affected systems since you restarted DHCP, same issue

Facilitator [11:31 AM] This is not making any sense to me.... Do you know who machine machines this is happening on?

Part3 [11:32 AM] it seems like most or all of the staff are affected, as well as various faculty

Part11 [11:32 AM] this sounds like a similar issue I had recently. It turned out to be a rogue wireless router handing out 192 IPs. I think I used something similar to this to track it down (ironically, this is from spiceworks.)
https://community.spiceworks.com/topic/407813-find-rogue-dhcp-server

Part3 [11:32 AM] these are wired connections

Part10 [11:35 AM] @Part3: The machines may be wired but a wireless router plugged into your switch running DHCP could cause problems like this though it seems weird that the DNS address is the only attribute affected, right?

Part3 [11:36 AM] yes

Part10 [11:36 AM] :thinking_face:

Facilitator [11:37 AM] after you see the dns change, issue ipconfig /all and look at the dhcp server attribute. does it also change?

Part3 [11:41 AM] no, still reports our DHCP, <School's DHCP Server IP> okay i ran that rouge dhcp server tool, and it's saying there's 2 rouge servers, ours and one with 192.168.1.1

Facilitator [11:42 AM] here's a far out idea -- set up a VM in bridged mode. Put it on the same net as 192.168.1.1. Ping 192.168.1.1 then issue arp -a intesting Or you can statically assign 192.168.1.2 to one of the affected machines, ping .1 and then arp. If we can get the mac, we can look on the switch to see what switch port it's on.

Part3 [11:44 AM] okay, i'm going to need to sit at an affected machine. brb

Part3 [12:02 PM] OKay I did that and arp-a shows <arp dump>

Facilitator [12:04 PM] aha! <culprit's MAC address>

Part3 [12:04 PM] yeah l2/l3 shows nothing unfortunately.

Facilitator [12:04 PM] tplink technologies

Part10 [12:04 PM] http://macaddress.webwat.ch/hwaddr/3C:46:D8 Facilitator beat me to it

Facilitator [12:05 PM] Do you recall the switch address, Part3?

Part3 [12:06 PM] Which switch?

Facilitator [12:06 PM] whichever one(s) the machines in your building would be connected to. You've given them to me in the past. I'm lazy.

Part3 [12:07 PM] machine i'm on now connects to <switch name>

Facilitator [12:07 PM] ok, good start. I'll look. vlan 999, port 2/52. wait, that's the trunked uplink. I think I got it. On <switch name>: 2/37 4023 connected 999 normal a-full a-100 10/100/1000 do you know where drop 4023 is?

Part3 [12:14 PM] yes, room 415

Facilitator [12:14 PM] seek and destroy kill superman destroy superman

Part3 [12:14 PM] thanks

Facilitator [12:15 PM] let us know how it turns out.

Part3 [12:23 PM] Mission successful. It was tucked away behind a desk and computer, wouldn't have found it easily otherwise. Thanks Facilitator, and everyone else for your suggestions.

Facilitator [12:24 PM] woo hoo - major Slack success! :stuck_out_tongue: Oouah. ...

Part8 [12:24 PM] What type of device is it?

Part3 [12:26 PM] TP-Link wireless router ...

Part7 [12:26 PM] :thumbsup: