THE SOCIOMATERIALITY OF TEAMWORK PROCESSES

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SUMMARY

Modern teams use and rely on technology to work together. Technology can enable and constrain teamwork, and can also expand the behaviors available to team members. This dissertation advances and tests the idea that the use of technology is a fundamental aspect of teamwork processes and a key determinant of team success. This work introduces the term *process sociomateriality* to reflect member interactions that are enabled, augmented, or impaired by the use of technology during taskwork. The sociomaterial view differs from prior work, which has favored *either* a technology centric (e.g. Kirkman & Mathieu, 2005) *or* human centric perspective (e.g., Marks, Mathieu, & Zaccaro, 2001). In contrast, the term *process sociomateriality* builds upon recent assertions that there is an inextricable linkage between the social (human-centric forces) and material (technology-centric forces) (Leonardi, 2011; Orlikowski & Scott, 2008).

This dissertation uses qualitative and quantitative methods to examine how process sociomateriality is embodied in modern teamwork, and how this phenomenon subsequently shapes team effectiveness. The program of research is divided into three studies: 1) a qualitative critical incident study, 2) survey development and pilot testing, and 3) a quasi field study. Studies 1 and 2 are foundational, developing the construct and a measure of process sociomateriality. Study 3 expands on this work by examining the effects of process sociomateriality on team functioning and effectiveness in a study of partially-distributed teams. This program of research focuses on the use of a specific form of technology: new media. New media is an analogous term to "communication technology", and refers to forms of electronic communication that may facilitate interaction amongst individuals (e.g. Skype, Facebook, Teleconference, E-Mail, etc.).

Study 1. In order to ground the concept of process sociomateriality, a critical incident study (Flanagan, 1954) was conducted to identify dimensions that capture sociomaterial team process. Eighty-nine participants who had just completed a semester long class project in one of 33 partially distributed teams generated the incidents. In all, 301 unique critical incidents were written detailing how a new media platform 1) helped or 2) hindered their teamwork. A panel of subject matter experts (SMEs) then sorted and categorized the incidents. This effort resulted in a tripartite taxonomy of the different types of process sociomateriality that a team may exhibit. The taxonomy is comprised of three higher-order factors (process facilitation, process impairment, and process expansion), each of which consists of 4-6 lower-order behaviors. The taxonomy was then validated using a second panel of SMEs.

Study 2. A survey measure of process sociomateriality was developed based upon the taxonomy developed in Study 1. The purpose of Study 2 was twofold: 1) to assess the content adequacy of the measure using a panel of SMEs, and 2) to pilot the measure in the general population via an online survey platform (Qualtrics). Participants completed the measurement battery concerning an effective team that they participated on ($n = 632$), an ineffective team ($n = 653$), or both ($n = 544$). Results from this administration revealed acceptable psychometric scale properties, and demonstrated support for a three-factor structure of process sociomateriality. Moreover, analysis of the nomological network yielded support for discriminant and convergent validity of process sociomateriality with relevant team constructs.

Study 3. Study 3 was an investigation of sociomaterial team process in a sample of 32, 6-7-person virtual teams. These teams were comprised of 213 undergraduate

students who participated in a semester-long group project. The measure developed in Study 2 was used in Study 3 to examine the predictive validity of process sociomateriality in relation to team emergent states and performance. Findings revealed that process sociomateriality (particularly facilitation and expansion) impacts team performance and viability by shaping team emergent states (team satisfaction, team trust, and collective efficacy). In addition, results demonstrate that, in many instances, process sociomateriality better predicts team viability and emergent states than do prior conceptualizations of the teamwork-technology relationship (e.g. team process, team virtuality, virtuality-as-a-moderator).

CHAPTER 1

INTRODUCTION

Two modern organizational teams are working interdependently to construct a task-relevant document. Team A is engaging in this behavior via email, whereas Team B uses Google Docs. According to current frameworks of team process, the interactive behavior of these teams would be classified as "Coordination" (Marks, Mathieu, & Zaccaro, 2001, pg. 363). Marks et al. (2001) posits that teams that engage in this behavior are more likely to succeed than those that do not. Thus, following to this logic, both teams will be equally effective.

This dissertation proposes that the functioning, and subsequent effectiveness, of the aforementioned teams may actually be quite different because of the material aspects of the technology within which their social interactions took place. In modern organizations, team process is shaped not only by member actions, but also by the use of technology. Almost all teams now frequently use and rely on technology to work together (Guinea, Webster, & Staples, 2012; Kirkman, Gibson, & Kim, 2012). Technological platforms possess different functional capabilities, which afford and constrain team process in different ways (Hutchby, 2001; Leonardi, 2012). For instance, email enables textual exchange between members, but constrains their ability to interact synchronously. On the other hand, Skype allows geographically distributed members to interact synchronously.

It is important to note that Team A uses email to construct the document. In this circumstance, individual members will construct their portions of the document in isolation, and then pass it off to their teammates one at a time for edits. Team B, on the other hand, uses Google Docs. This allows members to simultaneously contribute to and edit the document as it is being constructed (simultaneous collaboration). The act of watching a teammate compose part of the document may fundamentally change how another member thinks about the topic he or she is writing about. In this instance, this material capability is enabling a type of real-time mental collaboration not possible using other modalities. Thus, despite the fact that both teams are "coordinating," they are actually exhibiting fundamentally different team process behaviors – which may result in different levels of effectiveness.

Accordingly, this dissertation argues that process in modern teams cannot comprehensively be understood by solely considering process behaviors that only consider the social, but not material, aspects of teamwork (e.g. Marks et al., 2001). Rather, there are many instances in which team behavior is inherently intertwined with technology use. As the previous example illustrated, social action is embedded in technology use. Thus, the manner in which teams utilize technology shapes their behavioral processes.

In addition to collaborating simultaneously, technology use opens the door to a variety of other behaviors that are unique to the use of technology. For instance, a member of a geographically distributed team recently noted:

> "I found Basecamp [a project management platform] extremely helpful because everyone got **notifications** of what each person said, and it also gave us **constant reminders** of the work we had to do for this project."

This quotation reflects the fact that technology can automate member coordination by providing notifications and reminders, freeing up resources to focus on other aspects of the task

Likewise, a participant in the same project stated:

> "The video conferencing capabilities [in WebEx] are great, but the ability to calibrate and put down ideas was difficult to do on the platform itself. **We created a Google Doc to solve this problem**. "

This quotation demonstrates that members now have the ability to switch between technological platforms that possess different capabilities to avoid process loss.

Each of these instances depicts behaviors that are not possible without interaction through technology. Instead, they reflect an inextricable linkage between the use of technology and process behavior. Accordingly, the success of modern teams is now largely contingent upon the extent to which team members effectively implement these platforms to work together. Whereas technology can be used to facilitate previously established team process routines, it can also expand the types of behaviors that a team may enact. It follows that the most effective teams in modern organizations are those that can leverage technology to engage in prior process behaviors, while also embracing the potential for new behaviors.

Yet, despite the fact the use of technology has important implications for team success, relatively little is known about the relationship between team process and technology. Current work in this realm emphasizes *either* member actions (e.g. Marks et al., 2001; McGrath, 1964; Ilgen, Hollenbeck, Johnson, & Jundt, 2005) *or* technology (e.g. Gibson & Gibbs, 2006; Hertel, Geister, & Konradt, 2005; Kirkman & Mathieu, 2005;

Olson & Olson, 2000) as the key determinant of team outcomes. A third body of research posits that technology is a moderator that shapes the relationship between team inputs and outcomes (e.g. Bierly, Stark, & Kessler, 2009; Kirkman, Rosen, Tesulk, & Gibson, 2004). In particular, this third perspective examines the extent to which the use of technology (e.g. virtuality: Dixon & Panteli, 2010; Griffith, Sawyer, & Neale, 2003; Schweitzer & Duxbury, 2010) impacts "previously supported predictor-criterion relationships in work team models" (Kirkman & Mathieu, 2004, pg. 4). However, despite the fact that these seemingly disparate perspectives approach team science through a unique lens, each stance makes the assumption that the use of technology and member actions are separate phenomena.

Given that technology not only enables but also leads to new team behaviors, this dissertation asserts that technology is inextricably linked with process in modern teams. Thus, by viewing the use of technology and member actions as distinct phenomena, we are unable to capture the manner in which the use of technology directly contributes to novel process behaviors. To date, no theoretical efforts have embraced the notion that technology is embedded in team process; generally speaking, the literature investigates teams as though they are completely devoid of materiality. This has limited our ability to investigate critical questions such as: What does this synergy between members and technology mean for team functioning? What types of new process behaviors does technology enable? How does this constitutive entanglement between social processes and technology use impact team effectiveness?

This dissertation seeks to address these questions and, in doing so, will make three principle contributions to the literature on team effectiveness. First, this dissertation

will advance knowledge on team process itself. Traditional perspectives on teamwork have posited that team members are primarily responsible for the success and failure of team process (e.g. Crawford & LePine, 2013; Marks et al., 2001; McGrath, 1964), and have engaged in investigations that are devoid of considerations for materiality. It follows that the most widely supported taxonomies for team process do not explicitly consider the use of technology. This dissertation proposes that, in fact, technology use is critical aspect of process. In particular, the use of technology can provide phenomenological changes to the fabric of teamwork. Thus, team process can no longer be comprehensively conceptualized by embracing an entirely human-centric ontological lens.
Rather, this dissertation seeks to complement the existing frameworks of team process by emphasizing the importance of considering the inextricable linkage between process and technology use. This advancement will lead to a more robust and thorough understanding of team process.

To accomplish this aim, this dissertation will advance a theoretical framework designed to lay the foundation for the study of technology and team process. This effort will uncover knowledge on modern teamwork beyond that of traditional perspectives (e.g. Marks et al., 2001) by examining how team process is embodied in technology use. This framework will emphasize the idea that technology not only enables traditional process, but also expands the behavioral repertoire that is available to teams. To accomplish this aim, this dissertation will taxonomize the ways in which technology is inextricably linked with team process.

Second, this dissertation will improve the measurement of technology use in team settings. In particular, this program of research will develop a measure that draws directly upon the aforementioned taxonomy. This measure will allow researchers and practitioners alike to better capture the manner in which technology use is embedded in, and shapes, team process. This advancement will allow us to further understand the interactional dynamics within modern organization-based teams. Moreover, this effort will establish the nomological network between this measure and relevant team constructs (e.g. team process: Marks et al., 2001).

Third, this dissertation will demonstrate how the use of technology shapes critical team states and performance. The literature on teams has consistently demonstrated that team emergent states (e.g. trust, identity, cohesion, motivation) are essential determinants of team success (Salas, Rosen, Burke, & Goodwin, 2009; Mathieu et al., 2008). Previous efforts in this realm have maintained that use of technology (e.g. virtuality) is an irrevocable force that deterministically shapes team outcomes (e.g. Kirkman & Mathieu, 2005; Maynard et al., 2012; Schweitzer & Duxbury, 2010). However, this perspective discounts the fact that members may exhibit agency by altering how technological platforms are implemented and utilized to engage in taskwork, as asserted by Adaptive Structuration Theory (DeSanctis & Poole, 1994). Moreover, this lens also overlooks the manner in which technology leads to novel team process behaviors. Not accounting for these unique aspects of team functioning limits our ability to fully understand the factors that contribute to success and failure in modern teams. This dissertation proposes that these social and technological forces combine to shape team process and, ultimately, team effectiveness (Leonardi, 2011; 2012). Thus, this work will aim to more accurately capture how social action is embodied in technology use, which in turn, will improve our prediction of team outcomes.

CHAPTER 2

LITERATURE REVIEW

This chief problem space of this dissertation lies at the intersection of teams and technology. Therefore, the literature review is divided into two parts. Part one reviews the theoretical foundation for studies of teams and team process. Part two reviews the literature on technology and teams, largely through the lens of "virtuality" (e.g. Gibson & Gibbs, 2006; Kirkman & Mathieu, 2004). Each section includes a substantive critique of each perspective in order to lay the theoretical foundation for the present dissertation.

Part 1: Teams and Team Process

Organizations have come to rely heavily on team-based work to accomplish their objectives (Hollenbeck, Beersma, & Schouten, 2012). Teams are defined as small groups of interdependent individuals who share responsibility for outcomes (Ilgen, 1999). In fact, the majority of organizations now utilize teams as the standard units of production (Devine, Clayton, Philips, Dunford, & Melner, 1999; Garvey, 2002; Hollenbeck, Beersma, & Schouten, 2012). Survey data has revealed that the use of teams in organizational settings increased from 20% in 1980 to 80% in 2000 (Garvey, 2002), and recent findings suggest that as many as 85% of today's organizations use teams for project-based work (Blanchard, 2013).

Organizations are increasingly turning to teams because the combination of unique member skill sets enables problem solving that transcends the capabilities of individuals working on their own (Marks, Mathieu, & Zaccaro, 2001). However, successful teamwork in organizational settings is not achieved simply through grouping individuals with varied expertise together. Rather, the defining characteristic of teamwork is the implementation of effective *team processes* that serve to successfully integrate distinct member skills and experience (Hackman, 2012).

Team process captures the very essence of teamwork: member interaction. Interaction processes can manifest through sharing expertise and experience but can also hinder team functioning through poor coordination and communication (e.g. process loss). Accordingly, scholars on teams have continuously used the construct of team process to investigate why and how teams succeed and fail (Bachrach, Bendoly, & Podsakoff, 2001; Hackman, 1968; Kaplan, 1979; Mathieu & Schulze, 2006; Morris, 1966; for a review: LePine, Piccolo, Jackson, Mathieu, & Saul, 2008). This emphasis on process is further reflected by the fact that it plays a central role in the most widely supported theoretical models of team effectiveness (IPO: McGrath, 1964; IMOI: Ilgen, Hollenbeck, Johnson, & Jundt, 2005). The subsequent section will review the literature on team process through the lens of existing team effectiveness frameworks.

Frameworks of Team Effectiveness

The earliest investigations of team effectiveness centered upon antecedent-outcome relationships, in which a given team-level phenomenon was positioned as an independent variable that predicts a team-level outcome (Lewin, Lippitt, & White, 1939; Seashore, 1954). However, many posited that this cause-effect model did not sufficiently reflect the complexity that underlies all team functioning (Hackman, 2012). In particular, these conceptual approaches did not account for the critical role of group interaction process in team success.

IPO Model. To address this issue, McGrath (1964) developed the input-process-output (I-P-O) framework to conceptualize team effectiveness. This model serves as the conceptual foundation for much of research on teams today. Within this framework, inputs refer to stable, compositional traits manifested through individuals, teams, and organizations. Inputs include individual team member characteristics, team-level factors, and contextual factors (Mathieu, Maynard, Rapp, & Gilson, 2008). These factors combine to shape team processes (Hackman, 2012). Processes refer to dynamic interactions among group members that typify how teams plan for and engage in tasks, and manage conflict, emotion, and motivation (Bishop & Scott, 2000; De Cremer & van Knippenberg, 2002; Tesluk & Mathieu, 1999; Stout, Cannon-Bowers, Salas, & Milanovich, 1999). Moreover, processes serve as mediating constructs that direct inputs to outcomes (Marks et al, 2001). Lastly, outcomes refer to task and non-task consequences of a group's functioning (Marks et al., 2001; Martins, Gilson, & Maynard, 2004). The introduction of the IPO model set the stage for an entire body of research concerned with uncovering the mechanisms by which inputs shape outcomes in the collective context (Hackman, 2012).

IMOI Model. A point of critique of the IPO framework is that it failed to differentiate between different types of mediating mechanisms (Mathieu et al., 2008). As indicated by Ilgen, Hollenbeck, Johnson, and Jundt (2005), many of the mediating factors initially conceptualized as team behavioral processes were actually not processes at all. Rather, certain meditational factors are representative of group cognitive, affective, and motivational states, instead of behavioral interactions. These *emergent states* are thought to provide additional explanatory power in accounting for variability in team outcomes beyond behavioral processes (Kirkman, Gibson, & Kim, 2012).

Emergent states are not directly representative of team interaction, but rather are a product of team experiences (Mathieu, Maynard, Rapp, & Gilson, 2008; Mathieu, Gilson, & Ruddy, 2006). These states reflect properties of a team that are typically dynamic in nature and vary as a function of team context, inputs, processes, and outcomes (Marks et al., 2001). The literature has posited that emergent states are critical aspects of team functioning (Salas, Rosen, Burke, & Goodwin, 2009; Mathieu et al., 2008). In particular, the teams literature has indicated that a number of affective and motivational emergent states are closely related to team effectiveness, including: team cohesion (Beal, Cohen, Burke, & McLendon, 2003; Zaccaro, Gualtieri, Minioins, 1995), team identity (Bartels, Pruyn, De Jong, & Joustra, 2007; Bouas & Komorita, 1996), team satisfaction (Mathieu et al., 2008), team motivation (Kleingeld, van Mierlo, & Arends, 2001; O'Leary-Kelly, Martocchio, & Frink, 1994), and collective efficacy (Gully et al. 2002; Stajkovic et al., 2009). These states serve as mechanisms that propel members to act in specific ways due to the circumstances they experience. Accordingly, emergent states are important determinants of the manner in which a team carries out its work.

In order to account for the differentiation between team processes and emergent states, Ilgen et al. (2005) reconceptualized the IPO framework as the Input-Mediator-Output-Input (IMOI) model. In this latter model, the 'Mediator' factor was designed to capture both team process-oriented and state-oriented constructs (e.g. emergent states) that mediate the relationship between inputs and outputs.

The IMOI model also sought to further account for the role of time in the team life cycle. The IPO framework had initially been criticized for its inability to consider the complex role of temporal dynamics in teamwork. In particular, certain researchers had posited that, realistically, teamwork does not progress in the unidirectional fashion that is depicted by the IPO model (Marks et al., 2001; McGrath, 1991). Instead, teams tend to adjust their processes over time based upon outcomes. For instance, a given team may discover that poor member coordination hinders team performance. The team may subsequently use this experience to enhance member coordination on future tasks. Therefore, there is also a cyclical nature to team functioning (Kozlowski & Bell, 2008; Kozlowski, Gully, Nason, & Smith, 1999). Ilgen and colleagues (2005) accounted for this fundamental aspect of teamwork by incorporating feedback loops into their IMOI model. Thus, their model retains structure similar to the IPO model, but also accounts for the fact that outcomes may also shape mediators and inputs as teams transition from one episode to another (Mathieu et al., 2008).

Process as the Driver of Team Success. An important point of similarity between the IPO and IMOI models is the central role of behavioral process. The presence of a direct link between processes and outcomes in both models suggests that understanding processes is the chief avenue through which researchers can understand why and how teams accomplish certain outcomes (Lepine, Piccolo, Jackson, Mathieu, & Saul, 2008). This role is reflected in the most commonly supported definition of process: "members' interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioral activities directed toward organizing taskwork to achieve collective goals" (Marks et al., 2001, p. 357). This definition conveys the fact that interactive processes are the means through which members combine unique skills and expertise towards the accomplishment of team objectives. Thus, the very essence of what it means to be a team is predicated upon team behavioral process (Hackman, 2012).

Moreover, processes transmit the influence of individual members towards the final team outcome. Otherwise stated, team processes enable the actions of individual members to shape team effectiveness. This provides members with the opportunity to evaluate their own individual contribution to the overall success of the team. Thus, processes provide a form of transparency in teamwork that likely increases work engagement from individual members (Crawford & LePine, 2013; Lepine et al., 2008).

Dimensions of Process

A substantial amount of work in the literature on teams has focused on the conceptualization of process. While there seems to be an overall consensus on the broad definition of the construct of team process (e.g. Marks et al., 2001), our understanding of factors that underlie it appears to be consistently evolving. To date, the literature has conceptualized team process via three fundamental dimensions: *content* (Fleishman & Zaccaro, 1992; Prince & Salas, 1993), *timing* (Kozlowski, Gully, Nason, & Smith, 1999; McGrath, 1991; Weingart, 1997), and *structure* (Cronin, Weingart, Todorova, 2011; Katz & Kahn, 1978 McGrath, 1997; McGrath, Arrow, & Berdahl, 2000). Each of these dimensions provides unique information regarding behavioral processes and their role in facilitating team functioning.

Content. One body research on teams has sought to understand the specific types of process behaviors that team members may engage in (e.g. *content*: Marks et al., 2001). However, until 2001, this work accumulated in an inconsistent manner. Marks and her colleagues (2001) sought to address this issue by developing a taxonomy designed to categorize the content of all team processes. The first notable contribution of this work was the differentiation between emergent states and behavioral processes. Marks et al.

(2001) posited that team states to not comprise the content of team process, and thus excluded them from their taxonomy. As previously described, Ilgen and colleagues (2005) subsequently drew upon this distinction when developing the IMOI model.

The Marks et al. (2001) taxonomy was based upon a thorough review of previous work in this area. In particular, Marks and her colleagues drew from Fleishman and Zaccaro (1992), who had previously advanced a classification system for team performance functions. Their framework incorporated process-relevant constructs such as mission analysis, systems monitoring, and coordination. Other influential work was conducted by Prince and Salas (1993) who distinguished a group of seven behaviors critical to team functions, and Cannon-Bowers, Tannenbaum, Salas, and Volpe (1995) who posited that strategy formulation, monitoring progress, and conflict management are behaviors essential to team success. Marks et al. (2001) utilized these prior efforts to organize and classify all forms of process behaviors to develop their taxonomy. The resulting taxonomy conceptualized the *content* of team interaction into 10 distinct behavioral processes that are critical to team success. These processes are delineated in the subsequent section.

Timing. Time-related factors, such as scheduling and deadlines, can substantially impact team functioning (Kozlowski et al., 1999; Locke & Latham, 1990; McGrath, 1991). This temporal nature of teamwork fundamentally shapes the effectiveness and execution of behavioral processes (McGrath, 1993). In order to better capture the temporally based nature of teamwork, Marks et al. (2001) also explicitly integrated time into their taxonomy of team process. In particular, they postulated that each form of process-relevant behavior is most effective when enacted during a particular phase of taskwork (e.g. *timing*). In order to account for timing of process, their taxonomy positions each of the 10 behavioral processes (e.g. *content*) in one of three distinct, recurring phases of team process: transition, action, and interpersonal.

Transition phases are defined as periods of time when teams focus primarily on evaluation and/or planning activities to guide their accomplishment of a team goal or objective. Behavioral processes that occur within transition phases include goal specification, strategy formulation, and mission-analysis (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995; Dickinson & McIntyre, 1997; Levine & Moreland, 1990; Prince & Salas, 1993). Within the Marks et al. (2001) framework, transition phases lay the foundation for task execution, and thus occur prior to action phases.

Action phases, on the other hand, are periods of time when teams are engaged in acts that contribute directly to goal accomplishment (Marks et al., 2001). Action phase processes are coordination, backup behavior, team monitoring, systems monitoring, and monitoring progress towards goals (Brannick, Prince, Prince, & Salas, 1992; Dickinson & McIntyre, 1997; Jentsch, Barnett, Bowers, & Salas, 1999).

Lastly, interpersonal phases represent behaviors designed to manage relationships amongst team members (Marks et al., 2001). Interpersonal phase processes include conflict management, motivation and confidence building, and affect management (Cannon-Bowers et al., 1995; Fleishman & Zaccaro, 1992). These particular behavioral processes are most impactful when enacted throughout the task cycle. Therefore, they span both transition and action phases (Marks et al. 2001).

Structure. According to Marks et al. (2001), teams that exhibit *more* of the previously described behavioral processes are most effective. However, other work has postulated that member interactions occur in complex and dynamic patterns (Ilgen et al., 2005; Kozlowski & Klien, 2000; McGrath, Arrow, & Berdahl, 2000). Therefore, exclusively focusing on the general level or amount of process in a team inhibits researchers from investigating key patterns or configurations of interactions amongst individual team members (Crawford & LePine, 2013). Thus, Crawford and LePine (2013) sought to complement the contributions of Marks et al. (2001) by suggesting that theory on team process must also consider configurations of team interactions (e.g. *structure*).

In this vein, Crawford and LePine (2013) developed a configural theory of team process that delineates how certain structures of team process may shape team functioning. Prior work in the realm of social network analysis has suggested that certain types configurations of interaction are more beneficial to team functioning than others (Granovetter, 2005; Oh, Labianca, & Chung, 2006). Consequently, Crawford and LePine (2013) proposed that three specific types of team configuration are particularly impactful for team functioning: closure, centralization, and subgrouping.

Closure is defined as increased interconnectedness in interactions amongst team members (Balkundi & Harrison, 2006). Closure amongst team members is associated with increased trust and enhances a team's ability to coordinate and execute tasks (Reagans & Zuckerman, 2001). However, maximum closure may also overwhelm team members, which can decrease motivation (Beehr, Walsh, Taber, 1976). Thus, Crawford and LePine (2013) proposed that moderate levels of closure are most beneficial to team process.

Centralization refers to the concentration of connections to one or a few individuals while all others are more disconnected (Wasserman & Faust, 1994). Increased centralization may enhance the dispersion of information throughout the team (Hollenbeck, Ellis, Humphrey, Garza, & Ilgen, 2011). However, high centralization may also increase dependence on one particular team member, which may potentially lead to demotivation (Shaw, 1964). Accordingly, Crawford and LePine (2013) assert that centralized taskwork must be coupled with decentralized teamwork to facilitate effectiveness.

Lastly, subgrouping refers to a subset of members that exhibit increased connection within the subset coupled with decreased connection between subsets (Hanneman & Riddle, 2005). Subgrouping enables specialization and enhanced information exchange amongst team members (Carton & Cummings, 2012). However, it may also facilitate the development of ingroup biases, which can prove to be detrimental to overall team functioning (Scott, 2000). Crawford and LePine (2013) posit that subgrouping will negatively shape team functioning when no connections between subgroups are present.

Critique: The Relevance of Technology Use to Team Process

While foundational, a critical point of critique of the current dimensions of process is that they are agnostic to the material aspects of how members interact. This is an oversight when confronted with the fact that modern teamwork is increasingly embedded in technology use. The ubiquity of technology use is in part due to predominant trends toward globalization, but even teams who are collocated increasingly interact through technology. Thus, almost all organization-based teams interact through multiple technological platforms across space and time. Therefore, team process is not simply an interaction that occurs between members; it is an emergent phenomenon in which member interaction and coordination is embodied in technology use (Hoch & Kozlowski, 2012; Kanawattanachai & Yoo, 2002; Schweitzer & Duxbury, 2010).

Moreover, Marks and colleagues (2001) indicate that process represents *how* team members work together. The use of technology is a critical aspect of *how* teams work together that has long been overlooked. For instance, members may frequently collaborate through a chat interface to facilitate prior process routines. This interaction enables members to communicate and exchange knowledge through written text in real time. In this circumstance, the chat tool can set boundary conditions on the type, amount, and nature of information exchange between team members. The same can be said for member interactions over a multitude of technology platforms (e.g. telephone, videoconference, email, project management software, etc.). Therefore, in modern day organizations, the use of technology reflects a fundamental aspect of enabling previously conceptualized behavioral processes (e.g. Marks et al., 2001).

However, it is not sufficient to say that members use technology fulfill their needs; technology also inspires advances in member interaction. For instance, team members may use videoconferencing or teleconferencing to exchange ideas with a team member in another geographic location. This aspect extends the potential reach of each member in ways that would not be possible without the use of technology. Likewise, members may use email as a means of establishing a repository of team correspondence. Teams may also set up automatic task and meeting reminders in project management software (e.g. Basecamp), which can serve to automate their coordination. Thus, technology also provides new aspects of process that could not be achieved by without these platforms. Therefore, while technology can be seen as a facilitator of member actions, it also provides phenomenological changes to teamwork, and is a fundamental aspect of *how* team members work together.

In this vein, many scholars have posited that technology has become so embedded in workplace interactions that they are "inextricably related" (Orlikowski, 2007, p. 1437). In the case of each of the previous examples, the use of technology directly leads to the possibility of new team behaviors. In many instances, a technological platform enables the manifestation of the described behavior (e.g. automatic reminders, correspondence repository, etc.). In other words, these particular behaviors would not be possible without technology, and cannot fully be understood by being examined in isolation of technology. Therefore, given that technology use is directly linked with certain process behaviors, it would behoove teams researchers to consider it part of team process.

Relevance to the Process-Outcome Link. Many researchers on teams have posited that the principal rationale for studying team process is to uncover the factors that explain how and why teams achieve certain outcomes. This logic is founded on the process-outcome link in the IPO model. As indicated, the literature has theorized that conceptualizing the content, timing, and structure of process can inform how teams can succeed. In the same vein, investigating the use of communication technology as a part of team process can further elucidate team success and failure.

Technological platforms inherently possess certain capabilities (Hoch & Kozlowski, 2012; Kirkman & Mathieu, 2005). These capabilities include the ability to transmit information in real time, transfer vocal tone and facial gestures, and transmit written text, amongst many others. Thus, a given technology can enable certain types of member interactions while constraining others (Knappett & Malafouris, 2010). However, member interactions are not solely determined by the capabilities of a technological medium. Rather, members have the ability to implement these technologies in different situations to interact with different team members (Leonardi & Barley, 2008; Orlikowski & Scott, 2008). Over time, members may establish norms for technology use that are beneficial, or detrimental, to team success. For instance, members may utilize a select set of technological platforms that possess different capabilities that serve to complement each other, and match the use of these technologies to the demands of a given task. On the other hand, members may distribute their interactions across too many different technologies, which may overwhelm members and hinder overall communication.

Therefore, in order to appropriately understand process – and subsequently collective success – in modern teams, we must also consider how members utilize technology to interact effectively. This consideration directly compliments the existing dimensions of process. Content, timing, and structure (Crawford & LePine, 2013; Marks et al., 2001) each depict a distinct aspect of process. However, they do not explicitly account for the phenomenological changes to process that arise through the use of technology. Capturing the materiality of process would allow scholars to account for: 1) the manner in which members spread interactions across multiple communication tools, 2) how these technologies enable/constrain traditional process, and 3) the manner in which technology leads to new process behaviors. Such theory would provide informative recommendations for improving team process in modern organizations. Moreover, this theoretical advancement will enable teams scholars to more accurately capture the relationship between team process and performance. This effort would also strengthen support for the process-outcome link in the IPO model.

Part 2: Communication Technology and Teams

Literature Review

Teams researchers have largely overlooked materiality in the conceptualization of team process. However, a body of work has investigated the impact of communication technology on team outcomes. These efforts have typically used the term "communication technology" to refer to tools that members may use to facilitate team interaction, such as videoconferencing software, email, and telephones (Dixon & Panteli, 2010; Navarro, 2001). Research that has examined the relationship between communication technology and teamwork has predominantly positioned the use of communication technology as an independent variable that impacts team functioning (Cramton, 2001; Cramton, Orvis, & Wilson, 2007; Hinds & Mortensen, 2005), or as a moderator of process-outcome relations (Bierly et al., 2009; Hakonen & Lipponen, 2008; Kirkman et al., 2004; Kirkman & Mathieu, 2004). The theoretical foundation for this work implies that communication technology is distinct from process, and that scholars can understand aspects of team effectiveness by looking at the impact of communication technology on teamwork.

The logic for much of this work is predicated upon the fact that fluctuating market demands and dynamic organizational boundaries have changed the nature of organization-based work (Belanger & Watson-Manheim, 2006; Martins et al., 2004). To accommodate these changes, teams have been forced to incorporate technology into their everyday functioning. Certain efforts have suggested that communication technology can facilitate fundamental team processes by enabling flexible patterns of communication amongst team members and efficient workload allocation, while also lowering organizational costs over time (Bergiel, Bergiel, & Balsmeier, 2008; Abad, Castella, Cuena, & Navarro, 2002; Bell & Kozlowski, 2002). However, others have posited that these tools may also lead to a loss of mutual understanding amongst team members, hinder communication though technological breakdowns, and introduce interaction difficulties for members who do not possess technological expertise (Gibson & Gibbs, 2006; Hertel, Geister, & Konradt, 2005; Olson & Olson, 2000). The present chapter will review and critique the conceptual foundation for this body of literature specific to team process, as well as evaluate relevant empirical examinations of communication technology and process.

Virtual Teams vs. Virtuality in Teams

Virtual Teams. Initial work concerning the relationship between communication technology and teams used the label "virtual teams" (Guinea, Webster, Staples, 2012; Kirkman, Gibson, & Kim, 2012; Martins, Gilson, Maynard, 2004). Virtual teams are groups of geographically, organizationally, and/or temporally dispersed workers brought together by communication technologies to accomplish one or more organizational tasks (DeSanctis & Poole, 1997; Jarvenpaa & Leidner, 1999). These collectives were typically contrasted with "conventional" face-to-face teams in order to examine the costs and benefits of virtual work as it relates to team functioning (e.g. Guzzo & Dickson, 1996; Olson & Olson, 2000; Tang & Isaacs, 1993).

This perspective has largely maintained that, at the time, communication technologies were highly limited in their availability, cost, and quality (Olson & Olson, 2000). Thus, it was suggested that teams that rely on these tools to interact (e.g. virtual teams) would function less effectively than face-to-face teams (Cramton, 2001; Cramton, Orvis, & Wilson, 2007; Hinds & Mortensen, 2005; Galegher & Kraut, 1994; Olson & Olson, 2000; Mortensen & Hinds, 2001). Broad implications from this work were that face-to-face interaction should be implemented in lieu of using communication technology whenever feasible, and, at the very least, face-to-face interaction should be incorporated as much as possible into virtual teams (Maznevski & Chudoba, 2000; Powell, Piccoli, & Ives, 2004).

Virtuality as a Characteristic of All Teams. This dichotomy between virtual and face-to-face teams has been criticized for not acknowledging the fact that most modern teams, even those that are collocated, utilize communication technology to facilitate member interaction. Accordingly, more recent efforts have shifted towards focusing on "virtuality" as a potential characteristic of all teams (Dixon & Panteli, 2010; Griffith, Sawyer, & Neale, 2003; Schweitzer & Duxbury, 2010). The definition of virtuality itself has varied (Gilson, Maynard, Young, Vartiainen, & Hakonen, 2015). For instance, Gibson and Gibbs (2006) indicate that virtuality consists of electronic dependence, geographic dispersion, dynamic structural arrangements, and nationality diversity. On the other hand, Kirkman and Mathieu (2005) posit that virtuality is comprised of the frequency of use of communication technology, the informational value of said tools, and synchronicity of team member interaction. Moreover, Schweitzer and Duxbury (2010) state that the key dimensions of virtuality are: the extent to which members do not work face-to-face, the physical distance between members, member configuration patterns, and the extent to which interactions are asynchronous.

Nonetheless, most scholars in this area seem to agree that the term "virtuality" generally reflects the extent to which team members rely on and utilize communication tools to facilitate interaction (Schweitzer & Duxbury, 2010), and that teams differ in how "virtual" they are along a continuum ranging from face-to-face to highly virtual (e.g. Dixon & Panteli, 2010; Leenders, Engelen, & Kratzer, 2003). Empirical work in this area has subsequently sought to examine the manner in which the broad construct of team virtuality impacts effectiveness.

The conceptualization of virtuality is slightly more optimistic about using communication technology to facilitate teamwork than prior dichotomous face-to-face/virtual team comparisons. This perspective acknowledges that both the capabilities and availability of virtual communication tools have developed at rate that was not initially anticipated (Jarrahi, 2010). For instance, improved bandwidth now allows for audio and video transmissions that closely reflect face-to-face communication (Hambley, O'Neill, & Kline, 2007). Moreover, the use of communication technology has become ingrained in most organizational cultures (Pentland & Feldman, 2008; Rice & Leonardi, 2012; Scott & Orlikowski, 2013). Accordingly, many scholars on virtuality now recognize the fact that communication technology can potentially facilitate effective team interactions (Balthazard, Potter, & Warren, 2004; Sole & Edmonson, 2002; Hinds & Bailey, 2003).

Theoretical Foundation. A variety of theories have been utilized to investigate the impact of virtuality and virtual teaming on team functioning (Schiller & Mandviwalla, 2007). However, three theories have been particularly influential in framing research in this area: 1) Media Richness Theory, 2) Media Synchronicity Theory, and 3) Social Presence Theory. Each theory has significantly contributed the theoretical foundation that underlies the investigation of communication technology in team settings.

The consistent theme across each of these theories is their emphasis on technological capabilities. Each framework assumes that a given technology will shape human interactions in a stable and predictable manner. Therefore, these theories set the foundation for investigations of how these technological capabilities (e.g. richness, synchronicity, and presence) shape team functioning.

Critique of the Virtual Teams/ Virtuality Perspective

This empirical work has provided a notable contribution to the literature by examining the potential differences in processes between face-to-face and virtual teams. This work has emphasized the fact that virtual teams have similar needs to face-to-face teams. However, in most cases, this work has demonstrated that virtual teams do not function as effectively as face-to-face teams due to the limiting capabilities of communication technology.

While foundational, these investigations do not adequately capture the manner in which team process is actually embedded in technology use. Proponents of the virtuality perspective would state that it is evident that few empirical studies of process have embraced the notion that virtuality itself is a continuous construct (Curseu, Schalk, & Wessel, 2008; Gilson et al., 2015; Kirkman et al., 2012; Martins et al., 2004). From this stance, the face-to-face/virtual teams comparison invokes a strict dichotomy that does not actually exist in the modern workplace (Kirkman & Mathieu, 2005; Gonzalez-Navarro, Orengo, Zornoza, Ripoll, & Peiro, 2010; O'Leary & Cummings, 2007). For instance, almost all teams utilize communication technologies to enable process even if they are collocated, which renders the conceptualization of a purely face-to-face team somewhat unrealistic. Moreover, scholars on virtuality posit that the capabilities of virtual tools vary substantially, and that these differences lead to distinct types of member interactions. Therefore, classifying all teams that predominantly use any form of communication technology broadly as "virtual teams" overlooks the fact that teams within this grouping may exhibit fundamentally different interactions. For example, according to the aforementioned dichotomist perspective, teams that predominantly use e-mail and teams that utilize videoconferencing would both be classified as virtual teams. This lack of distinction disregards differences in member interactions across the two teams by overlooking which technologies were utilized and how they were implemented.

However, embracing the virtuality perspective (over the virtual teams perspective) may not be the solution to the theoretical and empirical difficulties in this area. Despite its aforementioned theoretical advancements, the virtuality lens is still limiting in that it does not capture the inherent complexity that accompanies the use of communication technology in team settings. Accordingly, the present manuscript argues that this theoretical framework still constrains our ability to appropriately understand team process. Therefore, the following subsections will discuss distinct points of critique of the virtuality perspective.

Critique #1: Communication Technology Is *Not* Distinct From Process. The virtuality lens considers the use of communication technology to be conceptually distinct from behavioral process. This assessment assumes that technology is only relevant to isolated instances of member interaction or events, and overlooks the fundamental role technology plays in organizing at all times (Orlikowski & Scott, 2008). In actuality, modern team process consists of a series of interactions in which members constantly exchange information and impact one another through multiple technologies.

Moreover, communication technology is so thoroughly embedded in modern member interactions that it is inappropriate to conceptually separate member interaction from the technology that facilitates it. As previously stated, communication technology can facilitate process, but it also allows for new process behaviors. For instance, members now have the ability to create visual representations of the collaborative process (e.g. scaffolds: Cuevas, Fiore, & Oser, 2002) through the use of communication technology. In other words, communication technologies now allow members to interact and accomplish teamwork in ways that are fundamentally different from prior collocated contexts. Therefore, the conceptualization and investigation of team process should reflect the inherent inseparability of humans and technology by considering the use of technology to be a part of process.

Critique #2: Communication Technology Does *Not* Unidirectionally Determine Process. Treating communication technology as conceptually distinct from behavioral process has led researchers to position virtuality as a stable construct that unidirectionally shapes team process (either as an input or moderator). This perspective largely assumes that the capabilities of communication technology are the principal determinant of the manner in which members interact. The fact that the virtuality literature largely draws upon the theories of media richness, media synchronicity, and social presence likely explains the prominence of this technology-centric perspective. Each of these theories proposes that communication technologies inherently possess certain features (e.g. transmission capacity, data storage capacity: Huber, 1990) that determine the quality and timing of information exchange amongst team members. However, recent work has suggested that this theoretical stance results in a form of technological determinism, in which the effects of communication technology on social interaction are assumed to be predetermined and inevitable (Orlikowski & Scott, 2008). This assumption overlooks the fact that team members have the ability to decide how and when to implement communication technologies to facilitate team interactions (Leonardi & Barley, 2010). Therefore, whereas communication technology may constrain or afford certain aspects of human behavior, the manner in which members choose to use a particular communication platform also shapes the relation between process and technology. Thus, the use of communication technology does not deterministically shape team process.

Summary. The use of communication technology is a foundational aspect of behavioral process in modern teams. These tools not only frequently facilitate interactions amongst team members that typify behavioral process, but they have fundamentally expanded the types of interactions members may experience when conducting teamwork. However, current conceptual efforts regarding the relationship between team process and communication technology (e.g. virtuality: Kirkman & Mathieu, 2005; Martins et al. 2004) do not adequately capture the dynamic and complex nature of this phenomenon. In order to appropriately incorporate this fundamental aspect of member interaction into our conceptualization of team process, teams researchers would benefit from moving away from the virtuality perspective towards adopting a new paradigm that considers communication technology to be embedded in team interaction.

CHAPTER 3

ADVANCING A THEORY OF TEAM PROCESS AND TECHNOLOGY USE THROUGH THE LENS OF SOCIOMATERIALITY

Sociomateriality: Combining Human- and Technology-Centric Forces

As evidenced by the previous section, two disparate trends are present in the literature regarding teams and technology. The first trend is that teams' scholars continue to conceptualize team process through a very human-centric lens by focusing on social interactions without considering the role of technology (e.g. Crawford & LePine, 2013; Marks et al., 2001). This trend is reflected by the current, widely supported technology-deprived dimensions of process (content, timing, structure). This perspective largely discounts the fact that technology is integral aspect of everyday life and human interaction (Schiffer, 1999). The second trend is that, when scholars do investigate technology in team settings, they adopt a technology-centric perspective by examining the impact of virtuality on team process, and frequently invoke an artificial dichotomy between face-to-face and virtual teams (e.g. Gibson & Cohen, 2003; Kirkman & Mathieu, 2005; Maruping & Agarwal, 2004). This virtuality perspective assumes that technology is only relevant to certain teams or to teamwork at certain points in time, and largely prohibits researchers on teams from considering the role that human agency and social processes play in shaping communication technology use.

The ontological perspective of *sociomateriality* explicitly emphasizes the inextricable linkage between the social (human-centric forces) and material (technology-centric forces). Sociomateriality advances the view that humans and technologies are fundamentally intertwined (Leonardi, 2012; Orlikowski & Scott, 2008). This lens posits that these two forces interact constantly, and that it is inappropriate to analyze either humans or technology in isolation from one another (Orlikowski, 2009; Scott & Orlikowski, 2013). In other words, only investigating social processes without considering the inherent presence of technology (and vice versa) is an endeavor that misrepresents reality (Volkoff, Strong, & Elmes, 2007; Wagner, Newell, & Piccoli, 2010). Thus, sociomateriality centers upon the investigation of how technology is inherent to everyday activities and interaction. In fact, this term is deliberately constructed to remind scholars that most every phenomenon that is considered “social” is also fundamentally “material” (Kolb, Caza, & Collins, 2012; Leonardi & Barley, 2008; Leonardi & Barley, 2010). The present dissertation posits that the sociomateriality lens can advance our understanding of team process by providing equal consideration the technological and human-driven forces that are present in modern teamwork. This section will describe the theoretical foundation for sociomateriality, and then discuss its incorporation into the literature on teams.

The theoretical foundation of sociomateriality directly draws from two distinct theoretical perspectives: social constructivism and materiality. Each perspective places ontological priority on either humans or technology, respectively, in shaping workplace functioning. The subsequent section will review the theoretical foundation for each perspective, and explicate how sociomateriality advocates for the fusion of these seemingly disparate streams of research.

Social Constructivism. Social constructivism maintains that any processes or outcomes that involve technology are predominantly determined by human interactions and social contexts (e.g. Rice & Leonardi, 2012). Scholars within this domain thus posit that the effects of technology are “socially constructed” (Leonardi & Barley, 2010, pg. 1). The social constructivist perspective is largely founded upon the concept of human agency. Human agency is defined as “the ability to form and realize one’s goals” (Leonardi, 2011, pg. 148). This view holds that an individual’s work or a team’s work is not determined by the technologies they utilize. Rather, it proposes that humans have the ability to implement technologies as they set fit in order to facilitate work processes. The literature within this realm has posited that even when humans are presented with highly constraining technologies, humans can still exhibit substantial agency in utilizing and determining how these technologies with shape their work (Azad & King, 2008; Boudreau & Robey, 2005). Thus, social constructivism builds upon this foundation to posit that human understanding and use of technology is neither “fixed nor universal” (Orlikowski, 2009, pg. 8). Rather, the use of technologies emerges and varies over time and across settings (Heath & Luff, 2000).

Over recent decades, one theoretical framework has emerged that has championed this social constructivist lens: Adaptive Structuration Theory (e.g. DeSanctis & Poole, 1994; Poole & DeSanctis, 2004). Adaptive Structuration Theory is concerned with the variability of use of technologies in work settings. Drawing from Giddens’ (1984) foundational Structuration theory, DeSanctis and Poole (1994) stated that technologies are designed to be utilized in pre-specified ways (i.e., they have a structure). However, humans have the ability to implement or “appropriate” the technology in a manner that is either consistent or inconsistent with this prescribed course of action (DeSanctis & Poole, 1994; Poole & DeSanctis, 1992). Through the lens of Adaptive Structuration Theory, the structural features of technology may initially impact human interaction but it is ultimately human actions that shape work processes. Thus, a central tenant of Adaptive Structuration Theory is that “multiple outcomes can result from implementation of the same technology” (DeSanctis & Poole, 1994, p. 142). Ontological priority is therefore given to humans and social contexts, which is consistent with the human-centric framework of social constructivism.

Materiality and Technological Affordance/Constraint. Materiality, on the other hand, is defined as “the ways physical and/or digital materials are arranged into particular forms that endure across differences in place and time” (Leonardi, 2012, pg. 31). Put differently, materiality reflects the physical characteristics and the capabilities of a technology that remain constant across settings.

Theorists in this area have sought to draw a direct connection between materiality and social interaction through the concepts of technological affordance and constraint (Leonardi, 2012). Technological affordance reflects the degree to which a specific technology enables human action, whereas technological constraint is defined as the manner in which a given technology inhibits human action (Hutchby, 2001). Table 1 contains a list of technological affordances as they relate to a number of common communication technologies.

Table 1.

Exemplar Technological Affordances

Affordance	Email	In-Person	Chat	Social Media	Videoconference
Interaction Storage/Reflection	X		X	X	
Synchronous Interaction		X	X		X
Social Cue Transmission		X			X
Multifunctionality				X	
Textual Exchange	X		X	X	

Note. This does not represent an exhaustive list of technological platforms or affordances. This table is included to provide a frame of references for a sample of platforms and affordances.

For example, videoconferencing affords individuals the ability to maintain eye contact and interpret body language while communicating but constrains the ability to interact asynchronously. Likewise, e-mail affords its users the ability to catalogue their correspondence, yet it constrains the users ability to interact in real time. Therefore, these affordances and constraints are materially-based factors that shape human interaction (Conole & Dyke, 2004; Suthers, 2006).

Human-Centric and Technology-Centric Fusion. The literature has posited that each of these perspectives (social constructivism and material affordance/constraint) has contributed to our understanding of the role of technology in workplace settings (Leonardi, 2012; Orlikowski & Scott, 2008). However, adhering to either perspective in isolation is subject to critique. For instance, social constructivism and Adaptive Structuration Theory enable researchers to focus on how humans exert agency in utilizing technology to interact and work with others at certain points in time (Leonardi, 2011). Nonetheless, this approach somewhat overlooks the manner in which the capabilities of technology enable and constrain workplace functioning. Likewise, materiality sets the general parameters for human interaction but allows for variance in social actions within these boundaries. Yet, this perspective overlooks the fact that humans have the ability not only to reject aspects of technology, but to also reject a technology as a whole (Constantinides & Barrett, 2005; Markus, 2004).

Sociomateriality posits that the forces present in both perspectives are enmeshed. In particular, sociomateriality posits that work functioning is shaped by the synergy between socially constructed uses of technology and technological affordance/constraint. Put otherwise, workplace functioning is, in part, a result of a constant entanglement between 1) how humans choose to use particular technologies (e.g. Adaptive Structuration Theory) and 2) how the capabilities of said technologies enable or limit human interaction (e.g. technological affordance). Sociomateriality posits that favoring either perspective creates an inaccurate representation of the modern workplace (Orlikowski, 2009; Scott & Orlikowski, 2013). Rather, each of these human-centric and technology-centric forces for a synergy that shapes work interactions.

Sociomateriality and Team Process

The lens of sociomateriality directly applies to the study of team process. As noted, the current conceptualizations of team process (e.g. Marks et al., 2001) leave little room for considering the manner in which technology use shapes team functioning. This is despite the fact that technology can enable and constrain previous process behaviors, while also expanding the behaviors available to team members. Other extant efforts (e.g.

virtuality: Kirkman & Mathieu, 2005) have broadly examined the relationship between teams and communication technology; however, these perspectives are limiting because they consider the role of communication technology use solely from a technology-centric perspective by only focusing on manner in which communication technology shapes team interaction overlooks key aspects of member agency. In most organizational settings, team members have access to a suite of technologies. In these circumstances, as posited by Adaptive Structuration Theory, members have the ability to accept or reject any number of these technologies throughout the course of their teamwork. Moreover, they can exhibit agency by varying who they decide to interact with via a given technology, thus establishing different interaction norms with different team members. Accordingly, in order advance our understanding of team process we must also consider the manner in which members actually utilize technology.

Embracing the lens of sociomateriality in the literature on teams allows for the consideration of both of these perspectives. Applied to research on teams, sociomateriality posits that team process can only be appropriately understood by considering the role of technological affordances/constraints and member agency to fundamentally dependent phenomena. Put otherwise, in order to comprehensively understand how modern teams work together it is important to examine not only how technology can facilitate and expand process behaviors, but also how member tool use and interaction shapes process. Embracing sociomateriality allows us to consider the inextricable linked between these two forces, which will enhance our understanding of modern team process. The following will further elucidate how incorporating sociomateriality into the literature on teams can enhance our understanding of team process.

Process Sociomateriality. Current work on team process suggests that teamwork is best understood through examining the types of behaviors teams engage in (*content*), when these behaviors are enacted (*timing*), and the configuration of interaction (*structure*). However, this human-centric perspective overlooks the fact that these social processes are inherently intertwined with materiality. Technology use has become such a prominent aspect of modern teamwork that it serves to not only facilitate team process but also expand the types of behaviors that are available to team members. Therefore, this dissertation has posited that the use of technology must be considered as an essential aspect of team process. This dissertation does not suggest a departure from the aforementioned tenets of team process, but rather the addition of a dimension that captures the use of technology. As indicated in the previous section, the ontological lens of sociomateriality will accommodate this theoretical advancement.

Just as investigations on teams consider process content, process timing, and process structure (e.g. Crawford & LePine, 2013; Marks et al., 2001), frameworks of team effectiveness should also consider process sociomateriality. This dissertation introduces the term *process sociomateriality* to reflect the enmeshment of technological affordances and social interaction during taskwork. Process sociomateriality captures the manner in which social and material forces intertwine in teamwork in modern organizations.

The enmeshment of these forces leads to the development of team process routines. Consistent with the assertions of Paul Leonardi (2011), the present manuscript posits that member actions and material affordances become entangled through a sequence of interactions called imbrication. Imbrication refers to the fact that these social and material forces are interdependent phenomena, and constantly interact, or "imbricate", throughout the team cycle. In the team setting, imbrication results in dynamic configurations of human actions and technological affordances, which ultimately shape team interaction.

The imbrication of social forces onto material forces leads to a technology being used in a particular manner that accommodates prior social practices (social → material). Simultaneously, the imbrication of material forces onto social forces results in technological affordances shaping how people interact (material → social). Otherwise stated, teams may frequently incorporate a novel technology into their work processes. At first, team members may adjust their use of this tool to accommodate prior work routines and processes; however, the new tool may eventually open the door to interacting and accomplishing taskwork in novel ways. For instance, a newly formed team may initially utilize email simply to facilitate communication amongst team members. Over the course of taskwork, however, team members may come to also use email as a repository for useful task information and as a portal for progress monitoring. Thus, team members are not only able to enact previously established communication routines through email (social → material), but may also come to leverage the affordances of email to store and refer back to important information (material → social). This example illustrates the ongoing process of imbrication, which underlies all sociomaterial phenomena. It follows that process sociomateriality encapsulates the manner in which technology may enable prior team behaviors, but may also lead to new behavioral possibilities as well. Either consideration depicts aspects of teamwork that are not captured by the current conceptualizations of process (e.g. Marks et al., 2001), yet are likely to shape the manner in which members work together. Otherwise stated, this perspective will provide additional explanatory power for the phenomenon of team process beyond that of traditional conceptualizations of process.

In summary, process sociomateriality posits that constitutive entanglement between member actions and technological affordances encapsulates modern team process. This lens postulates that the enmeshment between these two forces is enduring, and the way it is manifested is constantly evolving. Thus, embracing sociomateriality in the literature on teams would denote a marked shift in our understanding and investigation of the interactive processes in modern teams.

CHAPTER 4

PROGRAM OF RESEARCH SUMMARY

Process in modern organizations has become so enmeshed with technology use that it is inappropriate to analyze either in isolation. The key assertion of this dissertation is that teamwork is embodied in the technologies that members use to carry out taskwork and interact. This embodiment, or inextricable linkage, between member interactions and technology is captured by the construct *process sociomateriality*. This dissertation aims to establish process sociomateriality as a viable and distinct construct in the literature on teams, which has long overlooked the role of materiality. Understanding and investigating how member interactions are constitutively entangled will elucidate essential aspects of team process, and help us better understand team functioning in modern organizations.

In order to accomplish these aims, this dissertation constructed a program of research that was designed to establish, validate, and examine the effects of the construct of process sociomateriality. This program of research is divided into three sequential studies. The first is a qualitative critical incident study. This study examined and established the construct of process sociomateriality by qualitatively investigating how teamwork is embodied via technology use in a sample of multidisciplinary, distributed teams. The second study built upon this effort by developing and validating a psychometric measure of process sociomateriality in the general population. This measure was designed to enable researchers and practitioners alike to better assess and understand the manner in which teams utilize technology as part of their process. The final effort was a quasi-field study of distributed teams, in which the process sociomateriality measure was utilized to examine the predictive validity of process sociomateriality. The subsequent sections will explicate each investigation in detail. Each study will be presented and discussed independently. The dissertation closes with an overall discussion designed to summarize insights gained across the three studies. This overarching discussion contains high-level theoretical implications, study limitations, future directions, and practical implications for program of research.

It is important to note that the methodology of each of these studies focuses on a specific form of communication technology: new media. As previously indicated, the term new media reflects internet-based tools that enable interaction amongst individuals. New media was chosen as the focal technology for this program of research due to the fact that it is often used in modern organizations to enable team interaction.

CHAPTER 5

STUDY 1 – QUALITATIVE CRITICAL INCIDENT STUDY

Teamwork processes are the critical linking mechanism through which individuals align their thoughts, feelings, and actions toward the accomplishment of team goals. Existing theories of team processes (e.g., Marks, Mathieu, & Zaccaro, 2001) conceptualize organizing processes as devoid of and independent from materiality, or the relatively enduring properties of the technologies through which the organizing processes are occurring (Leonardi, 2012). Using the lens of sociomateriality (Orlikowski, 2007; Orlikowski & Scott, 2008), this dissertation recasts teamwork processes to consider how organizing processes are enmeshed with the material aspects of technologies.

Process sociomateriality describes member interactions that are constitutively entangled with technology. This view shifts thinking about virtuality from that of an input (e.g. Cramton, 2001; Hinds & Mortensen, 2005) or moderator (e.g. Hakonen & Lipponen, 2008; Kirkman & Mathieu, 2004), to one of embodied social action. Put otherwise, process sociomateriality captures the manner in which social and material forces intertwine in teamwork.

This perspective asserts that modern teamwork cannot be fundamentally understood without considering how member interactions are inextricably linked with the tools that they use. Pixar's President Ed Catmul characterizes the role of technology in creative animation: "technology inspires art, and then art challenges the technology (Catmul, 2008, p. 9)." In the same way, technology initially inspires team processes, scaffolding ideas and organizing member contributions as might occur when teams leverage web 2.0 tools (e.g., social networking sites, wikis, project management platforms), but then team processes become emboldened as members use the technology to interact in new ways. The technology becomes inextricably intertwined with member interactions, extending the range of human social interaction. Hence the sociomaterial perspective is one wherein technology, or its materiality (e.g. Leonardi, 2011), is conceptually integrated into the very notion of team process, as opposed to being considered as a parallel, separate, input or moderating factor. The central aim of this paper is to explore team process from a sociomaterial perspective.

The traditionally held perspective in the literature on teams maintains that technology use is separate from process. This stance implies that there is process, and there is technology use, and each represent distinct phenomena. The present manuscript, on the other hand, has proposed that technology is embedded in team process. In particular, this paper has suggested that the processes teams enact are shaped not only by the behaviors they exhibit, but also by the technology that they use. Therefore, the purpose of the present study is to establish the theoretical foundation of process sociomateriality by examining how technology is enmeshed in team process. In particular, this effort is aimed at answering the following overarching research question: *In what ways do teamwork processes embody sociomateriality?*

Research in the realm of sociomateriality has heralded the importance of qualitative work given the relative nascence of this theoretical perspective (Orlikowski, 2007). Prominent scholars of sociomateriality assert that in order to comprehensively understand the construct space of the phenomenon, researchers should conduct in-depth analysis of instances in which human behavior is inherently entangled with technology use (Leonardi, 2013; Orlikowski, 2009). Applied to the context of team process, these assertions highlight the utility of qualitative analysis in uncovering the manner in which this technology-behavior synthesis is fundamentally embodied in teamwork. Therefore, the principle aim of the present study is to develop the conceptualization of process sociomateriality by qualitatively investigating how technology use is constitutively entangled with behavioral process in modern teams.

Method

Sample and Procedure

The sample for the present study was comprised of eighty-nine students from a social psychology class that engaged in a semester-long project. Individuals were randomly assigned to teams. The purpose of the project was to work in an interdisciplinary team to develop a scientifically grounded, profitable product designed to change damaging ecological behavior. The students in the social psychology class worked with students from a management class located to accomplish this task. The social psychology members were located at a southeastern university in the United States, and the business members were located at an international Business school in France. The role of the social psychology team members was be to provide marketing recommendations drawn from social psychological theories of attitude and behavior change. The business team members, on the other hand, provided a business revenue model for the proposed product. The final output was a product proposal that integrated these two efforts. Thus, team members from both classes were highly interdependent.

New Media Platforms. This study, and the subsequent studies in this program of research, centers on the use of a particular form of technology: new media. “New media” refers to platforms that enable member interaction (Manovich, 2001). “New media” encompasses older forms of communication tools, often referred to as communication technology (e.g. teleconferencing etc.), while also accounting for new online interaction platforms such as Facebook, Basecamp, etc.

Each team was be provided with the following new media to facilitate communication: WebEx, GoogleGroups, and Basecamp. WebEx is videoconferencing software that enables users to share screens and record meetings for later reference. GoogleGroups provided each team with a listserv that is routed to the email addresses of each team member. Basecamp is an online project management platform that allows users to assign tasks, share and edit documents, and create a project calendar. These tools are explained in Table 2.

Table 2.

Suite of New Media Platforms (Study 1 & Study 3)

New Media Platform	Description
WebEx	Online platform that enables videoconferencing, desktop sharing, and chat. One account is provided to each team.
Basecamp	Online project management tool that provides to-do list, document sharing, and calendar capabilities. One account is provided to each team.
GoogleGroups	A listserv for each team. Members may communication to their entire team by addressing an email message (on any platform) to their team's GoogleGroup address.

Note. These tools were provided to participants in both the Critical Incident Study (Study 1) and the Quasi Field Study (Study 3).

Participants are provided with this particular suite of tools due to the fact that they maintain complementary capabilities. However, participants could use other new media platforms outside of this suite as well. The design of the study necessitated that teams use new media to collaborate given that team members were distributed, and due to the fact that the project occurred over an extended period of time. Thus, the use of new media was a particularly salient behavior to participants.

Critical Incident Technique

Study 1 utilized the critical incident technique to qualitatively examine the conceptual foundation of process sociomateriality. John Flanagan introduced the critical incident technique in 1954, and it has been a prominent form of qualitative data collection through the present day. Flanagan (1954) developed the technique to use direct observations of human behavior (e.g. "critical incidents") to inform the solution of practical problems and to facilitate the development of general psychological principles. This qualitative technique boasts widespread use through the social science disciplines, and is supported as an effective platform for systematically collecting and analyzing qualitative data (Kain, 2004; Lipu, Willimason, & Lloyd, 2007).

The technique itself centers upon examining critical incidents, which are significant instances of a specific activity that are experienced by humans (Lipu et al., 2007). The scope and behavioral domain of the critical incident may vary depending upon the research area of interest. Once the critical incidents have been accumulated, they are typically analyzed to uncover patterns that can inform theory development.

This present stream of research highlights the need for an overarching theoretical framework that taxonomizes the ways in which technology use is inherently intertwined in behavioral process. The critical incident technique appropriately aligns with this aim by enabling the collection and analysis of specific behavioral instances relevant to new media use. By following the critical incident technique, the present study collected qualitative instances in which a new media platform (and the manner in which it was used) helped and hindered team process. In particular, participants described 1) how the technology itself helped/hurt process AND 2) how their *use* of the technology helped/hurt process. After the project was completed, participants were prompted for both helpful and hurtful instances of new media use to enable them to think about the full range of the behavior. The prompt is included in Appendix A.

The qualitative prompt was administered to participants via an online survey platform (Qualtrics). Hard copies were also provided to students in class. Once collection was complete, all responses were compiled. In total, participants provided three hundred and fifty-six critical incidents. Fifty-five responses were blank or substantially incomplete responses, and were subsequently removed from the final dataset. All remaining responses were edited to enhance readability; however, edits were made to the extent that they do not alter the original meaning of the participant response. The final sample included 301 useable critical incidents.

Incident Sorting and Categorization

Two subject matter expert panels examined the data. Each panel consisted of 5 individuals who possessed scholarly expertise in the field of teams and the use of technology. Panel 1 was comprised of three doctoral students working in the area of team process, and two professors who have published works on team process. The purpose of the first panel was to develop categories that described groupings of the critical incidents. Each individual panelist was instructed to read the incidents, and classify them into as few distinct categories as possible. Once sorting was complete, each panelist provided each category with a descriptive title. The number of generated categories ranged from 12 to 18. All individuals on Panel #1 then met to come to consensus on the categories.

Table 3.

Subject Matter Expert (SME) Panels

Panel	Study	Description & Purpose
#1	#1 – Critical Incident	5 SMEs sorted critical incidents and construct process categories individually. This panel will meet to come to consensus on these categories.
#2	#1 – Critical Incident	5 SMEs sorted critical incidents into the categories developed in Study #1 to examine inter-rater reliability.
#3	#2 – Survey Pilot	9 SMEs classified measurement items into categories to assess content validity of the process sociomateriality measure.
#4	#3 – Quasi-Field Study	4 SMEs assisted the development of the behaviorally-anchored ratings scales utilized to assess objective team performance.
#5	#3 – Quasi-Field Study	2 SMEs developed examples of excellent, average, and poor indicators for each performance dimension within each team product.
#6	#3 – Quasi-Field Study	4 SMEs rated the team deliverables in the field study. These ratings were used as an indicator of objective team performance.

Content Validation

A second subject matter expert (panel #2) was organized to examine the validity of this taxonomy. This panel was comprised of three doctoral students and one post-doctoral student working in the area of team process. To accomplish this aim, the panelists sorted a subset (n = 64) of the critical incidents into the categories that were developed by Panel #1. Interrater reliability was then assessed using Fleiss' Kappa. Fleiss' Kappa is the most appropriate statistical measure of interrater reliability in this circumstance given that it examines the reliability of agreement between a fixed set of raters who have assigned categorical ratings to a target (Fleiss, 1971). In the present scenario, subject matter experts classified critical incidents into categories; therefore, Fleiss' Kappa examined the extent to which these raters agree on the placement of incidents into categories. Moreover, Fleiss' Kappa represents a more conservative assessment of interrater agreement given that it controls for agreement by chance (Gwet, 2010; Sim & Wright, 2005). According to Landis and Koch (1977), Kappa values above .41 represent moderate agreement, and values above .61 represent substantial agreement. Fleiss' Kappa was calculated for each of the higher-order categories to evaluate their validity. Analyses revealed acceptable interrater agreement for process facilitation (K = .62), process expansion (K = .91), and process impairment (K = .81). These categories are detailed in the results section.

Results

The resulting taxonomy contains 16 categories that reflect specific behavioral instances in which team process is intertwined with technology, particularly new media. These categories are organized in three higher-order categories: *process facilitation*, *process expansion*, and *process impairment*. Tables 4 through 6 describe each lower order category, classified by their respective higher-order categories. The subsequent section will define each of the categories, as well as provide direct quotations to further elucidate the nature of the specific process behavior.

Process Facilitation

Process facilitation is defined as the extent to which members utilize technology to facilitate team process behavior. This category captures instances of behavior that reflect traditional conceptualizations of team process, but may be facilitated through the use of technology. Put otherwise, process facilitation captures the use of a technology to accommodate prior social practices. Six lower order behaviors comprise the process facilitation category: idea generation, idea evaluation, activity synchronization, role and task assignment, team monitoring and backup, and motivation and confidence building (see Table 4).

Table 4.

Process Facilitation – Study 1 Qualitative Examples

Category	Definition	Critical Incident Quote
Idea Generation	Team members use technology to generate ideas. *Example*: Brainstorming through the use of a Basecamp discussion thread.	"WebEx was very helpful during the brainstorming phase of the project. It allowed many different people to chime in with their responses in real time (as opposed to delayed emails)."
Idea Evaluation	Team members use technology to evaluate their ideas. *Example*: Members come to consensus on a project idea on Basecamp.	"We used a Facebook poll to select a product idea from the ones we came up with in brainstorming. It was helpful because it was easy to set up and get results from."
Activity Synchronization	Team members use technology to organize their actions so that they fit together into a coherent team product. *Example*: All members use WebEx to carry out a task (e.g. complete team charter).	"We used basecamp as a forum to post comments and upload documents. It allowed us to have one source where all of the papers and opinions were located."
Role and Task Assignment	Team members use technology to decide who will do what, and allocate work to each member. *Example*: Using the 'to-do list' function in Basecamp to assign a task to a team member.	"Basecamp allowed us to quickly assign workloads when planning our website."
Team Monitoring and Backup	Team members use technology to monitor one another's activity, assess the quality of one another's work, and provide back up behavior to help struggling team members. *Example*: Reading through an email chain in which members provide updates regarding task progress.	"We used Facebook as it was efficient in keeping everyone updated and holding everyone involved accountable for their parts in the projects."
Motivation and Confidence Building	Team members use technology to motivate one another and build confidence in the team. *Example*: Hosting a "get-to-know-you" meeting on WebEx.	"WebEx allowed us to video chat and form a bond with the business team."

It should be noted that these constructs have been established previously in the literature on teams. This dimension of the taxonomy contributes to the literature by identifying those behaviors that are frequently enacted via technology, as determined through analysis of the critical incidents.

Idea Generation. Idea generation refers to team members producing task-relevant ideas. This behavior is frequently referred to as one of the first steps of decision-making or problem solving (Osborn, 1953). Furthermore, the literature has posited that idea generation in group settings typically stimulates creativity (Paulus, Dzindolet, Poletes, & Camacho, 1993). Thus, many scholars view teams as important vehicles for developing creative ideas (Paulus, 2000). The present study found that teams frequently utilized new media to facilitate their brainstorming. Moreover, qualitative analysis of the incidents revealed that the teams generated ideas via a variety of tools, including WebEx, Facebook, and Basecamp. For instance, one participant indicated:

> "The technology that was most helpful for us was Facebook. We created a private Facebook group with all of our group members so it would be easiest to communicate. This was especially useful when we needed to brainstorm product ideas. We bounced off ideas in Facebook and discussed our case for each idea as we filtered out for possibilities."

Likewise, another participant noted:

> "Basecamp was very helpful. For nearly every assignment, we used this as our primary communication. For example, when putting together the website, we used basecamp to brainstorm for ideas and put up our fully written paragraphs for the site."

Each of these quotations indicates that teams may generate ideas effectively across a variety of tools with varying affordances. It follows that effective teams are those that can generate task-relevant ideas via virtual means, while adjusting their brainstorming behaviors to accommodate the affordances of a particular tool.

Idea Evaluation. Idea evaluation is defined as team members evaluating their ideas, with the ultimate goal of coming to consensus. Scholars have stated that selecting and implementing an idea is equally, if not more, important as idea generation (West, 2002). Proponents of this perspective argue that teams may generate a multitude of ideas; however, if they cannot appropriately assess the strengths and weaknesses of each idea, and ultimately come to consensus on one, then the entire process may be futile (King, Anderson, West, 1992; King & Anderson, 1995). Findings from the critical incident study demonstrated that many teams also used communication tools to come to consensus on an idea. One participant explained:

> "It was helpful to use Facebook to communicate with the team in determining our product idea because it was an easy method of communication that everyone checked and could throw around ideas on. We essentially just posted ideas we had and then other group members would comment on them to see if they agreed that it was an idea we should explore more. It was helpful to be able to communicate so easily and decide on an idea so easily."

Another participant further explained their idea evaluation process by stating:

> "At the beginning of the project when we needed to come up with a product idea, I was able to use basecamp as a tool to make that decision by creating pseudo-

poll. I was able to initiate a discussion that everyone contributed to that eventually lead us to unanimously agree on a product idea."

These critical incidents indicate new media was frequently used to facilitate the idea evaluation process. It is important to consider that the differential affordances of these tools led to variation in how idea evaluation was manifested. Thus, the idea evaluation process may vary depending on the tool that is used. These behavioral differences further illustrate how process behaviors are enmeshed in the technology that teams use. Teams that fail to appropriately adjust their idea evaluation process to their tool of choice (or vice versa) will not be able to maximize the effectiveness of their product output.

Activity Synchronization. Activity synchronization occurs when team members organize their actions so that they fit together during taskwork (Fleishman & Zaccaro, 1992). According to previous work, effective teams are those that coordinate member behaviors such that they seamlessly combine to accomplish a given task (Zaccaro & Klimoski, 2002). Put otherwise, member actions must complement one another so as to adequately achieve task demands in an efficient manner (Marks et al., 2001). Without proper coordination of member actions, team process is likely to breakdown, reducing overall productivity (Tesluk, Mathieu, Zaccaro, & Marks, 1997). Analysis of the critical incidents revealed that this behavior is highly relevant to the functioning of teams that utilized new media. For example, one participant stated:

> "We used basecamp as a forum to post comments and upload documents. It allowed us to have one source where all of the papers and opinions were located."

Another team member indicated that:

"My team used basecamp. We used it to plan meetings and talk about our tasks. This was helpful because it got everyone on the same page. Without this technology, we would not have been able to talk things out or upload documents for everyone to see as efficiently."

Simply stated, teams utilized new media to ensure that member actions were coordinated appropriately. These quotations indicate that teams used new media to establish a central repository for information to enable the sequencing of member behaviors. Moreover, they imply that failure to sufficiently establish coordination norms via these tools would likely hinder overall process.

Role and Task Assignment. Role and task assignment is captured by team members deciding who will do what, and allocating work to each other. This behavior has been positioned as a critical aspect of strategy formulation and planning (Marks et al., 2001). Engaging in role and task assignment enables members to delineate responsibilities to maximize efficiency when executing a given task (Hackman & Oldham, 1980). Without specifying member roles and assigning tasks, teams may experience a diffusion of responsibility or confusion about task objectives. Qualitative analysis demonstrated the teams in the present sample often utilized new media to engage in role and task assignment. For instance, one of the participants stated:

"Basecamp allowed us to quickly assign workloads when planning our website."

Another participant further stated that:

"Facebook was useful for communicating with group members. Facebook would help decide who was doing what for our two assignments because it allowed us to

> delegate and communicate. It would have been difficult to do anything without Facebook."

It is evident that participants utilize various technologies to allocate task-relevant responsibilities to their team members. It can be argued that this process behavior is particularly important in limiting confusion for distributed teams, who are typically afforded limited opportunities for interaction.

Team Monitoring and Backup. Team monitoring and backup is defined as team members monitoring one another's activity, assessing the quality of one another's work, and providing back up behavior to help struggling team members. This process behavior involves aiding other team members as they engage in task-relevant work. Moreover, it enables teams to efficiently overcome the inadequacies of any specific team member. Team monitoring and backup has been a central component in prior taxonomies of team process (e.g. Dickinson & McIntyre, 1997; Marks et al., 2001). A participant from the present critical incident study noted that:

> "We mainly used Facebook as it was efficient in keeping everyone updated and holding everyone involved accountable for their parts in the projects."

Additionally, another participant indicated that:

> "[Basecamp] was helpful because [it] allowed our team to know when others had completed assignments[...]"

This behavior can be particularly helpful for teams that utilize new media by enhancing member accountability and confidence in taskwork. Team monitoring and backup can somewhat counteract the feelings of isolation that may accompany technology use by enabling members to feel supported by others on their team. Moreover, the affordances of certain tools (such as Basecamp) can actually provide readily observable markers of task progress (e.g. uploaded documents, discussion thread), thus enhancing team-monitoring capabilities.

Motivation and Confidence Building. Motivation and confidence building occurs when team members motivate one another and build confidence in the team. This behavior can be embodied in a variety of ways ranging from positive compliments about a team member's work to consistently completing tasks in an effective manner. The unifying theme is that these behaviors reinforce positive feelings towards the collective. As with role and task assignment, this behavior has also featured in multiple prior taxonomies of team process (e.g. Fleishman & Zaccaro, 1992; Marks et al., 2001). Drawing from the present data collection, teams frequently utilize tools to engage in motivation and confidence building. For instance, one participant explained:

> "WebEx was important in our ability to form social connections with the business team in a "face-to-face" relationship where we could also relate ideas with non-verbal cues (no confusion that can occur in text-relations). So our closeness with each other created an open atmosphere that allowed for free thought and the ability to constructively criticize."

Another participant indicated:

> "Facebook Messenger helped facilitate group conversations between the social analytics team and business team but also allowed individuals to reach out to specific individuals. Through this we were able to properly clear out any miscommunication, relay important information, and built positive feelings toward one another that made it easier to work together."

In each of these instances, team members used the functionality of the tools at hand to establish a bond with other members of the team. Moreover, each quotation conveys an awareness of the importance of establish this rapport towards enhancing overall team interaction and functioning. Teams that do not engage in these behaviors may be more prone to experience frustrations with one another, thus hindering team process.

Process Expansion

Process expansion depicts team processes that are enabled, scaffolded, and/or supported by technology. This dimension reflects collaborative team process behaviors that uniquely arise through use of technology. These behaviors are not captured by current conceptualizations of team process, and reflect instances in which technology use distinctively extends the behavioral capabilities of teams. Previously established social practices may set boundary conditions on the types of behaviors team members may exhibit. However, the constantly evolving properties of technology may allow team members to realize new capabilities for interaction. Thus, process expansion reflects the manner in which technology enhances the behavioral repertoire available to team members. Therefore, this dimension in particular may yield very novel insights into the interactive dynamics present in modern teams. The present critical incident study found that process expansion is manifested in six principal ways: simultaneous collaboration, creating scaffolds/artifacts, automated coordination facilitation, interaction variability, bridging time, and bridging space (see Table 5).

Table 5.
Process Expansion - Study 1 Qualitative Examples

Category	Definition	Critical Incident Quote
Simultaneous Collaboration	Teams use technology to work together on a task; integrating and building on one another's ideas. *Example*: Multiple team members simultaneously editing a GoogleDoc.	"By using Google Docs to simultaneously collaborate online, we were able to make our final report "flow", and the individual sections were consistent with each other."
Creating Scaffolds/Artifacts	Teams use technology to create a common visual representation of their workflow and work products. *Example*: Taking notes on the WebEx Whiteboard during a WebEx meeting.	"We used Basecamp as a forum to post comments and upload documents."
Automated Coordination Facilitation	Teams use technology to automate their organization, setting up automatic updates and reminders *Example*: Members receive an automatic reminder of an upcoming due date from the Basecamp calendar.	"I found Basecamp extremely helpful because everyone got notifications of what each person said and it also gave us constant reminders of the work that we had to do work for this project."
Interaction Variability	Teams use multiple channels to enable them to think both independently and jointly, thinking synergistically and avoiding process loss. *Example*: Using both WebEx and email to facilitate taskwork.	"The video conferencing capabilities [in WebEx] are great, but there were often times when people would get muted for random reasons, the ability to calibrate and put down ideas was difficult to do on the platform itself. We created a Google doc to solve this problem."
Bridging Time	Teams use technology to work together across different time zones *Example*: Processing an email on one's own time.	"Basecamp was helpful because we didn't all need to be online at the same time."
Bridging Space	Teams use technology to work together from different physical locations. Example: Email communication between a member from France and USA.	"We used the WebEx to meet with the French team .We were able to meet with the France team "Face to Face" and communicate better. Without WebEx, we would have had to fly to France.

Simultaneous Collaboration. Simultaneous collaboration is reflected through team members working concurrently on a task by integrating and building on one another's ideas. Many technological interfaces can provide a unique window into taskwork in real time. By leveraging these resources, members may view the contributions of another team members as they are occurring. This feature of technology has the ability to fundamentally change how team members approach a given team-based task. Put otherwise, team members may alter their course of action after viewing the taskwork of other members in real-time, resulting in a more synergistic product. In this circumstance, the materiality capability of a given tool, or set of tools, can enable a real-time mental collaboration that is not possible using other modalities. The current dissertation study found that distributed teams exhibited this behavior on multiple occasions. For instance, one team member noted:

> "Google Docs was a useful tool to use in communicating with the psychology members. We used Google-docs to collaborate in writing the final paper for the project. After we had delegated the sections that we would each be responsible for, we could all contribute each part to the on-going document using Google-docs. It was helpful to be able to simultaneously edit the paper and work on it at the same time. Without Google-docs, we would have had to e-mail several versions of the paper, but by using the technology we were able to efficiently collaborate and finalize the paper."

Likewise, another participant observed that:

> "The most helpful communication/collaboration technology for our group was definitely Google Drive (coupled with email to set up Google meetings). Google

Drive allowed everyone on the social analytics team to collaborate on the same document without interfering with each other. A specific instance in which Google Drive was particularly helpful was while doing the empirical write up of our survey results. Each team member was working on a specific section while also reviewing the rest of the document. By using Google Drive to collaborate online, we were able to make our final report "flow", and the individual sections were consistent with each other. No missed points or redundancies."

In both instances, participants discussed utilizing new media to allow members to simultaneously contribute to a task-relevant document. This action enabled members to process and contribute to the document at the same time, while also enabling a more comprehensive synthesis of member knowledge.

Creating Scaffolds/Artifacts. Creating scaffolds, or artifacts, is defined as team members creating external representations of their workflow and work products. This behavior is a fundamental aspect of technologically based interaction. A unique feature of many technological interfaces is that they enable team members to leave markers of interactions or productivity (Fiore, Rosen, Smith-Jentsch, Salas, Letsky, & Warner, 2010). This act allows the individual to offload thoughts or ideas onto a platform (e.g. word document, virtual notepad etc.). These artifacts serve to free up cognitive resources, and while also enabling task-relevant information sharing with other members (Cuevas, Fiore, Caldwell, & Strater, 2007). As noted by Fiore and Schooler (2004), these scaffolds or artifacts may take a variety of forms, but the common characteristic is that they are concrete depictions of the team's taskwork. Moreover, their creation enables team members to develop a shared cognitive schema about the taskwork at hand (Fiore, Salas, Cuevas, & Bowers, 2003). This data collection found that teams created scaffolds/artifacts frequently. One participant stated that:

> "We collaborated over Google Docs. Since we could leave notes about things we thought needed to be changed, we were able to work together. Without Google Docs, we would have needed to email a Word document around, which would have been a nightmare."

This particular team offloaded their ideas into Google Docs, which served as an artifact of their taskwork. They also left other artifacts by posting comments on various sections of the document, which enabled them to further integrate and improve their work. Another participant stated:

> "Our main source of communication was Facebook and it was extremely helpful as we posted questions, Google doc links, updates, even polls on our decision-making, etc. We could freely comment or express concerns or helpful tips that everyone could see […]."

This team member indicated that his or her team utilized a variety of platform functionalities to leave different types of artifacts. For instance, they used Google Docs to offload their taskwork, while also using Facebook polls to create artifacts of their decision-making. Each of these actions allowed the team to streamline their cognitive schemas to optimize their taskwork.

Automated Coordination Facilitation. Automated coordination facilitation is reflected through team members setting up updates and reminders to automate their organization of processes, deadlines, and assignments. As noted by previous taxonomies of team process (e.g. Brannick, Prince, Prince, & Salas, 1992; Flieshman & Zaccaro, 1992, Marks et al., 2001), coordination is an essential aspect of team functioning. Coordination itself has been defined as “orchestrating the sequence and timing of interdependent action” (Marks et al., 2001, pp. 636). This definition inherently implies that teams must use their resources to ensure that member actions are carefully executed in a sequential and pre-determined fashion. A variety of technological platforms now provide functionality that can automate the “sequence and timing” of these actions. Members may specify future interaction events (e.g. schedule a meeting, remind members of a deadline) in a given technological interface, with the knowledge that the technology will carry out the action automatically at a specified juncture. This capability frees up resources for members to focus on other task-relevant activities. In present qualitative study, one participant stated that:

> “WebEx was probably most helpful. We used this for meetings. This was helpful because it sent out reminders for meetings.”

Whereas another stated that:

> “I found Basecamp [a project management platform] extremely helpful because everyone got notifications of what each person said and it also was a constant reminder that we had to do work for this project.”

Each quotation demonstrates unique instances in which the materiality of a particular tool allowed members to partially automate their coordination, which freed up resources to work on other tasks. The second quotation is additionally informative because it demonstrates that this functionality also encouraged members to remain on-task, which likely enhanced team efficiency.

Interaction Variability. Interaction variability is defined as team members using multiple channels to enable them to think both independently and jointly, while working synergistically and avoiding process loss. Modern teams are now provided with a suite of technologies to accomplish their taskwork. Each of these tools possesses distinct capabilities that can uniquely map onto specific tasks, or phases of a task cycle. Accordingly, teams may switch between new media platforms so that their interactions and communications most appropriately match the task at hand. For example, a team may use videoconferencing software (e.g. WebEx or Skype) to engage in a brainstorming session, but then may switch to email during task engagement. This behavior of switching between new media platforms enables teams to avoid process loss in ways that would not be possible when constrained solely to one technological modality. In the present data collection, teams were provided with three new media platforms (WebEx, Basecamp, and GoogleGroups), each of which possessed unique affordances and capabilities. Moreover, given that this was a quasi-field study, participants were also free to use technologies outside of this suite if they so chose. Qualitative analysis of the critical incidents revealed that the teams did frequently exhibit interaction variability. For instance, one team member indicated that:

> "The extremely helpful technology we used was Google Docs and Google chat. We were originally using Basecamp, but we found sharing documents or screen sharing was difficult during our meetings, which is why we switched to Google Docs. This technology was helpful because we could all work on the document at the same time."

This quotation demonstrates that this team adapted their technology use to match their teamwork needs. Switching between Google Docs and Basecamp allowed members to leverage different technological affordances towards accomplishing their task objectives. Another participant stated that:

> "It was extremely helpful switching to Skype when WebEx failed us. Skype has a much better interface, and most people are already familiar with it."

This quotation demonstrates that teams may also switch between platforms of that possess similar capabilities when one technology malfunctions. In this circumstance, their teamwork necessitated a videoconferencing platform that enables real-time communication and information sharing. Given that WebEx initially malfunctioned, this particular team exhibited adaptive behavior by switching between platforms to instead utilize Skype.

Bridging Time. Bridging time occurs when team members interact and complete taskwork at different times. Technology provides its users with the enhanced ability to "reflect" (Conoloe & Dyke, 2004, pg. 118). Certain technologies (e.g. email, project management platforms) engender more asynchronous interactions, which encourages discussions to occur over a longer time frame. These technologies typically provide a repository for all member communications, and enable individuals to process, interpret, and respond on their own time. This affordance allows members to more efficiently comprehend and contribute to team collaborative efforts. In this circumstance, technology can expand the boundaries of teamwork beyond that of real-time synchronous collaboration to accommodate a longer time frame for member interaction. This enables members to maintain more flexible schedules, while also comprehensively digesting all team communications. The current study found that participants frequently utilized new media platforms to expand the temporal aspect of their teamwork. For instance, one participant stated:

> "Basecamp was very helpful to the functioning of the team because it was a forum that we all could participate on, and it we could do it on our own time without having to set up difficult meetings."

Likewise, another participant indicated that:

> "[We] used Basecamp for communication across time zones. It allowed us to stay on the same page across two teams and many time zones. By submitting assignments and coordinating workload, we were able to finish all of the work painlessly."

These quotations demonstrate that technology – in this instance Basecamp – expands teamwork capabilities by allowing members to collaborate on their own schedules and across time zones. Without technology, these forms of interaction and team process would not be possible.

Bridging Space. Bridging space is reflected through team members working together from different locations without being physically present. The literature has long stated that a chief benefit of communication technologies is that they enable individuals to collaborate across the world (Desanctis & Monge, 1999; Hinds, Liu, & Lyon, 2011). This allows organizations to comprise teams of the most experienced or most expert individuals, regardless of their physical location (Ahjua & Galvin, 2003; Hoch & Kozlowski, 2012). In these circumstances, removing technology from the workplace would remove the potential for collaboration. Thus, technology enhances team functioning by extending team member reach beyond face-to-face interaction. Put otherwise, technology expands the boundaries for teamwork, allowing team processes to occur across physical frontiers. Qualitative analysis of the critical incidents revealed that participants frequently recognized this benefit of technology, and used it for that very reason. For example, one participant stated that:

> "When working with the business team, it was extremely helpful to use WebEx when writing the initial idea brainstorm proposal. We used this technology to have a meeting. This technology was helpful in this instance because it allowed people in different parts of the world to speak. Without this technology, we would not have been able to get a good understanding of people's feelings about the topic."

Another team member reinforced this perspective by stating:

> "WebEx was extremely helpful for the team when we had to make the first proposal. We used this technology to talk to the students in France. This was helpful because was all didn't have to be in the same room since we are in different parts of the world."

Each of these quotations demonstrates that the participants frequently utilized new media to interact with other members in different locations. In fact, they were cognizant of the fact that collaboration with these individuals would not have been possible without their new media platforms.

Process Impairment

Lastly, process impairment is defined as the extent to which members must overcome impediments to team process behavior that are unique to technology use. This dimension describes team processes that are impeded and must overcome material constraints imposed by technology. The conceptual foundation of process impairment acknowledges the fact that although technology may augment or expand team process in multiple ways, technology may also introduce unique obstacles to team functioning, leading to process inefficiencies. Therefore, the most effective teams are those that may leverage the benefits that accompany process facilitation and process expansion behaviors, while appropriately mitigating the process loss that typifies process impairment. Qualitative analysis of the critical incidents revealed that process impairment is comprised of four lower order behaviors: familiarity, preference, technology/process mismatch, and technology breakdown (see Table 6).

Table 6.

Process Impairment - Study 1 Qualitative Examples

Category	Definition	Critical Incident Quote
Familiarity	Team functioning is hindered because one or more members are not familiar with a particular technology. *Example*: Using Facebook to collaborate despite the fact that multiple members have never used it before.	"None of us were familiar with WebEx, and even the most technologically savvy still had issues. We only tried to use it the first two meetings before giving up on it. It wasted our time."
Preference	Team functioning is hindered because different team members use different technologies. *Example*: Subsets of members prefer to use WebEx to engage in taskwork, while others prefer Skype.	"The only thing that was harmful was the fact that my group members tried to use 4 different forms of communication. None of these alone were bad, but it got confusing and annoying to try and keep up with all four at once."
Technology/Process Mismatch	Team functioning is hindered because the technology they are using is not well matched to their needs. *Example*: Using email to facilitate a 'get-to-know-you' meeting (instead of a videoconferencing medium).	"Basecamp was a harmful technology, because only one user could live edit a document at a time, and so, it caused major conflicts during our scheduled drafting time. We could've been more productive in Google Docs."
Technology Breakdown	Team functioning is hindered because technologies are not functioning properly. *Example:* WebEx meeting prematurely ends due to loss of connection.	"WebEx didn't work for us at the start of one meeting so that limited our productivity and wasted time."

Familiarity. Familiarity captures hindrances in team functioning due to one or more members not being familiar with a particular technology. As evidenced by the process facilitation and process expansion dimensions, technologies provide many unique capabilities for team interaction; however, these capabilities are enabled by variations in functionality across tools. Varying technological functionality means that each tool is typically accompanied by predetermined rules of use. Oftentimes, if an individual has not used a given tool previously, he or she may be unfamiliar with its interface and functionality. This can lead to an inability to use to the tool entirely or a period of learning how to use the tool. Thus, modern teams may frequently be confronted with instances in which certain members know how to utilize and implement a given tool, while others do not. This lack of familiarity can lead to inefficiencies in team collaboration as the less technologically savvy members of the group work to improve their knowledge of tool use. The critical incident study revealed that members frequently confronted technological familiarity issues during team collaboration. For instance, on participant noted:

> "None of us were familiar with [WebEx], and even the most technologically savvy still had issues. We only tried to use it the first two meetings before giving up on it. It wasted our time. Skype is much better to use because it's simple, even if you can only voice chat and not video chat."

Similarly, another participant stated that:

> "Our team relied exclusively on Basecamp and WebEx for everything that we did. The only problem with this was WebEx tended to be difficult to learn to use. One

> occasion, a virtual meeting took almost 30 minutes longer than it should have because we couldn't figure out how to use the program at first."

In each of these instances, participants referred to a lack of familiarity with WebEx as being detrimental to team functioning. The quotations also signify that the ways to overcome this issue were to either learn functionality and proper usage of the technology, or switch to a technology that all members we more familiar with. It is likely that the most effective teams will aim to overcome technological familiarity issues by efficiently and uniformly choosing one of these routes in order to improve team interaction.

Preference. Preference reflects hindrances to team functioning due to different members using different technologies. Given that technologies are accompanied by different interfaces, rules of use, and functionalities, it is likely than team members will develop individual preferences for which tools they favor over others. These preferences are typically manifested in which tools members actually choose to utilize during team interaction. Therefore, these preferences can become problematic when different members of a given team prefer to use different technological platforms. For instance, some individuals may prefer to utilize Google groups to communicate, whereas others may prefer a project management platform such as Basecamp. These varying technology preferences are likely to prompt breakdowns in communication and impediments to information sharing. In the present sample, team members noted that they frequently experienced incongruent technology preferences in their teamwork. For instance, one individual noted:

> "I personally felt that Facebook was a technology that could have been very harmful for our team if widely used. I personally do not use my Facebook account

> normally or at all, and at the beginning of the class, we used Facebook to get in touch. If this had continued, I would have always missed out on communication."

Moreover, another participant explained:

> "Facebook helped tremendously when communicating with the business team, because that team did not really like using Basecamp. They saw the tool as a place to turn in documents rather than hold discussions. Since all members of both teams checked Facebook regularly, it was easy to keep in touch with one another. Whether it came to scheduling meetings, discussing project ideas, or distributing assignments, Facebook played a strong part."

The first quotation conveys how incongruent member preferences may engender process loss. This particular individual did not frequently use Facebook; therefore, had the rest of the team continued to use that platform, team functioning would have been hindered. On the other hand, the second quotation demonstrates the importance of communicating technological preferences. If this individual had not known about the other members dislike for Basecamp, they would not have known to shift communications to Facebook. Thus, this particular team overcame a potential process impediment by encouraging an open dialogue about tool use.

Technology-Process Mismatch. Technology-process mismatch captures hindrances in team functioning due to using a technology that does not fit the needs of the team. Previous literature on team process has established that different phases of taskwork require different types of team processes (e.g. transition phase processes, action phase processes: Marks et al., 2001). These processes vary in terms of the type of member interaction that is required (Carter, Seely, DeChurch, & Zaccaro, 2015;

Maznevski & Chudoba, 2000). For instance, transition phase processes may require in-depth synchronous interactions to maximize strategy and planning capabilities. In this circumstance, a team must utilize a technology that best fits these process needs, such as WebEx or Skype. Due to their capabilities, other technologies, such as email, may not satisfy these functional needs, thus inhibiting or diminishing team functioning. Therefore, it is very important that team members utilize tools that match the process demands of the team, and are able to adjust their tool use as process demands change. Analysis revealed that mismatches between technology and process needs were a common occurrence in the present data collection. One participant explained:

> "Basecamp was a harmful technology, because only one user could live edit a document at a time, and so, it caused major conflicts during our scheduled drafting time. We could've been more productive in Google Docs."

Similarly, another participant stated:

> "The harmful technology we used was trying to share/edit documents on Basecamp. Initially, we were trying to fill out the charter via Basecamp, but because only one person can share their desktop at a time, we had trouble efficiently filling out forms. If we had used another technology, such as Google Docs, we could have finished the charter in <5 minutes, because all 7 of us could type in our information at once."

In these instances, each team was attempting to engage in synchronous collaboration with the objective of completing a task-relevant document from all members. As noted by the participants, Google Docs would have satisfied these process needs. However, each team chose to enact this behavior via Basecamp, which only allows one member to post and edit a document at a time. Thus, the mismatch between technology use and process needs led to a unique form of process loss.

Technological Breakdown. Technology breakdown reflects hindrances in team functioning due to malfunctioning tools. Given that technology is inextricably linked and embedded in team process, inefficiencies in collaboration may arise not only from inappropriate member actions but also from the tools themselves. Technologies are constructed to perform certain actions automatically, such as connecting members to a WebEx call or transmitting an email. However, technologies may not follow through on these actions due to malfunctioning hardware issues, software problems, or other technical difficulties. Given that technology is embedded in process, a malfunctioning tool will lead to a breakdown in team collaboration and cause process loss. Participants in the current data collection noted that this form of process impairment was a frequent occurrence. For instance, one member stated:

> "We used WebEx for our two meetings with the psychology team. It was harmful because we lost about two hours in total trying to fix it, but still could not succeed. The picture and the sound were lost; we could not discuss issues like we normally do."

Similarly, another participant explained:

> "WebEx didn't work for us at the start of one meeting so that limited our productivity and wasted time."

Each of these quotations depicts how breakdowns in the functioning of WebEx limited team interaction. In both instances, had this tool functioned properly, team members could have interacted and collaborated. However, impairment unique to the use of technology obstructed teamwork processes.

Discussion

This work fundamentally contributes to the literature on team process in multiple ways. To begin with, this study addresses multiple calls to move away from conceptualizing human behavior and technology use and distinct or parallel phenomena (e.g. Leonardi, 2011; 2012; 2013; Orlikowski & Scott, 2008; Scott & Orlikowski, 2013). The conceptual framing of the present work extends this sociomaterial perspective to the realm of team process to assert that there is a fundamental embeddedness between technology use and human behaviors, and is embodied through the term *process sociomateriality*.

Findings from the qualitative critical incident data collection provided evidence for the prevalence of the phenomenon of process sociomateriality among a sample of partially-distributed teams. Qualitative analysis of the critical incidents revealed that the inextricable linkage between member behavior and technology use is manifested in three primary ways: process facilitation, process expansion, and process impairment. Process facilitation reflects member behaviors that are enabled, scaffolded, and/or supported by technology. Marks et al. (2001) previously conceptualized the *content* and *timing* of behavioral processes into distinct behavioral processes that are uniquely critical to team success. Process facilitation captures the fact that teams frequently exhibit many of these behaviors via technology, and that technology can serve enable or impede these actions. This notion that technology can place boundary conditions on member behaviors has been repeatedly raised in the literature on teams. Teams researchers have consistently pointed out that the use of technology can both afford and constrain process (Kirkman & Mathieu, 2005; Martins et al., 2004; Suthers, 2006). Affordance reflects the degree to which a specific technological platform enables existing team processes, whereas constraint can indicate the manner in which a given technology inhibits team processes (Hutchby, 2001). For example, videoconferencing affords member coordination (Marks et al. 2001) by allowing members to sequence their actions towards task accomplishment in real time. On the other hand, email can constrain coordination (Marks et al., 2001) by limiting real-time interaction. Thus, process facilitation depicts the manner in which technology may afford or constrain team process behaviors (e.g. Marks et al., 2001). Altogether, this dimension conveys how technology enables or restricts team process behaviors that were previously conceptualized without consideration of the role of materiality.

On the other hand, process expansion depicts team processes that connect members' thoughts, feelings, and actions that are enabled only by virtue of a material aspect of a technology. These behaviors are not captured by current conceptualizations of team process, and reflect instances in which technology use uniquely extends the behavioral capabilities of teams. In today's dynamic and globalized workplace, technology is made to suit team objectives, but it also extends the realm of possibility for collective action. Therefore, just as teams use technology to augment process, technology also inspires advances in member interaction. Accordingly, a central finding of the present dissertation is that technology can also expand the types of processes that teams may exhibit. Put simply, technology now allows members to interact and accomplish teamwork in fundamentally new ways. Therefore, the use of technology not only facilitates traditional process behaviors but it also extends the behavioral capabilities of teams.

Finally, process impairment describes team processes that are impeded and must overcome material constraints imposed by technology. Whereas the use of technology may facilitate or expand team process, it may also lead to many process difficulties that are unique to interacting via these platforms. These difficulties may inhibit the implementation of previously established team processes, or they may inhibit teams from reaping the benefits of novel process behaviors that uniquely arise from the use of technology. For instance, technological breakdowns are an all-too-common occurrence in modern team settings. These issues provide hindrances to teamwork that would not be experienced in an entirely face-to-face setting. Teams must actively work around these issues in order to ensure optimal team functioning is maintained. Likewise, team members may exhibit different preferences for technological platforms, which can lead to team coordination issues. In these circumstances, members must also work to establish consistent collaboration norms so as to avoid process hindrances. Thus, technology use can introduce unique instances of process loss. Accordingly, this dimension reflects the extent to which team members must cope with process loss unique to the use of technology.

Taken together, these findings reveal that the phenomenon of process sociomateriality captures *member interactions that are enabled, augmented, or impaired by the use of technology during taskwork*. This three-factor structure is consistent with prior work on team process that has theorized (Marks et al., 2001), and found support for (LePine et al., 2008), the multidimensional nature of team process. In particular, these works have revealed that although transition, action, and interpersonal phase processes comprise the overarching construct of team process, the behaviors indicative of each of these respective dimensions are relatively distinct. Similarly, findings from the present critical incident study support the idea that the dimensions of facilitation, expansion, and impairment all comprise the construct space of process sociomateriality, but are each represented by distinct member behaviors.

A final contribution of this work is that it provided a rich, qualitative analysis that served to establish the construct space of process sociomateriality. This effort lays the foundation for future work to empirically examine the nomological network of process sociomateriality to investigate how it relates to other relevant team process constructs. Moreover, this study highlights the need to also examine the extent to which the process sociomateriality factors predict essential team outcomes in an effort to further uncover the factors that contribute to the success and failure of modern teams.

Summary. A substantial amount of research has sought to uncover the factors that enhance and hinder team process. Despite its ubiquitous presence in the modern workplace, technology is notably absent from the conceptualization of team process. The present study leverages modern organization thinking on the role of technology to advance research on team process by introducing a taxonomy that depicts the inextricable linkage between process behaviors and technology. This taxonomy fills a notable void in the conceptual space of team process, and will enable researchers to better understand the interactional dynamics of modern teams.

CHAPTER 6

STUDY 2 – MEASURE DEVELOPMENT AND PILOT TESTING

A chief aim of the present dissertation is to not only inform the theory of technology use in team settings, but to also advance its measurement. As previously conveyed, research on teams has typically investigated the use of technology in team settings through the virtuality lens. The conceptual framing of much of this work has centered on comparing the effectiveness of face-to-face teams and virtual teams. Accordingly, the most frequently employed research paradigm has been an experimental design that compares the team functioning adhoc team of face-to-face participants with an adhoc team of participants that use one particular form of communication technology (Kirkman et al. 2012; Martins et al., 2004).

This paradigm has been criticized for inaccurately representing modern teams. Research efforts within this realm of research have proposed that virtuality is a characteristic of all teams, and virtuality itself is a continuous construct (Bell & Kozlowski, 2002; Griffith, Sawyer, & Neale, 2003; Schweitzer & Duxbury, 2010). In particular, almost all teams now use to technology regardless of their level of geographic dispersion; therefore, all teams can be classified along the continuum of virtuality. Therefore, separating teams into “virtual” and “face-to-face” groupings creates an artificial dichotomy that is not actually present in the modern workplace (Kirkman et al., 2012). As such, a small number of researchers on teams have developed continuous measures of virtuality (see Table 7).

Table 7.
Measures of Team Virtuality

Citation	Construct Name and Description	Sample Item/Procedure
Bierly, Stark, & Kessler (2009)	Team Virtuality: Designed to assess the overall virtuality level of a team.	"Our project team was considered a virtual project team; that is, we primarily interacted through computer and telecommunications technologies."
Cummings, Espinosa, & Pickering (2009)	Synchronicity: Designed to assessed the interaction synchronicity and asynchronicity of a team.	Participants were instructed to indicate the how often they communication via a variety of synchronous and asynchronous communication modes.
Golden & Raghuram (2009)	Electronic Tool Use	Assesses the extent to which team members used specified electronic tools to connect with others and gather information.
Ferguson (2005)	Communication Percentage	Participants were asked to indicate what percentage of their of their team communication occurred through a variety of mediums (face-to-face interaction, phone, email etc.)
Rapp, Ahearne, Mathieu, & Rapp (2010)	Degree of Virtuality	Subtracted f-f meeting percentage from 100% to index degree of virtuality and aggregated to team level.
Lurey & Raisinghani (2001)	Tools and Technology	"The team is equipped with adequate tools and technologies to perform our tasks."
Sweitzer & Duxbury (2010)	Degree of Virtuality	Calculated three indices: 1) Proportion of team work time spent working virtually 2) Proportion of virtuality 3) Degree of separation
Kirkman, Rosen, Tesluk, & Gibson (2004)	Face-to-Face Meetings	"How many times did your entire team meet face-to-face in the past year?"

For instance, Bierly, Stark, and Kessler (2009) developed a three-item measure of virtuality designed to assess the virtuality level of each team. Likewise, Cummings, Espinosa, and Pickering (2009) developed measures of synchronous and asynchronous communication. For each measure, participants were instructed to indicate the how often they communication via a variety of synchronous and asynchronous communication modes. Golden and Raghuram (2009) also developed a measure of electronic tool use that was constructed to assess the extent to which team members used specified electronic tools to connect with others and gather information.

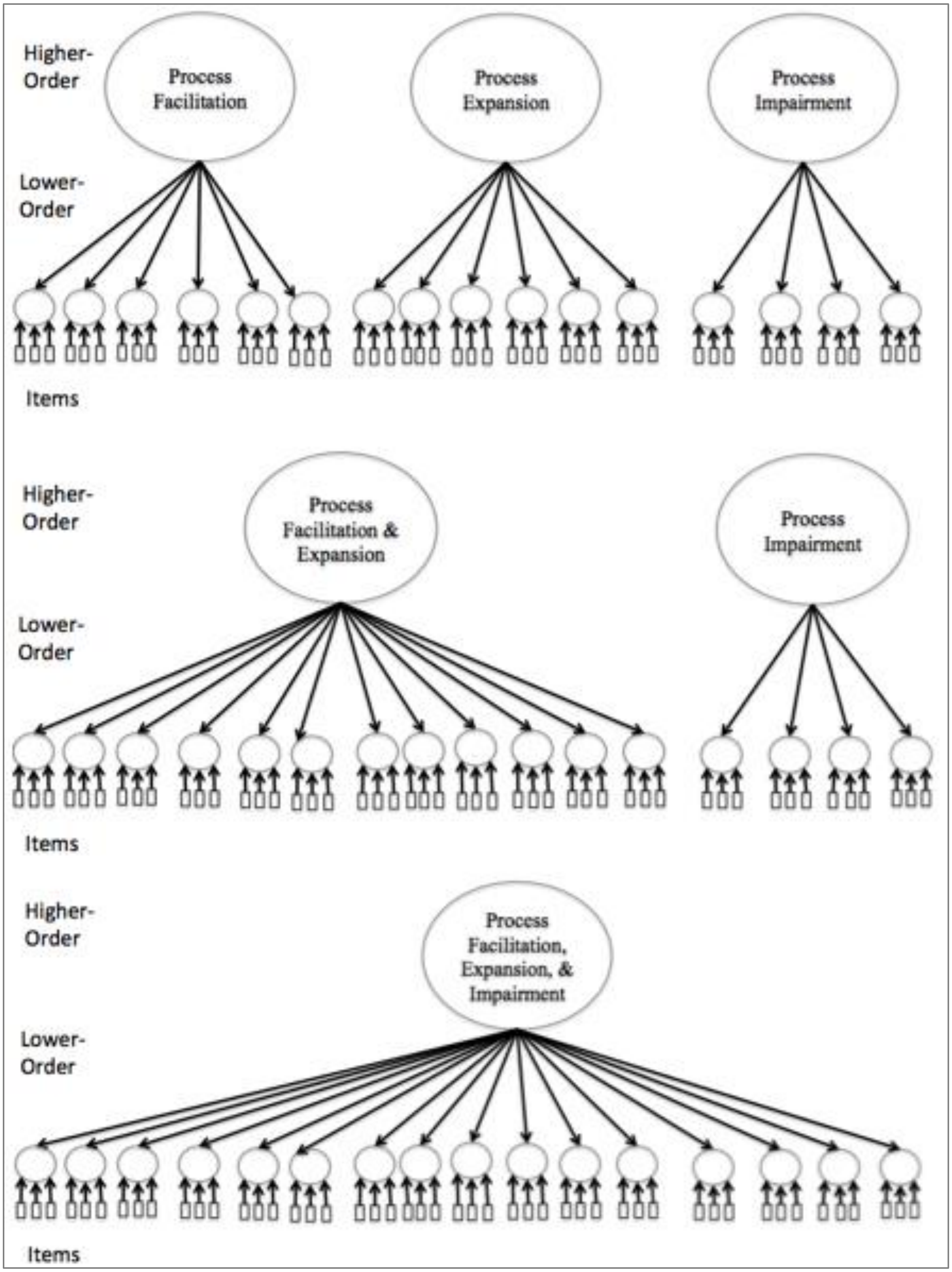
Although these efforts do represent advancement beyond artificial face-to-face/virtual team dichotomizations, they still fall short of capturing the complexity of technology use in modern team settings. For instance, the Bierly et al. (2009) and Golden and Raghuram (2009) scales broadly measure the extent to which a team is virtual. This assessment is very limited in its ability to capture nuanced team process behaviors that are interwoven with technology use. The following sample item from Bierly et al. (2009) scale illustrates this deficiency: "Our project team was considered a virtual project team; that is, we primarily interacted through computer and telecommunications technologies." Almost all modern teams utilize communication technology; thus, this item is relatively uninformative regarding differences in behavioral process between teams. Put otherwise, these forms of assessment are unable to detect variance in how teams utilize technology to accomplish collective goals. Likewise, the Cummings et al. (2009) measure only considers one aspect of technological affordance (synchronicity), and does not account for the role of human agency in technology use.

To date, no one has developed a measure that directly assesses the manner in which process behavior is intertwined with technology use. This dissertation sought to develop and validate such a measure designed to gauge specific instances of member behaviors that are embedded in technology use. This measure will allow academics and practitioners alike to better capture the extent to which team members use technology in ways that facilitate, impair, and expand team process. Moreover, researchers will be able to use this measure to better capture the manner in which these behaviors shape critical team states and performance. Therefore, the purpose of Study 2 within the present research program was to develop and validate a psychometric measure of process sociomateriality.

Factor Structure

The present study will examine the extent to which the factor structure of the survey matches the three-factor structure of process sociomateriality that was advanced in Study 1. Since no prior research on the construct of process sociomateriality exists, it is important to test the hypothesized factor structure against alternate models. Therefore, as is common practice (e.g. Cohen, Ledford, & Spreitzer, 1996; Harrison, Newman, & Roth, 2006; Mathieu, Hofmann, & Farr, 1993), the fit of the three-factor model will also be compared that of other theoretically-plausible factor structures (see Figure 1). The following will detail each of these factor structures.

Figure 1. Three-factor (Model A), two-factor (Model B), and one-factor (Model C) models of Process Sociomateriality.



Model A: 3 Factors. Model A draws from the results of the qualitative critical incident study (Study 1), and posits that process sociomateriality possesses a tripartite structure. From these findings, team process appears to be intertwined with technology use in three ways: facilitation, expansion, and impairment. First, teams utilize technology as conduit for process behavior (e.g. idea generation, role assignment). Second, teams employ technology to engage in novel forms of interaction. These behaviors capture the manner in which technology extends the behavioral process capabilities of teams (e.g. simultaneous collaboration, interaction variability). Third, teams experience process hindrances that are unique to technology use. Teams must overcome obstacles that are specific to technology use (e.g. familiarity, malfunctions).

Model B: 2 Factors. Model B represents a two-factor structure in which facilitation and expansion are merged into one factor, with the second factor being process impairment. It is plausible that technology and process are so intertwined that it is illogical to tease apart the facilitation and expansion dimensions. By introducing the notion of imbrication, Leonardi (2012) posits that teams utilize technology to fit their needs (e.g. facilitation), and, in turn, technology extends the realm of possible behaviors (e.g. expansion). This ongoing cycle represents an inherent connection between facilitation and expansion behaviors, perhaps to the extent that they are not distinct phenomena. Process impairment, on the other hand, can still be said to exist outside the realm of imbrication as it reflects technological impediments to team functioning.

Model C: 1 Factor. Model C supports the notion that all technologically-relevant behavior can be categorized by one overarching process sociomateriality factor. In this scenario, all behavioral indicators discussed in Study 1 would load directly onto one higher order category of process sociomateriality. This structure indicates that there is no theoretical distinction between facilitation, expansion, and impairment behaviors, and is consistent with prior assertions that were may be one overarching factor that encompasses all team process behaviors (LePine et al., 2008).

Nomological Network

Another central aim of this study was to develop, and subsequently assess the construct validity of the process sociomateriality measure, as well as examine its psychometric properties. According to the seminal work of Cronbach and Meehl (1955), construct validity can be appropriately examined through establishing the nomological network for the construct of interest. The primary means of establishing the nomological network occurs through examining convergent and discriminant validity of the construct of interest (Campbell & Fiske, 1959).

Convergent Validity. Convergent validity reflects the degree to which theoretically related constructs are actually related (Campbell & Fiske, 1959). A principal focus of this work is to establish the use of technology as an important consideration within frameworks of team process. In particular, this dissertation posits that technology use reflects a unique aspect of behavioral interaction that fundamentally shapes process in modern teams. The process sociomateriality measure will be constructed to capture this process-related phenomenon. Given that process sociomateriality reflects a particular aspect of team process, this novel construct should be positively related to existing the conceptualizations of process set forth by Marks et al. (2001). Both the Marks et al. (2001) measure and the process sociomateriality measure capture aspects of process;

therefore, this manuscript postulates that *team process* and *process sociomateriality* will exhibit convergent validity.

Hypothesis 1: Team process factors and process sociomateriality factors are positively related.

Discriminant Validity. Discriminant validity is the degree to which theoretically unrelated constructs are empirically distinct (Campbell & Fiske, 1959). Process sociomateriality reflects member behaviors specific to the use of technology within the context of team process. It follows that the construct of process sociomateriality does not overlap conceptually with team constructs that are outside the realm of behavioral process. Campion, Medsker, and Higgs (1993) developed a team-relevant measure that is designed to assess work group characteristics (see Table 8 for a definition of each work group characteristics construct).

Table 8.

Work Group Characteristics Constructs (Campion, Medsker, & Higgs, 1993)

Grouping	Construct	Definition
Job Design	Self-Management	The extent to which the group is autonomous.
	Participation	The degree to which all members are allowed to participate in decisions.
	Task Variety	Giving each member the chance to perform a number of the group's tasks.
	Task Significance	The extent to which member's believe that their group's work has important consequences.
Interdependence	Task Interdependence	The extent to which group members interact and depend on one another to accomplish work.
	Goal Interdependence	The degree to which a defined group mission or purpose is present.
	Interdependent Feedback and Rewards	The extent to which the group's performance is linked with individual feedback and rewards.
Composition	Member Heterogeneity	Group diversity in terms of abilities and experiences.
	Member Flexibility	Whether members have the ability to perform each other's jobs.
	Teamwork Preference	Member preference for group work.
Context	Training	Team instruction regarding group decision-making, interpersonal skills, and technical knowledge.
	Managerial Support	The extent to which the manager provides the group with the resources necessary to make group functioning possible.
Process	Potency	The belief by a group that it can be effective.
	Social Support	The extent to which members help each other and have positive social interactions.
	Workload Sharing	The extent to which members distribute work.
	Within Group Communication & Cooperation	The process of working together and sharing information.

The superordinate groups of these constructs are: 1) Job Design (e.g. self-management, task variety), 2) Interdependence (e.g. task and goal interdependence), 3) Composition (heterogeneity, flexibility), 4) Context (e.g. training), and 5) Process (e.g. social support, communication). Although these constructs depict aspects of the prevailing team environment, the first four dimensions are conceptually distinct from the collective use of technology in team process. For instance, task variety reflects the degree to which team members experience different tasks during teamwork, whereas team training reflects the extent to which members feel as though they receive appropriate task instruction. Thus, even though these constructs reflect aspects of the team environment, they are not a part of the team process construct space. Therefore, this dissertation postulates that the dimensions of process sociomateriality will discriminate from the constructs within the groupings of job design, interdependence, composition, and context that comprise the Campion et al. (1993) work group characteristics battery.

Hypothesis 2: Process sociomateriality factors are less strongly related to job design, team interdependence, team composition, and context constructs than to the team process factors.

Method

Item Development and Content Validation

The taxonomy established by Study 1 was used to develop a measure of process sociomateriality – the Process Sociomateriality Scale (PSS). Items were developed to directly correspond to the lower-order categories established by the taxonomy. Three to four unique items were developed for each lower-order construct within the taxonomy. In order to maintain consistency with previous team process measures (e.g. Marks et al., 2001; see Appendix B), the same response scale (1 = Not at all…5 = To a Very Great Extent) was used for the process sociomateriality items. This scale directly assesses the frequency of process behaviors relevant to new media use. Moreover, given that the findings of Study 1 informed the development of the PSS, the technological referent “new media” was utilized for all items. This term was utilized to ensure that the behavioral processes that are gauged by the PSS are consistent with the technologically embedded behaviors uncovered in Study 1.

In total, 56 unique items were developed. Content validity was then assessed using a subject matter expert panel (panel #3). This panel was comprised of nine individuals who possessed expertise in teams and technology use. Content validity reflects the extent to which a measure adequately reflects the construct it is attempting to measure (Lawshe, 1975). The present effort examined the extent to which the developed items accurately reflected the categories delineated in the taxonomy from Study 1. Subject matter experts were provided with each item, and were instructed to indicate which category(s) the item applies to. Raters were also given the opportunity to indicate that a particular item does not align with any of the specified categories. Item order was randomized to ensure that panelists are not primed to select certain categories. This procedure was completed through an online survey platform (Qualtrics).

Content validity was then assessed for each individual item by calculating an agreement percentage for each item. In particular, agreement was operationalized as the extent to which the panelists agreed on placing a given item the “correct” category. Items that exhibited an agreement of 67% (6 out of 9 panelists) or higher were retained (Gwet, 2010); items that did not meet this criteria were excluded. The extent to which each item loaded highly on categories other than the previously designated "correct" choice was also assessed. In this circumstance, if the 67% agreement threshold was met for a particular item on an "incorrect" category, that item was re-classified under the new category.

In total, three items were removed from the process facilitation scale for failing to meeting the aforementioned agreement criteria (Item 3 – Idea Generation; Item 10 – Activity Synchronization; Item 21 – Motivation and Confidence Building). In addition, two items were excluded from the process expansion scale (Item 31 – Automated Coordination Facilitation; Item 36 – Bridging Time), and one item was re-classified (Item 25 – Simultaneous Collaboration). Lastly, one item was excluded (Item 43 – Familiarity) from the process impairment scale, and one item was re-classified (Item 54 – Technology Breakdown). The resulting 50-item measure is depicted in Appendix B.

Survey Pilot and Validation

Sample. The finalized 50-item process sociomateriality measure (see Appendix B) was administered to the general population to examine its nomological network and psychometric properties. Given that confirmatory factor analysis will be conducted to assess the item loadings and factor structure of the process sociomateriality measure and requires a high degree of power, a large sample size was needed (Stone, 1978). Therefore, this study followed the variable-to-response ratio of 1:10 posited by Schwab (1980). Participants were recruited from Facebook, Amazon's Mechanical Turk, and Sona Systems at a southeastern university (see Table 9 for a description of each platform).

Table 9.

Study 2 Recruitment Platforms

Recruitment Platform	Description
Facebook	Online social media platform.
Amazon's Mechanical Turk	Crowdsourcing internet platform. Participants must reside in the United States and have a minimum 80% HIT rate acceptance.
Sona Systems	Experimental systems platform located at Georgia Tech. Provides undergraduates with a forum to facilitate their participation in research studies.

In total, 2130 participants were recruited to complete the survey. Participants were excluded if they did not complete the process sociomateriality measure (n = 246). Furthermore, in order to assess participant attentiveness, four items were included in the battery (Meade & Craig, 2012). A sample attention check item is "To monitor quality, please respond with a one for this item." Fifty-five participants were excluded due to scoring below 50% on the attention check. The final sample was comprised of 1829 useable cases. See Table 10 for a breakdown of sample size for each recruitment platform by condition.

Table 10.

Overall Sample - Sample Size Distribution Across Recruitment Platforms and Condition

Condition	Prompt	Facebook	SONA	Mechanical Turk
1 (n = 632)	Effective	36	435	161
2 (n = 653)	Ineffective	34	454	165
3 & 4 (n = 544)	Both	14	399	131
Total (1829)		84	1288	457

Note. Condition 3 n = 288; Condition 4 n = 256.

The sample was 57.72% male, with a mean age of 24.13. The education level of the participants was: 25.5% high school diploma, 47.8% some college, 4.5% Associate's degree, 15.5% Bachelor's degree, 4.8% Master's Degree, 1.6% PhD/JD/MD, and .4% other. All participants were, at the very minimum, conversational in English.

Condition Assignment. Participants were randomly assigned to one of four conditions in which they were instructed to complete a measurement battery based on 1) an effective team they participated on (Condition 1), 2) an ineffective team (Condition 2), or 3) both (Conditions 3 & 4). For participants that completed both, the order of presentation of the effective/ineffective prompt was randomized to control for order effects. In particular, participants in condition 3 first completed the survey based on an effective team, and then based on an ineffective team. Likewise, participants in condition 4 first completed the survey based on an ineffective team, and then based on an effective team. This condition structure allowed the present study to examine 1) how participants evaluate process sociomateriality when participating in effective vs. ineffective teams and 2) how the process sociomateriality measure performs both between and within subjects. Survey administration and condition assignment were conducted through Qualtrics survey software.

Survey Structure and Measurement. The survey was divided into four sections: 1) Consent, 2) Individual and Team Demographics, 3) Condition Assignment – Effective/Ineffective Team Prompt, 4) Process Sociomateriality, and 5) Convergent/Discriminant Validity Measures. All participants were instructed to complete all five sections. All measures from this battery are included in Appendix B. The condition assignment (#3) procedure was described in the previous paragraph. Due to condition assignment, the only variation between participants was presentation of the effective or ineffective team prompt; the rest of the measurement battery was the same across all participants. The effective team prompt was “Think of an **effective** team that you are currently on or an **effective** team that you participated on in the past. The remainder of these items asks about your experiences on that team.” The ineffective team prompt was “Think of an **ineffective** team that you are currently on or an **ineffective** team that you participated on in the past. The remainder of these items asks about your experiences on that team.”

After receiving the team referent, participants were asked to describe the characteristics of that team. The following team characteristics were assessed in the team demographics section: team type, team tenure, team size, and virtuality. Descriptives for each of these characteristics are presented in the results section. It bears mention that the virtuality index was created for this particular study. Participants were instructed to describe their team’s pattern of technology use by allocating 100 percentage points across seven different modalities (videoconferencing, audioconferencing, email, project management platforms, instant messaging, face-to-face, and other). Thus, for each participant, the percentage points across the seven options summed to 100%. This scale was purposefully constructed in this pattern to capture the pattern of technology use for a particular team, and under the assumption that participants cannot endorse more or less than 100% of their team interaction. The virtuality measure can be found in Appendix B.

Process sociomateriality was assessed using the 50-item psychometric measure developed in the present study. A sample item is “To what extent does your team actively work to use new media to generate ideas?” In order to assess convergent validity, the

Mathieu & Marks (2006) 30-item team process measure was administered. A sample item is "To what extent does your team actively work to use clearly defined metrics to assess your progress?" The response scale for both the process sociomateriality and the team process measures ranges from 1 (Not at all) to 5 (To a Very Great Extent). In order to assess discriminant validity, the Campion et al. (1993) work group characteristics battery was administered. A sample item is "Most members of my team get a chance to learn the different tasks the team performs." The response scale for this measure ranges from 1 (strongly disagree) to 5 (strongly agree). Reliability indices are discussed in the results section. To control for order effects, the order of presentation each of the measures was randomized.

Results

Participants were assigned to one of four conditions. Participants in conditions 1 (effective team only) and 2 (ineffective team only) were placed into the between-subjects sample given that they completed the measurement battery based on only one level of team effectiveness (effective or ineffective). On the other hand, participants in conditions 3 (effective, then ineffective) and 4 (ineffective, then effective) were placed into the within subjects sample. Accordingly, the results section will report the between subjects findings first, followed by the within subjects findings.

Between Subjects Sample

There were 632 subjects that reported about an effective team (Condition 1) and 653 students that reported about an ineffective team (Condition 2). In order to enable comparisons across effective and ineffective teams, the current section will present findings about effective and ineffective teams separately.

Effective/Ineffective Team Demographics. The mean size of the effective teams was 9.98 (*SD* = 8.77). The team type breakdown was: 26.4% leisure (e.g. sports, video games), 39.6% academic (e.g. class project), 32.4% work (e.g. decision-making, planning, project), and 1.6% action (e.g. firefighting, emergency management). 68.3% of effective teams were together for at least "a few months." The mean percentage use for each technological platform across effective teams was: *M* = 1.97% videoconferencing, *M* = 3.79% teleconferencing, *M* = 14.90% email, *M* = 2.06% project management platforms, *M* = 12.40% instant message, *M* = 62.75% face-to-face, and *M* = 1.93% other. Demographics for effective teams are detailed in Table 11.

The mean size of the ineffective teams was 9.04 (*SD* = 8.54). The team type breakdown was: 17.6% leisure, 52.2% academic, 28.9% work, and 1.2% action. 53.1% of ineffective teams were together for at least "a few months." The mean percentage use for each technological platform across ineffective teams was: *M* = 1.65% videoconferencing, *M* = 4.00% teleconferencing, *M* = 18.66% email, *M* = 1.56% project management platforms, *M* = 15.29% instant message, *M* = 56.45% face-to-face, and *M* = 2.49% other. Demographics for ineffective teams are detailed in Table 11.

Table 11.

Between Subjects Sample - Team Demographics for Effective and Ineffective Teams

Team Valence	**Demographic Characteristic**	**Sample Composition**	
Effective Teams	*Team Size*	*M*	9.92
		SD	8.77
	Team Type	25.3%	Leisure
		40.9%	Academic
		32.2%	Work
		1.6%	Action
	Team Tenure	*M*	3.79
		SD	1.05
	Team Communication Tool Use	1.97%	Videoconferencing
		3.79%	Teleconferencing
		14.90%	Email
		2.06%	Project Management Platforms
		12.40%	Instant Message
		62.75%	Face-to-Face
		1.93%	Other
Ineffective Teams	*Team Size*	*M*	9.04
		SD	8.54
	Team Type	23.6%	Leisure
		42.6%	Academic
		32.1%	Work
		1.6%	Action
	Team Tenure	*M*	3.43
		SD	1.09
	Team Communication Tool Use	1.65%	Videoconferencing
		4.00%	Teleconferencing
		18.66%	Email
		1.56%	Project Management Platforms
		15.29%	Instant Message
		56.45%	Face-to-Face
		2.49%	Other

Note. The team tenure scale was 1 = a few hours, 2 = a few days, 3 = a few weeks, 4 = a few months, and 5 = a year or more.

Supplemental analyses were conducted to examine the potential for any significant demographic differences between the effective and ineffective team samples (see Table 12).

Table 12.

Between Subjects Sample - Team Demographics Comparison Between Effective and Ineffective Teams

		Effective Teams		Ineffective Teams	
Variable	**Test Statistic**	***M***	***SD***	***M***	***SD***
Team Size	t = 1.95, p > .01	9.98	8.76	9.04	8.54
Team Tenure	t = 6.52, p < .001	3.83	1.06	3.44	1.10
		Type	**%**	**Type**	**%**
Team Type	$\chi^2 = 24.14$, p < .05	Leisure	26.4%	Leisure	17.6%
		Academic	39.6%	Academic	52.2%
		Work	32.4%	Work	28.9%
		Action	1.6%	Action	1.2%

Note. n for effective teams = 632; n for ineffective teams = 653. The team tenure scale was 1= a few hours, 2 = a few days, 3 = a few weeks, 4 = a few months, 5 = a year or more

Independent samples t-tests were conducted to test for differences in team tenure and team size across effective and ineffective teams. Findings revealed that team size did not differ between effective teams and ineffective teams (t = 1.95, $p > .05$). However, there was a statistically significantly difference in team tenure between effective and ineffective teams (t = 6.52, $p < .01$), such that effective teams (M = 3.83, SD = 1.06) were together slightly longer than ineffective teams (M = 3.44, SD = 1.10). In addition, a chi-square test revealed that effective and ineffective teams differed in team type (χ^2 = 24.14, $p < .05$). It is important to note that although there was a statistically significant difference in team type between effective and ineffective teams, the rank ordering of prevalence of each team type is consistent across the two samples. In both samples the largest portion of teams was academic, followed by work, leisure, and action.

Profile analysis, via MANOVA, was utilized to test whether there were differences in the overall pattern of technology use across effective and ineffective teams. The method is commonly used to compare patterns of responses on several related measures of an overarching dependent variable across groups (Ding, 2001). Therefore, profile analysis is the most appropriate analytic tool for the virtuality measure given that participants allocated a percentage of usage across the seven categories of virtual tools to yield an overarching virtuality profile for each team. The multivariate test revealed that there is a statistically significant difference between effective and ineffective teams on the virtuality factor (Pillai's Trace F = 2.42, $p < .05$, see Table 13).

Table 13.

Between Subjects Sample – Multivariate Test (MANOVA) of Differences in Virtual Tool Use Patters Across Effective and Ineffective Teams

Test	**Value**	**F**	**Hypothesis df**	**Error df**	**p-value**
Pillai's Trace	.03	2.42	7	618	.02
Wilk's Lambda	.97	2.42	7	618	.02
Hotellings's Trace	.03	2.42	7	618	.02
Roy's Largest Root	.03	2.42	7	618	.02

Note. Effective teams n = 309, ineffective teams n = 317.

Tests of the between-subjects effects (see Table 14) revealed that there were statistically significant differences in email use (F = 6.52, p < .05), instant messaging use (F = 4.83, p < .05), and face-to-face interaction (F = 8.82, p < .01).

Table 14.

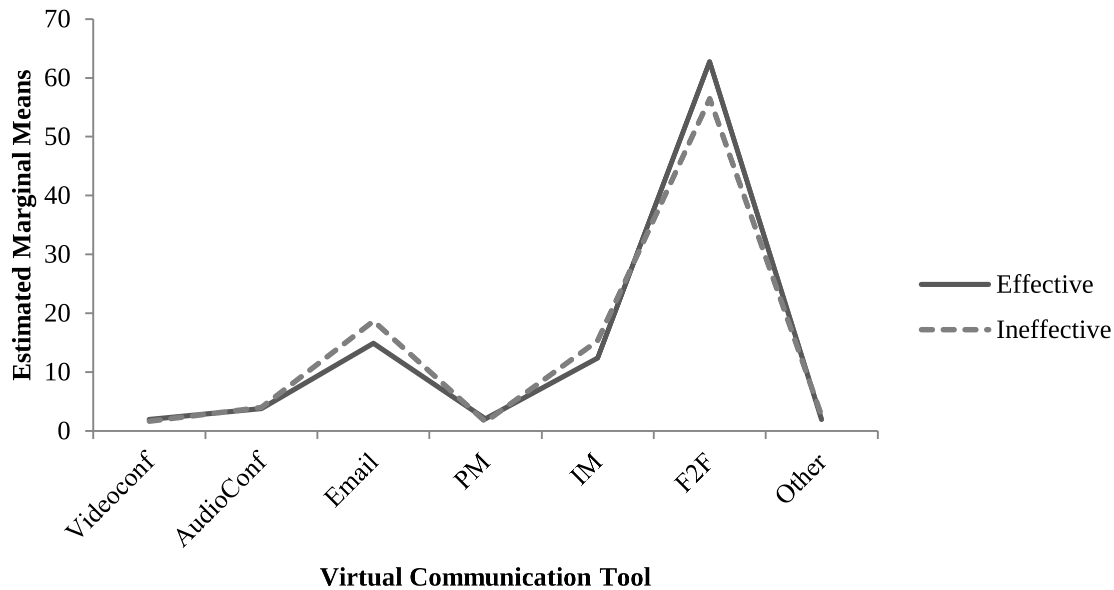
Between Subjects Sample - MANOVA of Between-Subjects Effects in Virtual Tool Use Patterns Across Effective and Ineffective Teams

Virtual Tool	**df**	**Mean Square**	***F***	***p*-value**
Videoconferencing	1	18.50	.44	.51
Teleconferencing	1	11.52	.09	.77
Email	1	2204.70	6.52	.01
Project Management Platforms	1	37.24	.64	.43
Instant Message	1	1280.74	4.83	.03
Face-to-Face	1	6341.18	8.82	.00
Other	1	58.74	.63	.43

Note. Effective teams n = 309, ineffective teams n = 317.

An examination of the profile plot reveals that effective teams engaged in slightly more face-to-face interaction, and slightly less interaction via email and instant messaging than ineffective teams (see Figure 2).

Figure 2. Between subjects profile plot for the MANOVA profile analysis examining the pattern of virtuality across effective and ineffective teams.



However, it must be noted that these differences are small, and that the effective and ineffective team virtuality profiles were largely similar. The impact of the robustness of sample size may be at issue here, especially given that the multivariate test for the overall profile comparison was not significant at alpha = .01.

Factor Structure. The present study examined the factor structure of the process sociomateriality measure. As previously indicated, the process sociomateriality scale is comprised of three higher-order categories (process facilitation, process impairment, and process expansion). Each of these higher-order categories is comprised of 4 to 6 lower-order categories, representing observable process sociomateriality behaviors specific to each factor (see Figure 1). Confirmatory factor analyses (CFA) were conducted to examine the factor structure of the measure (Fox, 1983; Hoyle, 2000). This technique examines the extent to which the measured variables share variance that is attributed to a factor.

Fit indices were used to examine the extent to which the data fit the hypothesized model three-factor model, as compared with two other theoretically plausible models (2-factor, 1-factor). Hu and Bentler (1998, 1999) and Kline (2010) posit that Chi-square, RMSEA, CFI, and SRMR are the most stable and robust fit indices. It is important to note that the Chi-square statistic is sensitive to large samples sizes, but is reported nonetheless to ensure comprehensiveness. Accordingly, the present dissertation assessed model fit using these indices. Each index is described in Table 15. This analysis was conducted using Lavaan package of the R software platform.

Table 15.

Confirmatory Factor Analysis (CFA) Fit Indices

Index Name	**Brief Description**	**Values**
Chi-Square	The chi-squared test is a measure of fit and denotes the difference between the expected and observed covariance matrices.	Values closer to zero indicate a better model fit; Significant tests indicate that the model is a poor fit.
Root Mean Square Error of Approximation (RMSEA)	The RMSEA examines the discrepancy between the hypothesized model and the population covariance matrix.	Values closer to zero indicate a better model fit; Values of .08 or less are indicative of an acceptable model.
Standardized Root Mean Square Residual (SRMR)	The SRMR is the standardized difference between the predicted correlation and the observed correlation.	Values closer to zero indicate a better model fit; Values of .08 or less are indicative of an acceptable model.
Comparative Fit Index (CFI)	The CFI examines the discrepancy between the hypothesized model and the normed fit index.	Values closer to 1 indicate a better model fit; Values of .90 or larger are considered an acceptable model fit.

Confirmatory factory analysis (CFA) of the process sociomateriality measure revealed that the three-factor model better demonstrated acceptable fit to the data for both effective teams (χ^2_{1156}=3960.60, p < .01, SRMR = .06, RMSEA = .06, CFI = .92) and ineffective teams (χ^2_{1156}=3544.79, p < .01, SRMR = .06, RMSEA = .06, CFI = .92). However, the two-factor model comprised of a facilitation/expansion composite dimension and an impairment dimension also demonstrated acceptable fit for both effective teams (χ^2_{1158}=4165.95, p < .01, SRMR = .06, RMSEA = .06, CFI = .92) and ineffective teams (χ^2_{1158}=3741.23, p < .01, SRMR = .06, RMSEA = .06, CFI = .92). The one-factor model did not demonstrate acceptable fit for effective teams (χ^2_{1159}=6115.53, p < .01, SRMR = .14, RMSEA = .08, CFI = .85) or ineffective teams (χ^2_{1159}=5473.33, p < .01, SRMR = .14, RMSEA = .08, CFI = .86). Table 16 displays these results.

Table 16.

Between Subjects Sample - Process Sociomateriality Factor Structure

Effective Teams CFA (n = 632)	**SRMR**	**RMSEA**	**CFI**	**Chi-Square**
Three-Factor	.06	.06	.92	χ^2_{1156}=3960.60, p < .01
Two-Factor	.06	.06	.92	χ^2_{1158}=4165.95, p < .01
One-Factor	.14	.08	.85	χ^2_{1159}=6115.53, p < .01
Ineffective Teams CFA (n = 653)				
Three-Factor	.06	.06	.92	χ^2_{1156}=3544.79, p < .01
Two-Factor	.06	.06	.92	χ^2_{1158}=3741.23, p < .01
One-Factor	.14	.08	.86	χ^2_{1159}=5473.33, p < .01

Note. The Three-Factor model was comprised of Process Facilitation (factor 1), Process Expansion (factor 2), and Process Impairment (factor 3). The Two-Factor model was comprised of Process Facilitation/Process Expansion (factor 1) and Process Impairment (factor 2).

A chi-square difference test was subsequently conducted to examine the fit of the three-factor model relative to the two-factor model. Results indicate that the three-factor model better fits the data than the two-factor model for both effective teams (χ^2_{diff} =205.35, p < .01) and ineffective teams (χ^2_{diff} =196.44, p < .01).

Measurement Reliability. Measurement reliability reflects the overall consistency of a given measure. The present study assessed internal consistency to determine the reliability of the process sociomateriality measure. This metric examines the extent to which the results from item responses within a given measure are consistent. The most widely supported index of internal consistency is Cronbach's alpha (Cronbach, 1951). Cronbach's alpha ranges from 0 to 1. Cronbach's alpha above .70 reflects acceptable internal consistency (Nunnally, 1978). Cronbach's alpha was calculated for the items within each lower-order category of the process sociomateriality measure, as well as for all items within each higher order category.

Analyses revealed satisfactory reliabilities for both the lower- and higher-order process sociomateriality factors (see Table 17).

Table 17.

Between Subjects Sample - Process Sociomateriality Scale Reliability

Construct	Effective (n = 632)	Ineffective (n = 653)	# of Items
Process Facilitation	.96	.96	20
Idea Generation	.90	.88	2
Idea Evaluation	.90	.89	3
Activity Synchronization	.87	.87	3
Role and Task Assignment	.94	.94	5
Team Monitoring and Backup	.90	.89	4
Motivation and Confidence Building	.88	.87	3
Process Expansion	.97	.96	16
Simultaneous Collaboration	.93	.94	2
Creating Scaffolds/Artifacts	.92	.91	3
Automated Coordination Facilitation	.86	.84	2
Interaction Variability	.92	.91	4
Bridging Time	.89	.86	2
Bridging Space	.95	.95	3
Process Impairment	.96	.96	14
Familiarity	.92	.91	3
Preference	.86	.86	3
Technology/Process Mismatch	.91	.88	4
Technology Breakdown	.92	.93	4
Overall	.98	.97	50

For the lower order dimensions, the PSS demonstrates satisfactory reliabilities for both effective teams and ineffective teams (α range .84 to .94). The PSS also demonstrates satisfactory reliability for the higher-order factors for both effective teams and ineffective teams (α range .96 to .97). Reliability for the team process measure and work group characteristics measures are presented in Tables 18 and 19, respectively.

Table 18.

Between Subjects Sample - Team Process (Marks et al., 2001) Scale Reliability

Consruct	**Effective (n = 625)**	**Ineffective (n = 644)**	**# of Items**
Transition Process	.86	.89	9
Mission Analysis	.76	.79	3
Goal Specification	.76	.82	3
Strategy Formulation & Planning	.68	.73	3
Action Process	.88	.89	9
Monitoring Progress Toward Goals	.72	.79	3
Resource Systems Monitoring	.84	.83	3
Team Monitoring & Backup	.66	.70	3
Coordination	.82	.83	3
Interpersonal Process	.91	.92	9
Conflict Management	.81	.85	3
Motivation & Confidence Building	.88	.85	3
Affect Management	.83	.83	3
Overall	.95	.94	30

Table 19.

Between Subjects Sample - Work Group Characteristics (Campion et al., 1993) Scale Reliability

Construct	**Effective (n = 622)**	**Ineffective (n = 644)**	**# of Items**
Self-Management	.81	.71	3
Participation	.86	.80	3
Task Variety	.70	.70	3
Task Significance	.91	.86	3
Task Identity	.74	.66	3
Task Interdependence	.76	.70	3
Goal Interdependence	.70	.71	3
Interdependent Feedback & Rewards	.74	.76	3
Heterogeneity of Membership	.75	.69	3
Member Flexibility	.65	.66	3
Teamwork Preferences	.90	.89	3
Training	.88	.84	3
Managerial Support	.89	.81	3
Potency	.76	.76	3
Social Support	.80	.75	3
Workload Sharing	.82	.86	3
Communication/Cooperation	.82	.78	3

Team Effectiveness and Process Sociomateriality. A central assumption of this work is that the behaviors associated with process sociomateriality a beneficial for team functioning. According to this logic, effective teams are more likely to display process sociomateriality behavior compared with ineffective teams. This assumption was tested in the between subjects sample using independent sample t-tests (see Table 20).

Table 20.

Between Subjects Sample – Process Sociomateriality Comparison Between Effective and Ineffective Teams

		Effective Teams		**Ineffective Teams**	
Variable	**Test Statistic**	***M***	***SD***	***M***	***SD***
Process Facilitation	$t = 2.48, p < .05$	2.95	.99	2.84	.92
Process Expansion	$t = 1.33, p > .05$	2.93	1.12	2.85	1.04
Process Impairment	$t = -5.33, p < .01$	1.77	.80	2.01	.84

Participants reported engaging in more process facilitation behaviors ($M = 2.95$, $SD = .99$) on effective as compared to ineffective teams ($M = 2.84$, $SD = .92$), $t = 2.48$, $p < .05$). However, there was not a statistically significant difference in process expansion behaviors reported when working on effective and ineffective teams ($t = 1.33$, $p > .05$). Finally, participants reported engaging in fewer process impairment behaviors ($M = 1.77$, $SD = .80$) when working on effective as compared to ineffective teams ($M = 2.01$, $SD = .84$), $t = -5.33$, $p < .01$).

Convergent Validity. Pearson's R correlation coefficients (Cohen, Cohen, West, & Aiken, 2003) among the higher-order factors of the Marks et al. (2001) and the higher-order factors of the process sociomateriality measure were calculated to indicate the degree of convergent validity between these constructs (see Table 21).

Table 21.

Between Subjects Sample - Convergent Validity Examination: Zero-Order Correlations Among Process Sociomateriality and Team Process.

Variable	*M*	*SD*	1	2	3	4	5
Effective Teams							
1. Process Facilitation	2.97	1.00					
2. Process Expansion	2.93	1.13	.87**				
3. Process Impairment	1.77	0.80	.34**	.36**			
4. Transition Process	3.83	0.63	.22**	.20**	.00		
5. Action Process	3.61	0.68	.26**	.28**	.10*	.71**	
6. Interpersonal Process	3.97	0.71	.22**	.17**	-.07	.60**	.63**
Ineffective Teams							
1. Process Facilitation	2.79	.94					
2. Process Expansion	2.78	1.06	.86**				
3. Process Impairment	1.99	.87	.26**	.26**			
4. Transition Process	3.12	.78	.31**	.31**	-.05		
5. Action Process	2.82	.76	.33**	.33**	.02	.77**	
6. Interpersonal Process	2.96	.82	.29**	.25**	-.10**	.63**	.71**

Note. $^{*}p \leq .05$. $^{**}p \leq .01$. For process sociomateriality factor correlations: n = 632 for effective teams, and n = 653 for ineffective teams. For process sociomateriality – team process correlations: n = 625 for effective teams; n = 644 for ineffective teams.

As is common practice (e.g. Finkelstein, 1992; Kalshoven, Hartog, & Hoogh, 2011), convergent validity is supported if 1) the higher order factors of the Marks et al. (2001) process scale demonstrate significant and positive correlations with the higher order factors of the process sociomateriality scale and 2) if these correlation coefficients are larger than the coefficients that depict the relationship between process sociomateriality factors and theoretically discriminant factors (Campbell & Fiske, 1959).

Analyses revealed significant and positive intercorrelations among the three dimensions of process sociomateriality for effective teams (ranging from r = .34 to r = .87) and ineffective teams (ranging from r = .26 to r = .86). The team process dimensions were positively related to the process facilitation and expansion dimensions of process sociomateriality for both effective teams (ranging from r = .17 to r = .28) and ineffective teams (ranging from r = .25 to r = .33). Process Impairment was less strongly related to team process for effective (ranging from r = -.07 to r = .10) and ineffective teams (ranging from r = -.10 to r = .02). Following the recommendations of Cronbach and Meehl (1955), these results suggest that the process facilitation and expansion dimensions of process sociomateriality exhibit stronger convergent validity with team process than process impairment, demonstrating partial support for Hypothesis 1.

Supplemental analyses were conducted to compare the magnitude of these correlations across effective and ineffective teams (see Table 22).

Table 22.

Between Subjects Sample - Correlation Magnitude Comparison Across Conditions - Process Sociomateriality and Team Process

Variable 1	Variable 2	Correlation Coefficient Effective Teams (*r*)	 Ineffective Teams (*r*)	Z-Value	*p* - value
Facilitation	*Expansion*	.87**	.86**	.71	.48
Facilitation	*Impairment*	.34**	.26**	1.57	.12
Expansion	*Impairment*	.36**	.26**	1.98	.05
Facilitation	*Transition*	.22**	.31**	-1.72	.09
Facilitation	*Action*	.26**	.33**	-1.36	.17
Facilitation	*Interpersonal*	.22**	.29**	-1.33	.18
Expansion	*Transition*	.20**	.31**	-2.09	.04
Expansion	*Action*	.28**	.33**	-.98	.33
Expansion	*Interpersonal*	.17**	.25**	-1.49	.14
Impairment	*Transition*	.00	-.05	.89	.37
Impairment	*Action*	.10*	.02	1.43	.15
Impairment	*Interpersonal*	-.07	-.10*	.54	.59

Note. For process sociomateriality factor correlations: n = 632 for effective teams, and n = 653 for ineffective teams. For process sociomateriality – team process correlations: n = 625 for effective teams; n = 644 for ineffective teams.

With regard to the process sociomateriality factor intercorrelations, findings revealed that team effectiveness had no bearing on the relationship between facilitation and expansion, or facilitation and impairment. However, expansion and impairment are more strongly related in effective teams (r = .36, p < .01) than in ineffective teams (r = .26, p < .01), Z = 1.98, p < .05. Results also indicated that the relationships between the process facilitation and expansion factors and team process maintained similar magnitude and valence regardless of team effectiveness, with the notable exception of the expansion – transition process relationship. Findings demonstrated that process expansion and transition are more strongly related in ineffective teams (r = .31, p < .01) than in effective teams (r = .20, p < .01), Z = -2.09, p < .05.

Discriminant Validity. According to previous literature, discriminant validity is supported if 1) the work group characteristics constructs (Campion et al., 1993) demonstrate non-significant correlations with the higher order factors of the process sociomateriality scale or 2) if these correlation coefficients are smaller than the coefficients that depict the relationship between process sociomateriality factors and theoretically related factors (Campbell & Fiske, 1959). The work group characteristics battery (Campion et al., 1993) includes a variety of measures that are relevant to the domain of team functioning, the majority of which are theoretically distinct from team process. These constructs are organized into the broad groupings of 1) Job Design (e.g. self-management, task variety), 2) Interdependence (e.g. task and goal interdependence), 3) Composition (heterogeneity, flexibility), 4) Context (e.g. training), and 5) Process (e.g. social support, communication). The final grouping is relevant to process, and will be discussed later in this section.

Accordingly, correlational patterns between the process sociomateriality dimensions and the work group characteristics measures were examined to establish discriminant validity. Analyses (see Table 23) revealed weaker (as compared with the process sociomateriality – team process relations), yet positive, relationships among the process facilitation and expansion dimensions and measures from the groupings 1 through 4 of the work group characteristics battery for effective teams (ranging from r = .01 to r = .31) and ineffective teams (ranging from r = .06 to r = .27).

Table 23.

Between Subjects Sample - Discriminant Validity Examination: Zero-Order Correlations Between Process Sociomateriality and Work Group Characteristics.

	Variable	*M*	*SD*	1	2	3			*M*	*SD*	1	2	3
	Effective Teams							Ineffective Teams					
1.	Process Facilitation	2.97	1.00				1.	Process Facilitation	2.82	0.93			
2.	Process Expansion	2.93	1.13	$.87^{**}$			2.	Process Expansion	2.85	1.04	$.86^{**}$		
3.	Process Impairment	1.77	0.80	$.34^{**}$	$.36^{**}$		3.	Process Impairment	2.01	0.84	$.26^{**}$	$.26^{**}$	
4.	Self-Management	3.73	0.92	$.27^{**}$	$.32^{**}$	.06	4.	Self-Management	3.50	0.91	$.20^{**}$	$.22^{**}$	$-.09^{*}$
5.	Participation	4.05	0.81	$.30^{**}$	$.31^{**}$	.01	5.	Participation	3.62	0.90	$.25^{**}$	$.27^{**}$	$-.17^{**}$
6.	Task Variety	3.63	0.80	$.16^{**}$	$.16^{**}$	$.09^{*}$	6.	Task Variety	3.27	0.84	$.22^{**}$	$.20^{**}$	-.02
7.	Task Significance	3.58	0.97	.07	$.10^{**}$	$.13^{**}$	7.	Task Significance	3.24	0.92	$.19^{**}$	$.20^{**}$	.06
8.	Task Identity	3.68	0.80	$.18^{**}$	$.22^{**}$	.04	8.	Task Identity	3.51	0.74	$.17^{**}$	$.22^{**}$	-.05
9.	Task Interdependence	3.88	0.81	$.11^{**}$	$.14^{**}$	.01	9.	Task Interdependence	3.73	0.79	$.16^{**}$	$.19^{**}$	$-.09^{*}$
10.	Goal Interdependence	3.75	0.78	$.14^{**}$	$.14^{**}$	$-.09^{*}$	10.	Goal Interdependence	3.52	0.80	$.16^{**}$	$.12^{**}$	$-.13^{**}$
11.	Feedback and Rewards	3.69	0.83	$.15^{**}$	$.15^{**}$	.03	11.	Feedback and Rewards	3.54	0.87	$.20^{**}$	$.23^{**}$	$-.15^{**}$
12.	Member Heterogeneity	4.02	0.74	.06	.01	.00	12.	Member Heterogeneity	3.64	0.76	$.17^{**}$	$.17^{**}$	-.07
13.	Member Flexibility	3.67	0.78	$.12^{**}$	$.10^{*}$	-.05	13.	Member Flexibility	3.38	0.81	$.11^{**}$	$.10^{*}$	$-.15^{**}$
14.	Teamwork Preference	3.66	0.94	$.16^{**}$	$.11^{**}$	.04	14.	Teamwork Preference	3.26	1.04	$.19^{**}$	$.15^{**}$	-.04
15.	Training	3.31	0.88	$.16^{**}$	$.15^{**}$	.07	15.	Training	3.01	0.87	$.17^{**}$	$.15^{**}$	-.01
16.	Managerial Support	3.90	0.88	$.20^{**}$	$.19^{**}$	-.03	16.	Managerial Support	3.54	0.89	$.16^{**}$	$.16^{**}$	$-.14^{**}$
17.	Potency	4.02	0.69	$.12^{**}$	.08	$-.12^{**}$	17.	Potency	3.21	0.87	$.18^{**}$	$.16^{**}$	$-.11^{**}$
18.	Social Support	4.14	0.63	$.15^{**}$	$.10^{*}$	$-.14^{**}$	18.	Social Support	3.55	0.78	$.17^{**}$	$.14^{**}$	$-.19^{**}$
19.	Workload Sharing	3.61	0.86	.07	.08	$-.09^{*}$	19.	Workload Sharing	2.86	1.04	.08	.06	$-.08^{*}$
20.	Communication/ Cooperation	4.20	0.61	$.15^{**}$	$.12^{**}$	$-.17^{**}$	20.	Communication/ Cooperation	3.67	0.79	$.15^{**}$	$.15^{**}$	$-.24^{**}$

Note. $^{*}p \leq .05$. $^{**}p \leq .01$.

On the other hand, process impairment was largely unrelated to the work group characteristics in groupings 1 through 4 for both effective teams (ranging from r = -.09 to r = .13) and ineffective teams (ranging from r = -.17 to r = .06). Taken together, these findings indicate that process impairment reflects stronger discriminant validity with the work group characteristics measures than process facilitation or expansion. However, it is important to note that the strength of the correlations between the work group characteristics constructs and facilitation and expansion are generally weaker than the process sociomateriality-team process coefficients. This pattern reveals overall support for the discriminant validity of process sociomateriality with conceptually distinct teams constructs, demonstrating support for Hypothesis 2.

It bears mention that the process sociomateriality dimensions exhibited statistically significant correlations with a majority of the process-relevant dimensions of the work group characteristics battery (grouping #5 – Process: potency, social support, workload sharing, and communication). The bivariate correlations between these constructs and facilitation and expansion were positive for both effective teams (ranging from r = .07 to r = .15) and ineffective teams (ranging from r = .06 to r = .18). On the other hand, process impairment was negatively related to the work group characteristics process dimensions for both effective teams (ranging from r = -.17 to r = - .09) and ineffective teams (ranging from r = -.24 to r = -.08). These findings reveal further support for the convergent validity of the process facilitation and process expansion factors with other process-relevant constructs.

Supplemental analyses were conducted to examine the consistency of each of these relationships across effective and ineffective teams (see Table 24).

Table 24.

Between Subjects Sample - Correlation Magnitude Comparison Across Conditions - Process Sociomateriality and Work Group Characteristics Constructs

		Correlation Coefficient			
Variable 1	**Variable 2**	**Effective Teams (*r*)**	**Ineffective Teams (*r*)**	**Z-Value**	***p* - value**
Facilitation	*Self-Management*	.27**	.20**	1.32	.19
Facilitation	*Participation*	.30**	.25**	.96	.34
Facilitation	*Task Variety*	.16**	.22**	-1.11	.27
Facilitation	*Task Significance*	.07	.19**	-2.17	.03
Facilitation	*Task Identity*	.18**	.17**	.18	.86
Facilitation	*Task Interdependence*	.11**	.16**	-.90	.37
Facilitation	*Goal Interdependence*	.14**	.16**	-.36	.72
Facilitation	*Feedback and Rewards*	.15**	.20**	-.92	.36
Facilitation	*Membership Heterogeneity*	.06	.17**	-1.98	.04
Facilitation	*Member Flexibility*	.12**	.11**	.18	.86
Facilitation	*Preference for Group Work*	.16**	.19**	-.55	.58
Facilitation	*Training*	.16**	.17**	-.18	.86
Facilitation	*Managerial Support*	.20**	.16**	.73	.47
Facilitation	*Potency*	.12**	.18**	-1.09	.28
Facilitation	*Social Support*	.15**	.17**	-.36	.72
Facilitation	*Workload Sharing*	.07	.08	-.18	.86
Facilitation	*Communication & Cooperation*	.15**	.15**	0	.1

Note. n = 622 for effective teams and n = 644 for ineffective teams.

Table 24 (ctd.)

Between Subjects Sample - Correlation Magnitude Comparison Across Conditions - Process Sociomateriality and Work Group Characteristics Constructs

Variable 1	**Variable 2**	**Correlation Coefficient** Effective Teams (*r*)	Ineffective Teams (*r*)	**Z-Value**	***p* - value**
Expansion	*Self-Management*	.32**	.22**	1.92	.06
Expansion	*Participation*	.31**	.27**	.78	.44
Expansion	*Task Variety*	.16**	.20**	-.73	.47
Expansion	*Task Significance*	.10**	.20**	-1.82	.07
Expansion	*Task Identity*	.22**	.22**	0	1
Expansion	*Task Interdependence*	.14**	.19**	-.91	.36
Expansion	*Goal Interdependence*	.14**	.12**	.36	.72
Expansion	*Feedback and Rewards*	.15**	.23**	-1.26	.21
Expansion	*Membership Heterogeneity*	.01	.17**	-2.87	.00
Expansion	*Member Flexibility*	.10*	.10*	0	1
Expansion	*Preference for Group Work*	.11**	.15**	-.72	.47
Expansion	*Training*	.15**	.15**	0	1
Expansion	*Managerial Support*	.19**	.16**	.55	.58
Expansion	*Potency*	.08	.16**	-1.44	.15
Expansion	*Social Support*	.10*	.14**	-.72	.47
Expansion	*Workload Sharing*	.08	.06	-.36	.72
Expansion	*Communication & Cooperation*	.12**	.15**	-.54	.59

Note. n = 622 for effective teams and n = 644 for ineffective teams.

Table 24 (ctd.)

Between Subjects Sample - Correlation Magnitude Comparison Across Conditions - Process Sociomateriality and Work Group Characteristics Constructs

Variable 1	**Variable 2**	**Correlation Coefficient** Effective Teams (*r*)	Ineffective Teams (*r*)	**Z-Value**	***p* - value**
Impairment	*Self-Management*	.06	-.09*	-.54	.59
Impairment	*Participation*	.01	-.17**	3.22	.00
Impairment	*Task Variety*	.09*	-.02	1.96	.05
Impairment	*Task Significance*	.13**	.06	1.25	.21
Impairment	*Task Identity*	.04	-.05	1.60	.11
Impairment	*Task Interdependence*	.01	-.09	1.78	.08
Impairment	*Goal Interdependence*	-.09**	-.13**	.72	.47
Impairment	*Feedback and Rewards*	.03	-.15**	-2.15	.03
Impairment	*Membership Heterogeneity*	.00	-.07	1.24	.22
Impairment	*Member Flexibility*	-.05	-.15**	1.79	.07
Impairment	*Preference for Group Work*	.04	-.04	0	1
Impairment	*Training*	.07	-.01	1.42	.16
Impairment	*Managerial Support*	-.03	-.14**	1.97	.04
Impairment	*Potency*	-.12**	-.11**	-.18	.86
Impairment	*Social Support*	-.14**	-.19**	.91	.36
Impairment	*Workload Sharing*	-.09*	-.08*	-.18	.86
Impairment	*Communication & Cooperation*	-.17**	-.24**	1.30	.19

Note. n = 622 for effective teams and n = 644 for ineffective teams.

Fisher's two sample Z-test was utilized to test for differences in correlations across effective and ineffective teams. Findings demonstrated the correlations among the process sociomateriality factors and the constructs contained within the work group characteristics model were largely consistent across effective and ineffective teams.

However, there were some exceptions of note. To begin with, facilitation was more strongly related to task significance in ineffective teams (r = .19, p < .01) than in effective teams (r = .07, p > .01), Z = -2.17, p < .05. Moreover, facilitation was more strongly related to member heterogeneity in ineffective teams (r = .17, p < .01) than in effective teams (r = .06, p < .01), Z = -2.22, p < .05. Results also demonstrated that the correlation between process expansion and member heterogeneity was stronger in ineffective teams (r = .17, p < .01) than in effective teams (r = .01, p > .01), Z = -2.87, p < .05. Process impairment was also more strongly related to participation in ineffective teams (r = -.17, p < .05) than in effective teams (r = .01, p > .05), Z = 3.22, p < .05. Impairment was also more strongly related to feedback and rewards in ineffective teams (r = -.15, p < .05) than in effective teams (r = .03, p > .05), Z = -2.15, p < .05. Lastly, impairment was more strongly related to managerial support in ineffective teams (r = -.14, p < .05) than in effective teams (r = -.03, p > .05), Z = 1.97, p < .05.

Within Subjects Findings

The study design enabled an examination of not only between-subjects effects, but also within-subjects effects. There were 544 total participants assigned to Conditions 3 and 4. Two hundred and eighty-eight participants completed the measurement battery based upon an effective team, and then an ineffective team (Condition 3), whereas 256 participants completed the measurement battery first based on an ineffective team, and then an effective team (Condition 4). As with the between subjects sample, the current section will present findings about effective and ineffective teams separately.

Effective/Ineffective Team Demographics. The mean size of the effective teams was 9.85 (*SD* = 8.77). The team type breakdown was: 23.2% leisure (e.g. sports, video games), 43.0% academic (e.g. class project), 32.2% work (e.g. decision-making, planning, project), and 1.7% action (e.g. firefighting, emergency management). 66.40% of effective teams were together for at least "a few months." The mean percentage use for each technological platform across effective teams was: M = 1.40% videoconferencing, M = 3.49% teleconferencing, M = 15.96% email, M = 2.05% project management platforms, M = 15.02% instant message, M = 59.75% face-to-face, and M = 2.37% other. Demographics for effective teams are detailed in Table 25.

The mean size of the ineffective teams was 8.40 (SD = 7.09). The team type breakdown was: 21.3% leisure, 54.8% academic, 22.6% work, and 1.3% action. 51.50% of ineffective teams were together for at least "a few months." The mean percentage use for each technological platform across ineffective teams was: M = 1.46% videoconferencing, M = 3.45% teleconferencing, M = 16.41% email, M = 1.68% project management platforms, M = 15.87% instant message, M = 58.44% face-to-face, and M = 2.78% other. Demographics for ineffective teams are detailed in Table 25.

Table 25.

Within Subjects Sample - Team Demographics for Effective and Ineffective Teams

Team Valence	**Demographic Characteristic**	**Sample Composition**	
Effective Teams	*Team Size*	*M*	9.85
		SD	8.77
	Team Type	23.2%	Leisure
		43.0%	Academic
		32.2%	Work
		1.7%	Action
	Team Tenure	*M*	3.73
		SD	1.04
	Team Communication Tool Use	1.40%	Videoconferencing
		3.49%	Teleconferencing
		15.96%	Email
		2.05%	Project Management Platforms
		15.02%	Instant Message
		59.75%	Face-to-Face
		2.37%	Other
Ineffective Teams	*Team Size*	*M*	8.40
		SD	7.09
	Team Type	21.3%	Leisure
		54.8%	Academic
		22.6%	Work
		1.3%	Action
	Team Tenure	*M*	3.43
		SD	1.09
	Team Communication Tool Use	1.46%	Videoconferencing
		3.45%	Teleconferencing
		16.41%	Email
		1.68%	Project Management Platforms
		15.87%	Instant Message
		58.44%	Face-to-Face
		2.78%	Other

Note. The team tenure scale was 1 = a few hours, 2 = a few days, 3 = a few weeks, 4 = a few months, and 5 = a year or more.

Similar to the between subjects analyses, supplemental analyses were conducted to examine the potential for any significant demographic differences between the effective and ineffective team samples (see Table 26).

Table 26.

Within Subjects Sample - Team Demographics Comparison Between Effective and Ineffective Teams

		Effective Teams		**Ineffective Teams**	
Variable	**Test Statistic**	***M***	***SD***	***M***	***SD***
Team Size	$t = 3.56$, $p < .01$	9.85	8.77	8.40	7.09
Team Tenure	$t = 5.77$, $p < .01$	3.73	1.04	3.41	1.04
		Type	**%**	**Type**	**%**
Team Type	$\chi^2 = 26.75$, $p < .05$	Leisure	24.9%	Leisure	19.3%
		Academic	41.2%	Academic	53.4%
		Work	32.2%	Work	26.1%
		Action	1.6%	Action	1.3%

Paired sample t-tests were conducted to examine any potential differences in team size and team tenure across effective and ineffective teams. Findings revealed that team size significantly differed between effective teams and ineffective teams ($t = 3.56$, $p < .01$), such that effective teams ($M = 9.85$, $SD = 8.77$) were slightly larger than ineffective teams ($M = 8.40$, $SD = 7.09$). Effective and ineffective teams also differed in team tenure ($t = 5.77$, $p < .05$), such that effective teams ($M = 3.73$, $SD = 1.04$) were together slightly longer than ineffective teams ($M = 3.41$, $SD = 1.08$). Finally, the McNemar-Bowker difference test revealed statistically significant differences between effective and ineffective teams in team type ($\chi^2 = 26.75$, $p < .05$). It is important to note that although there was a statistically significant difference in team type between effective and ineffective teams, the rank ordering of prevalence of each team type is consistent across the two samples (1 - academic, 2 - work, 3- leisure, and 4 - action).

Profile analysis, via repeated measures MANOVA, was utilized to test whether there were differences in the overall pattern of technology use across effective and ineffective teams within subjects. The multivariate test demonstrated that there is a not significant difference in the pattern of virtual tool use across effective and ineffective teams within subjects (Pillai's Trace $F = .139$, $p > .05$, see Table 27).

Table 27.

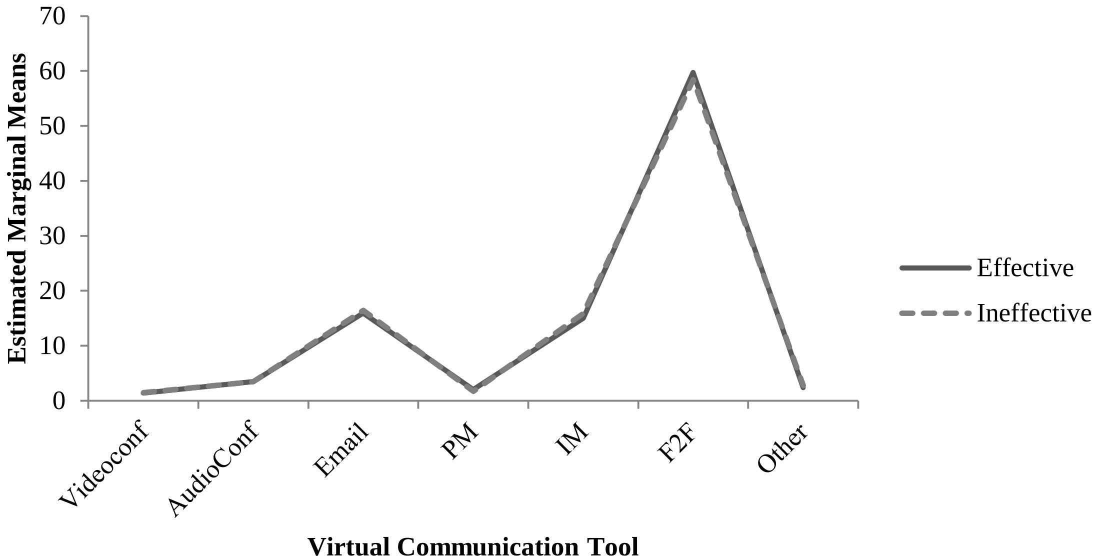
Within Subjects Sample – Repeated Measures MANOVA of Differences in Virtual Tool Use Patterns Across Effective and Ineffective Teams

Test	**Value**	**F**	**Hypothesis df**	**Error df**	**p-value**
Pillai's Trace	.00	.139	6	265	.99
Wilk's Lambda	.99	.139	6	265	.99
Hotellings's Trace	.00	.139	6	265	.99
Roy's Largest Root	.00	.139	6	265	.99

Note. Effective teams $n = 544$, ineffective teams $n = 544$.

A profile plot (see Figure 3) displays the similarly in virtuality pattern across effective and ineffective teams for the within subjects sample.

Figure 3. Within subjects profile plot for the repeated measures MANOVA profile analysis examining the pattern of virtuality across effective and ineffective teams.



Factor Structure. As in the between subjects sample, a confirmatory factor analysis of the process sociomateriality measure was conducted in the within subjects sample separately for effective and ineffective teams. Results are displayed in Table 28.

Table 28.
Within Subjects Sample - Process Sociomateriality Factor Structure

Effective Teams CFA (n = 544)	**SRMR**	**RMSEA**	**CFI**	**Chi-Square**
Three-Factor	.05	.06	.93	χ^2_{1156}=3401.50, p < .01
Two-Factor	.05	.06	.92	χ^2_{1158}=3619.76, p < .01
One-Factor	.15	.08	.86	χ^2_{1159}=5322.25, p < .01
Ineffective Teams CFA (n = 544)				
Three-Factor	.05	.06	.92	χ^2_{1156}=3527.68, p < .01
Two-Factor	.06	.06	.92	χ^2_{1158}=3703.13, p < .01
One-Factor	.15	.08	.85	χ^2_{1159}=5516.77, p < .01

Findings revealed that the three-factor model better demonstrated acceptable fit to the data for both effective teams (χ^2_{1156}=3401.50, p < .01, SRMR = .05, RMSEA = .06, CFI

= .93) and ineffective teams (χ^2_{1156}=3527.68, p < .01, SRMR = .06, RMSEA = .06, CFI = .93). However, the two-factor model comprised of a facilitation/expansion composite dimension and an impairment dimension also demonstrated acceptable fit for both effective teams (χ^2_{1158}=3619.76, p < .01, SRMR = .05, RMSEA = .06, CFI = .92) and ineffective teams (χ^2_{1158}=3703.13, p < .01, SRMR = .06, RMSEA = .06, CFI = .92). The one-factor model did not demonstrate acceptable fit for effective teams (χ^2_{1159}=5322.25, p < .01, SRMR = .14, RMSEA = .08, CFI = .87) or ineffective teams (χ^2_{1159}=5516.77, p < .01, SRMR = .14, RMSEA = .08, CFI = .86). A chi-square difference test was subsequently conducted to examine the fit of the three-factor model relative to the two-factor model. Results indicate that the three-factor model better fits the data than the two-factor model for both effective teams (χ^2_{diff} =218.26, p < .01) and ineffective teams (χ^2_{diff} =176.45, p < .01). These findings are consistent with the between subjects sample.

Measurement Reliability. Analyses revealed satisfactory reliabilities for both the lower- and higher-order process sociomateriality factors (see Table 29).

Table 29.

Within Subjects Sample - Process Sociomateriality Scale Reliability

Construct	**Effective (n = 544)**	**Ineffective (n = 544)**	**# of Items**
Process Facilitation	.97	.97	20
Idea Generation	.92	.92	2
Idea Evaluation	.92	.92	3
Activity Synchronization	.89	.89	3
Role and Task Assignment	.95	.94	5
Team Monitoring and Backup	.91	.90	4
Motivation and Confidence Building	.90	.89	3
Process Expansion	.97	.96	16
Simultaneous Collaboration	.92	.93	2
Creating Scaffolds/Artifacts	.93	.92	3
Automated Coordination Facilitation	.85	.86	2
Interaction Variability	.94	.93	4
Bridging Time	.90	.85	2
Bridging Space	.96	.95	3
Process Impairment	.96	.97	14
Familiarity	.91	.91	3
Preference	.88	.90	3
Technology/Process Mismatch	.91	.91	4
Technology Breakdown	.93	.94	4
Overall	.98	.97	50

For the lower order dimensions, the PSS demonstrates satisfactory reliabilities for both effective teams and ineffective teams (α range .85 to .96). The PSS also demonstrates satisfactory reliability for the higher-order factors for both effective teams and ineffective teams (α range .96 to .97). Reliability for the team process measure and work group characteristics measures are presented in Tables 30 and 31, respectively.

Table 30.

Within Subjects Sample - Team Process (Marks et al., 2001) Scale Reliability

Consruct	**Effective (n = 544)**	**Ineffective (n = 544)**	**# of Items**
Transition Process	.88	.91	9
Mission Analysis	.79	.83	3
Goal Specification	.74	.82	3
Strategy Formulation & Planning	.70	.78	3
Action Process	.88	.91	9
Monitoring Progress Toward Goals	.74	.78	3
Resource Systems Monitoring	.82	.83	3
Team Monitoring & Backup	.66	.77	3
Coordination	.81	.86	3
Interpersonal Process	.91	.93	9
Conflict Management	.81	.86	3
Motivation & Confidence Building	.86	.85	3
Affect Management	.82	.87	3
Overall	.95	.94	30

Table 31.

Within Subjects Sample - Work Group Characteristics (Campion et al., 1993) Scale Reliability

Construct	**Effective (n = 544)**	**Ineffective (n = 544)**	**# of Items**
Self-Management	.83	.80	3
Participation	.88	.87	3
Task Variety	.72	.79	3
Task Significance	.90	.88	3
Task Identity	.77	.79	3
Task Interdependence	.79	.79	3
Goal Interdependence	.76	.77	3
Interdependent Feedback & Rewards	.80	.80	3
Heterogeneity of Membership	.71	.70	3
Member Flexibility	.69	.74	3
Teamwork Preferences	.88	.88	3
Training	.87	.89	3
Managerial Support	.83	.85	3
Potency	.77	.84	3
Social Support	.85	.84	3
Workload Sharing	.84	.91	3
Communication/Cooperation	.79	.83	3

Team Effectiveness and Process Sociomateriality. Paired sample t-tests were utilized to test for differences in process sociomateriality behaviors between effective and ineffective teams (see Table 32).

Table 32.

Within Subjects Sample – Process Sociomateriality Comparison Between Effective and Ineffective Teams

		Effective Teams		**Ineffective Teams**	
Variable	**Test Statistic**	***M***	***SD***	***M***	***SD***
Process Facilitation	$t = 7.79$, $p < .01$	3.11	1.05	2.73	.96
Process Expansion	$t = 5.78$, $p < .01$	3.01	1.14	2.69	1.07
Process Impairment	$t = -6.11$, $p < .01$	1.74	.79	1.97	.91

Findings demonstrated that effective teams engaged in more process facilitation behaviors ($M = 3.11$, $SD = 1.05$) than ineffective teams ($M = 2.73$, $SD = .96$), $t = 7.79$, $p < .05$. Effective teams also engaged in more process expansion behaviors ($M = 3.01$, $SD = 1.14$) than ineffective teams ($M = 2.69$, $SD = 1.07$), $t = 5.78$, $p < .01$. Lastly, effective teams engaged in fewer process impairment behaviors ($M = 1.74$, $SD = .79$), than ineffective teams ($M = 1.97$, $SD = .91$), $t = -6.11$, $p < .01$.

Convergent Validity. Analyses demonstrated significant and positive intercorrelations among the three dimensions of process sociomateriality for effective teams (ranging from $r = .26$ to $r = .88$) and ineffective teams (ranging from $r = .25$ to $r = .86$). The team process dimensions were positively related to the process facilitation and expansion dimensions of process sociomateriality for both effective teams (ranging from $r = .14$ to $r = .26$) and ineffective teams (ranging from $r = .26$ to $r = .42$). Process Impairment was less strongly related to team process for effective (ranging from $r = -.16$ to $r = -.03$) and ineffective teams (ranging from $r = -.09$ to $r = .01$). See Table 33 for the full correlation matrix. Following the recommendations of Cronbach and Meehl (1955), these results suggest that the process facilitation and expansion dimensions of process sociomateriality exhibit stronger convergent validity with team process than process impairment, again demonstrating partial support for Hypothesis 1.

Table 33.

Within Subjects Sample - Convergent Validity Examination: Zero-Order Correlations Among Process Sociomateriality and Team Process.

Variable	*M*	*SD*	1	2	3	4	5
Effective Teams							
1. Process Facilitation	3.12	1.05					
2. Process Expansion	3.01	1.14	.88**				
3. Process Impairment	1.74	0.79	.26**	.34**			
4. Transition Process	3.90	0.62	.21**	.16**	-.10*		
5. Action Process	3.68	0.66	.27**	.25**	-.03	.75**	
6. Interpersonal Process	4.03	0.66	.22**	.14**	-.16**	.58**	.63**
Ineffective Teams							
1. Process Facilitation	2.70	0.97					
2. Process Expansion	2.69	1.08	.86**				
3. Process Impairment	1.97	0.91	.25**	.27**			
4. Transition Process	3.05	0.81	.32**	.26**	-.09*		
5. Action Process	2.72	0.77	.42**	.36**	.01	.79**	
6. Interpersonal Process	2.83	0.84	.35**	.29**	-.08	.60**	.72**

Note. $^{*}p \leq .05$. $^{**}p \leq .01$. N = 544 for effective teams; N = 544 for ineffective teams.

Supplemental analyses were conducted to compare the magnitude of these correlations across effective and ineffective teams (see Table 34).

Table 34.

Within Subjects Sample - Correlation Magnitude Comparison Across Conditions - Process Sociomateriality and Team Process

Variable 1	**Variable 2**	**Correlation Coefficient** Effective Teams (*r*)	Ineffective Teams (*r*)	**Z-Value**	***p* - value**
Facilitation	*Expansion*	.88	.86	1.41	.16
Facilitation	*Impairment*	.26	.25	.19	.85
Expansion	*Impairment*	.34	.27	1.78	.07
Facilitation	*Transition*	.21	.32	-2.19	.03
Facilitation	*Action*	.26	.42	-2.73	.01
Facilitation	*Interpersonal*	.22	.35	-2.43	.02
Expansion	*Transition*	.16	.26	-1.76	.08
Expansion	*Action*	.25	.36	-2.13	.03
Expansion	*Interpersonal*	.14	.29	-2.70	.01
Impairment	*Transition*	-.10	-.09	-.24	.81
Impairment	*Action*	-.03	.01	-.63	.53
Impairment	*Interpersonal*	-.16	-.08	3.97	.00

Note. n = 544 for effective teams, and n = 544 for ineffective teams.

Given the fact that this is a within-subjects sample, paired-samples Z-tests (Raghunathan, Rosenthal, & Rubin, 1996) were conducted to investigate differences in correlations between effective and ineffective teams. Findings revealed that team effectiveness had no bearing on the intercorrelations between the process sociomateriality factors. However, results did demonstrate that the relationships between facilitation and expansion and the team process factors were generally stronger in ineffective teams. In particular, process facilitation and transition process are more strongly related in ineffective teams (r = .32, p < .01) than in effective teams (r = .21, p < .01), Z = -2.19, p < .05. Likewise, process facilitation and action process are more strongly related in ineffective teams (r = .42, p <

.01) than in effective teams ($r = .26$, $p < .01$), $Z = -2.73$, $p < .05$. Process facilitation and interpersonal process are also more strongly related in ineffective teams ($r = .35$, $p < .01$) than in effective teams ($r = .22$, $p < .01$), $Z = -2.43$, $p < .05$. In addition, process expansion and action process are more strongly related in ineffective teams ($r = .36$, $p < .01$) than in effective teams ($r = .25$, $p < .01$), $Z = -2.13$, $p < .05$. Finally, process expansion and interpersonal process are also more strongly related in ineffective teams ($r = .29$, $p < .01$) than in effective teams ($r = .14$, $p < .01$), $Z = -2.70$, $p < .05$. The relationships between process impairment and transition and action process, respectively, did not differ between effective and ineffective teams. However, process impairment was more strongly related to interpersonal process in effective teams ($r = -.16$, $p < .01$) than in ineffective teams ($r = -.08$, $p < .01$), $Z = -3.97$, $p < .05$.

Discriminant Validity. Similar to the between subjects sample, correlational patterns between the process sociomateriality dimensions and the work group characteristics measures were examined to establish discriminant validity. Analyses (see Table 35) revealed weaker (as compared with the process sociomateriality – team process relations), yet positive, relationships among the process facilitation and expansion dimensions and measures from the groupings 1 through 4 of the work group characteristics battery for effective teams (ranging from $r = .04$ to $r = .25$) and ineffective teams (ranging from $r = .14$ to $r = .30$).

Table 35.

Within Subjects Sample - Discriminant Validity Examination: Zero-Order Correlations Between Process Sociomateriality and Work Group Characteristics.

	Variable	*M*	*SD*	1	2	3			*M*	*SD*	1	2	3
	Effective Teams							Ineffective Teams					
1.	Process Facilitation	3.12	1.05				1.	Process Facilitation	2.70	0.97			
2	Process Expansion	3.01	1.14	.88**			2.	Process Expansion	2.69	1.08	.86**		
3.	Process Impairment	1.74	0.79	.26**	.34**		3.	Process Impairment	1.97	0.91	.25**	.27**	
4.	Self-Management	3.79	0.94	.24**	.26**	-.01	4.	Self-Management	3.36	1.01	.20**	.24**	-.02
5.	Participation	3.97	0.88	.25**	.27**	-.05	5.	Participation	3.39	1.01	.29**	.30**	-.13**
6.	Task Variety	3.65	0.81	.12**	.13**	-.03	6.	Task Variety	3.07	0.94	.24**	.21**	-.05
7.	Task Significance	3.61	0.99	.12**	.14**	.01	7.	Task Significance	3.02	0.97	.18**	.16**	.04
8.	Task Identity	3.76	0.77	.15**	.18**	-.02	8.	Task Identity	3.35	0.89	.21**	.23**	-.05
9.	Task Interdependence	3.89	0.79	.04	.06	-.08	9.	Task Interdependence	3.61	0.90	.18**	.18**	.01
10.	Goal Interdependence	3.85	0.78	.13	.10*	-.11**	10.	Goal Interdependence	3.40	0.89	.16**	.15**	-.06
11.	Feedback and Rewards	3.74	0.87	.20**	.20**	-.07	11.	Feedback and Rewards	3.37	0.94	.21**	.22**	.00
12.	Member Heterogeneity	3.94	0.75	.10*	.08	-.09*	12.	Member Heterogeneity	3.54	0.84	.18**	.15**	-.02
13.	Member Flexibility	3.73	0.78	.10*	.11**	-.04	13.	Member Flexibility	3.14	0.90	.19**	.16**	-.15**
14.	Teamwork Preference	3.57	0.98	.07	.04	.02	14.	Teamwork Preference	3.26	1.01	.14**	.14**	.00
15.	Training	3.47	0.83	.05	.07	.00	15.	Training	2.85	0.93	.17**	.20**	-.04
16.	Managerial Support	3.98	0.80	.05	.06	-.02	16.	Managerial Support	3.55	0.92	.14**	.15**	-.06
17.	Potency	4.05	0.69	.18**	.14**	-.19**	17.	Potency	2.89	0.99	.31**	.27**	-.07
18.	Social Support	4.13	0.69	.21**	.14**	-.20**	18.	Social Support	3.26	0.94	.30**	.26**	-.11*
19.	Workload Sharing	3.73	0.87	.12**	.10*	-.12**	19.	Workload Sharing	2.57	1.08	.25**	.20**	-.06
20.	Communication/ Cooperation	4.12	0.74	.11**	.07	-.20**	20.	Communication/ Cooperation	3.35	0.94	.27**	.26**	-.14**

Note. $^{*}p\leq.05$. $^{**}p\leq.01$

On the other hand, process impairment was largely unrelated to the work group characteristics in groupings 1 through 4 for both effective teams (ranging from r = -.11 to r = .02) and ineffective teams (ranging from r = -.15 to r = .01). Taken together, these findings indicate that process impairment reflects stronger discriminant validity with the work group characteristics measures than process facilitation or expansion. However, it is important to note that the strength of the correlations with the work group characteristics constructs and facilitation and expansion are generally weaker than the process sociomateriality-team process coefficients. This reveals overall support for the discriminant validity of process sociomateriality with conceptually distinct teams constructs, demonstrating support for Hypothesis 2.

As with the between subjects sample, all process sociomateriality dimensions exhibited statistically significant correlations with the process-relevant dimensions of the work group characteristics battery (grouping #5 – Process: potency, social support, workload sharing, and communication). The bivariate correlations between these constructs and facilitation and expansion were positive for both effective teams (ranging from r = .07 to r = .21) and ineffective teams (ranging from r = .20 to r = .30). On the other hand, process impairment was negatively related to the work group characteristics process dimensions for both effective teams (ranging from r = -.20 to r = - .12) and ineffective teams (ranging from r = -.14 to r = -.06). These findings reveal further support for the convergent validity of the process facilitation and process expansion factors with other process-relevant constructs.

Supplemental analyses were conducted to examine the consistency of each of these relationships across effective and ineffective teams (see Table 36).

Table 36.

Within Subjects Sample - Correlation Magnitude Comparison Across Conditions - Process Sociomateriality and Work Group Characteristics Constructs

Variable 1	**Variable 2**	**Correlation Coefficient** Effective Teams (*r*)	Ineffective Teams (*r*)	**Z-Value**	***p* - value**
Facilitation	*Self-Management*	.24**	.20**	.56	.58
Facilitation	*Participation*	.25**	.29**	-.81	.41
Facilitation	*Task Variety*	.12**	.24**	-2.00	.04
Facilitation	*Task Significance*	.12**	.18**	-.95	.34
Facilitation	*Task Identity*	.15**	.21**	-.99	.32
Facilitation	*Task Interdependence*	.04	.18**	-2.41	.02
Facilitation	*Goal Interdependence*	.13	.16**	-.63	.53
Facilitation	*Feedback and Rewards*	.20**	.21**	-.29	.77
Facilitation	*Membership Heterogeneity*	.10*	.18**	-1.36	.17
Facilitation	*Member Flexibility*	.10*	.19**	-1.58	.11
Facilitation	*Preference for Group Work*	.07	.14**	-1.41	.16
Facilitation	*Training*	.05	.17**	-2.11	.03
Facilitation	*Managerial Support*	.05	.14**	-1.65	.10
Facilitation	*Potency*	.18**	.31**	-2.20	.03
Facilitation	*Social Support*	.21**	.30**	-1.60	.11
Facilitation	*Workload Sharing*	.12**	.25**	-2.09	.04
Facilitation	*Communication & Cooperation*	.11**	.27**	-2.92	.00

Note. n = 542 for effective teams and n = 542 for ineffective teams.

Table 36 (ctd.)

Within Subjects Sample - Correlation Magnitude Comparison Across Conditions - Process Sociomateriality and Work Group Characteristics Constructs

Variable 1	**Variable 2**	**Correlation Coefficient**		**Z-Value**	***p* - value**
		Effective Teams (*r*)	**Ineffective Teams (*r*)**		
Expansion	*Self-Management*	.26**	.24**	.49	.63
Expansion	*Participation*	.27**	.30**	-.51	.61
Expansion	*Task Variety*	.13**	.21**	-1.43	.15
Expansion	*Task Significance*	.14**	.16**	-.32	.75
Expansion	*Task Identity*	.18**	.23**	-.89	.37
Expansion	*Task Interdependence*	.06	.18**	-2.01	.04
Expansion	*Goal Interdependence*	.10*	.15**	-.97	.33
Expansion	*Feedback and Rewards*	.20**	.22**	-.33	.74
Expansion	*Membership Heterogeneity*	.08	.15**	-1.18	.24
Expansion	*Member Flexibility*	.11**	.16**	-.81	.41
Expansion	*Preference for Group Work*	.04	.14**	-1.84	.07
Expansion	*Training*	.07	.20**	-2.23	.03
Expansion	*Managerial Support*	.06	.15**	-1.52	.13
Expansion	*Potency*	.14**	.27**	-2.23	.03
Expansion	*Social Support*	.14**	.26**	-2.03	.04
Expansion	*Workload Sharing*	.10*	.20**	-1.75	.08
Expansion	*Communication & Cooperation*	.07	.26**	-3.45	.00

Note. n = 544 for effective teams and n = 544 for ineffective teams.

Table 36 (ctd.)

Within Subjects Sample - Correlation Magnitude Comparison Across Conditions - Process Sociomateriality and Work Group Characteristics Constructs

Variable 1	Variable 2	Correlation Coefficient Effective Teams (*r*)	Ineffective Teams (*r*)	Z-Value	*p* - value
Impairment	*Self-Management*	-.01	-.02	.34	.74
Impairment	*Participation*	-.05	$-.13^{**}$	1.25	.29
Impairment	*Task Variety*	-.03	-.05	.38	.70
Impairment	*Task Significance*	.01	.04	-.65	.51
Impairment	*Task Identity*	-.02	-.05	.45	.65
Impairment	*Task Interdependence*	-.08	.01	-1.59	.11
Impairment	*Goal Interdependence*	$-.11^{**}$	-.06	-.84	.40
Impairment	*Feedback and Rewards*	-.07	.00	-1.14	.25
Impairment	*Membership Heterogeneity*	$-.09^{*}$	-.02	-1.14	.25
Impairment	*Member Flexibility*	-.04	$-.15^{**}$	1.85	.06
Impairment	*Preference for Group Work*	.02	.00	.39	.70
Impairment	*Training*	.00	-.04	.61	.54
Impairment	*Managerial Support*	-.02	-.06	.77	.44
Impairment	*Potency*	$-.19^{**}$	-.07	-2.19	.03
Impairment	*Social Support*	$-.20^{**}$	$-.11^{*}$	-1.45	.15
Impairment	*Workload Sharing*	$-.12^{**}$	-.06	-1.07	.29
Impairment	*Communication & Cooperation*	$-.20^{**}$	$-.14^{**}$	-.95	.34

Note. n = 544 for effective teams and n = 544 for ineffective teams.

Findings demonstrated the correlations among the process sociomateriality factors and the constructs contained within the work group characteristics model were largely consistent across effective and ineffective teams. However, there were some statistically significant differences. To begin with, facilitation was more strongly related to task variety in ineffective teams (r = .24, p < .01) than in effective teams (r = .12, p < .01), Z = -2.00, p < .05. Moreover, facilitation was more strongly related to task interdependence in ineffective teams (r = .18, p < .01) than in effective teams (r = .04, p >.05), Z = -2.41, p < .05. The relationship between facilitation and training also exhibited a statistically significant difference (Z = -2.11, p < .05), such that these constructs were more strongly related in ineffective teams (r = .17, p < .01) than in effective teams (r = .05, p > .05). In addition, the relationship between facilitation and team potency exhibited a statistically significant difference (Z = -2.20, p < .05), such that this relationship was stronger in ineffective teams (r = .31, p < .01) than in effective teams (r = .18, p < .01). Facilitation and workload sharing were also more strongly related in ineffective teams (r = .25, p < .01) than in effective teams (r = .12, p < .01), Z = -2.09, p < .05. Finally, facilitation and communication/cooperation were also more strongly related in ineffective teams (r = .27, p < .01) than in effective teams (r = .11, p < .01), Z = -2.92, p < .01.

Results also demonstrated that the correlation between process expansion and task interdependence was stronger in ineffective teams (r = .18, p < .01) than in effective teams (r = .06, p > .05), Z = -2.01, p < .05. In addition, the correlation between expansion and team potency was stronger in ineffective teams (r = .27, p < .01) than in effective teams (r = .14, p < .01), Z =

-2.23, $p < .05$. Moreover, expansion and social support were more strongly related in ineffective teams ($r = .26$, $p < .01$), than in effective teams ($r = .14$, $p < .01$), $Z = -2.03$, $p < .05$. Lastly, expansion and communication/cooperation were also more strongly related in ineffective teams ($r = .26$, $p < .01$) than in effective teams ($r = .07$, $p > .05$), $Z = -3.45$, $p < .01$.

There were no significant differences in the process impairment – work group characteristics relationships across effective and ineffective teams, with the exception of the impairment – team potency relationship. Findings revealed that impairment and team potency were more strongly related in effective teams ($r = -.19$, $p < .01$) than in effective teams ($r = -.07$, $p > .05$), $Z = -2.19$, $p < .05$.

Supplemental Analysis – Condition Assignment. An additional set of supplemental analyses concerned the effect of condition assignment within the effective and ineffective team sample, respectively. Participants were randomly assigned to one of four conditions. In condition 1, participants completed the measurement battery based upon an effective team, and in condition 2 based upon an ineffective team. In condition 3, participants first completed the battery based upon an effective team, and then based upon an ineffective team, whereas participants in condition 4 did the reverse: they completed the battery based upon an ineffective team, and then an effective team. This manipulation through condition assignment enabled the present dissertation to examine whether participant evaluations about the process sociomateriality of an effective team are altered when first prompted to respond about an ineffective team (and vice versa). Put otherwise, it is possible that evaluating the process sociomateriality of an ineffective team before an effective team changes how an individual assesses the process sociomateriality of the effective team, as compared to a scenario in which the effective team is evaluated first. The reverse may hold true as well. This is due to the fact being confronted with an ineffective team first may alter the cognitive schema that participants use to evaluate effective teams, and vice versa.

In order to examine this effect, a series of mean-difference significance tests were conducted. This investigation was first conducted within the sample of effective teams. Responses about process sociomateriality for effective teams from participants in condition 3 (effective, then ineffective prompt; n = 288) were compared to responses about process sociomateriality for effective teams from participants in condition 4 (ineffective, then effective prompt; n = 256). Given the difference in sample size across the two groups, there is potential for violating the assumption of equal variance (Brown & Forsythe, 1974). Accordingly, Levene's test for homogeneity of was conducted prior to each t-test to examine homoscedasticity. In instances in which Levene's test was significant, Welch's t-test was conducted in lieu of the independent samples t-test. Welch's t-test is an approximation of the independent samples t-test and does not require equal sample variances (Ruxton, 2006). Results indicated that ascriptions of process sociomateriality did not differ between those who completed the effective team battery first, as compared with participants who completed the effective team battery after the ineffective team battery (see Table 37).

The same analyses were then conducted within the sample of ineffective teams. Ratings of process sociomateriality about ineffective teams from participants in condition 4 (ineffective, then effective prompt; n = 256) were tested against ratings of process sociomateriality about ineffective teams from participants in condition 3 (effective, then ineffective prompt; n = 288). Findings are displayed in Table 37. Results indicated that participants who completed the measure based upon an ineffective team first (condition 4) more strongly endorsed process facilitation behaviors in ineffective teams (M = 2.86, SD = .90) as compared with individuals who completed the measure about an effective team first, and then the ineffective team (condition 3; M = 2.56, SD = 1.01), Welch's t = -3.69, p < .01. Similarly, participants who first completed the measure based upon ineffective teams endorsed more process expansion behaviors (M = 2.85, SD = 1.06) than individuals who were first confronted with an effective team, and then an ineffective team (M = 2.56, SD = 1.08), t = -3.17, p < .001.

Table 37.

Effect of Condition Assignment on Effective & Ineffective Teams

Team Effectiveness	Construct	Condition 3		Condition 4		Levene's Test for Homogeneity of Variance	Test Statistic	df	p-value
		M	SD	M	SD				
Effective	Facilitation	3.15	.97	3.08	1.13	F = 13.94, $p < .001$	Welch's $t = .76$	503.90	.45
	Expansion	3.04	1.08	2.97	1.19	F = 6.35, $p < .05$	Welch's $t = .70$	517.80	.49
	Impairment	1.75	.78	1.74	.85	F = 1.40, $p > .05$	$t = .13$	542	.67
		Condition 3		**Condition 4**					
		M	**SD**	**M**	**SD**				
Ineffective	Facilitation	2.56	1.01	2.86	.90	F = 3.95, $p < .01$	Welch's $t = -3.69$	541.98	.00
	Expansion	2.56	1.08	2.85	1.06	F = .01, $p > .05$	$t = -3.17$	542	.00
	Impairment	1.99	.97	1.93	.84	F = 8.10, $p > .01$	Welch's $t = .71$	541.70	.47

Note. For effective teams, condition 3 n = 288, condition 4 n = 256. For ineffective teams, condition 4 n = 256, condition 3 n = 288

Supplemental Analysis – Recruitment Platform Comparison. As noted in the method section, participants were recruited from the general population via three different platforms: Facebook, SONA Systems at a southeastern undergraduate university, and Amazon's Mechanical Turk. The purpose of this data collection was to examine how the process sociomateriality measure and construct performs across a wide variety if individuals from the general population; therefore, the inherent differences in these recruitment platforms add to the richness of the sample. Nonetheless, it is important to ascertain how the performance of the process sociomateriality measure may differ depending upon the recruitment platform. Therefore, the between and within subjects datasets were separated into a SONA-only sample, and a combined Facebook/MTurk sample. This was a logical structure given that the SONA sample was comprised of undergraduates who more frequently referenced academic teams (58.40% in the between subjects sample; 59.40% in the within subjects sample) than work teams (16.40% in the between subjects sample; 16.80% in the within subjects sample) whereas the Facebook and MTurk samples predominantly participated in work teams (62.60% in the between subjects sample; 56.60% in the within subjects sample), as compared with academic teams (18.20% in the between subjects sample; 20.00% in the within subjects sample). In order to assess whether recruitment platform impacted the manifestation of any of the findings of the present study, all of the previously described analyses were run within each sample independently. Findings regarding factor structure, scale reliability, and convergent/discriminant validity revealed similar patterns of results across the two groups (SONA vs. Facebook/Mturk participants).

Discussion

The present study builds upon work in the realm of process sociomateriality (e.g. Study 1) to further emphasize the inextricable linkage between technology use and team process. In particular, this study has directly contributed to the literature on team process in five principle ways. First, by developing and validating a measure of process sociomateriality, this manuscript has introduced an instrument that can gauge the fundamental connection between team process behaviors and materiality. Prior efforts within this realm have centered upon assessing team virtuality (e.g. Bierly et al., 2009, Cumming et al., 2009, Golden & Raghuram, 2009), and have inadequately captured the nuanced enmeshment of technology in modern teamwork. This deficiency has limited our ability to appropriately conceptualize and understand modern team process. The present work has addressed this need by developing a theoretically grounded, reliable psychometric instrument that directly gauges the extent to which team members engage in behaviors that are inextricably linked with technology use.

Second, the present data collection provided support for the tripartite structure of process sociomateriality advanced in Study 1. Analyses examined the extent to which a three-factor (facilitation, expansion, impairment), two-factor (facilitation/expansion composite, impairment), and one factor model each fit the data across between and within subjects samples of participants responding about effective and ineffective teams. Results indicated that both the three-factor structure and two-factor structure fit the data in an absolute sense, but that the three-factor structure better fit the data relative to the two-factor model. However, it is important to note that strong relationships among the facilitation and expansion factors, coupled with the good fit of the data to the two-factor model, suggest the presence of a higher order facilitation/expansion factor. In their meta-analysis on team process, LePine et al. (2008) found overall support for a three-factor model of team process, but indicated that strong correlations among the three factors and support for a one factor model insinuated the presence of an overarching process factor. Therefore, the finding that facilitation and expansion are strongly related is consistent with the notion that team process factors are historically strongly related. Moreover, this finding lends support to Paul Leonardi's (2012) assertion that the manner in which teams use technology to match their needs (e.g. facilitation) and the manner in which technology leads to new behavioral possibilities (e.g. expansion) are inherently related phenomena. The imbrication, or sequential overlapping, that may occur between these two forces may render them difficult to tease apart.

The discussion of factor structure provides a direct segue into the third contribution of the present study: investigating and establishing the nomological network of process sociomateriality. All three factors of process sociomateriality were significantly, and positively related to each other, supporting convergent validity. However, it is important to note that the process impairment factor is less strongly related to both facilitation and expansion when compared to the magnitude of the facilitation-expansion correlation across effective and ineffective teams. This is likely due to the fact that impairment captures an aspect of process that is separate from the proactive and positive behaviors that comprise facilitation and expansion. Impairment, instead, captures the extent to which teams must work to overcome hindrances that are unique to the use of technology, and thus is more reflective of reactive behaviors. Otherwise stated, increasing facilitation and expansion behaviors should generally improve team functioning, whereas impairment can be seen as reactive behavior that is necessary to avoid process loss specific to technology use. Therefore, whereas high levels of facilitation and expansion may enhance team effectiveness, high levels of process impairment behaviors may indicate that the team is struggling to perform effectively.

Significant and strong correlations among the facilitation and expansion factors with the team process factors and the process constructs in the Campion et al. (1993) battery (e.g. Potency, Social Support, Workload Sharing, and Communication/Cooperation) demonstrate further support for the convergent validity of the process sociomateriality construct. These findings support the assertion the process sociomateriality is relevant to the construct space of team process. Contrastingly, the relationship between process impairment and the team process factors was weaker in magnitude and generally negative. This further highlights the prior postulation that process impairment captures an aspect of the team process construct space that differs from the current team process factors. This is likely due to its focus on the prevalence of behaviors relevant to process loss avoidance, rather than behaviors that directly enhance team functioning.

Findings also demonstrated support for the discriminant validity of the process sociomateriality with less conceptually relevant team constructs. Results indicated that the relationships between process sociomateriality and the work group characteristics constructs (specifically the job design, interdependence, composition, and context groupings) were of weaker magnitude compared with both the process sociomateriality factor intercorrelations and the team process correlations with process sociomateriality (particularly the facilitation and expansion factors). These findings support the assertion that process sociomateriality occupies a construct space that is distinct from the variety of teams constructs present in the work group characteristics battery. Interestingly, although process impairment was largely unrelated to any of the job design, interdependence, composition, or context team constructs, particularly for effective teams, it was significantly and negatively related to the process constructs (social support, workload sharing, communication/cooperation). This is consistent with the previous finding that process impairment is predominantly negatively related to Marks et al. (2001) team process behaviors, thus reaffirming the idea that increasing team impairment behaviors may hinder team functioning.

Supplemental analyses revealed that, in certain instances, the magnitude of sociomateriality intercorrelations, and sociomateriality – team process correlations might depend on team effectiveness. In particular, expansion and impairment were more strongly, positively related in effective teams than in ineffective teams in the between subjects sample. In addition, process facilitation and expansion were each more strongly related to the team process factors in ineffective teams than in effective teams in both the between and within subjects samples.

Further analysis of the process sociomateriality – work group characteristics construct relationships demonstrated that the majority of correlations were consistent in magnitude and strength regardless of team effectiveness. However, there were some notable exceptions. In the between subjects sample, facilitation was more strongly related to task significance and member heterogeneity in ineffective teams. Expansion was also more strongly related to member heterogeneity in ineffective teams. Moreover, impairment was more strongly related to participation, feedback and rewards, and managerial support in ineffective teams. In the within subjects sample, facilitation was more strongly related to task variety, task interdependence, training, team potency, workload sharing, and communication/cooperation in ineffective teams. Moreover, expansion was more strongly related to task interdependence, team potency, social support, and communication/cooperation.

Although the relationships of interest were predominantly consistent in magnitude and strength regardless of team effectiveness, these particular findings reveal a very intriguing pattern in which the process sociomateriality factors are more strongly related to other teams constructs in ineffective teams than effective teams. A potential explanation for this trend may be that effective teams incorporate technology more seamlessly into their work, so much so that, on the surface, their technologically-embedded behavior does not seem to be directly related to other aspects of team functioning. Ineffective teams, on the other hand, may not know how to efficiently coordinate work through the use of technology. Although counterintuitive, perhaps this renders technology as consistently salient aspect of teamwork in ineffective teams as they constantly struggle to use it appropriately, leading them to feel as though it permeates many aspects of team functioning beyond just process. Nonetheless, these findings raise an interesting possibility for future inquiry.

The fact that similar patterns of results were uncovered in both the within subjects and between subjects samples further strengthens the contribution of this study. In particular, findings revealed that the process sociomateriality measure maintained a three-factor structure and acceptable measurement reliability across effective and ineffective teams when comparing two independent samples of participants, and when comparing within participants. Moreover, both the between subject and within subject analyses revealed support for the convergent and discriminant validity of the process sociomateriality construct. This consistency supports the robustness and generalizability of these findings.

The fourth contribution of this work was the comparison of process sociomateriality behaviors in effective and ineffective teams. Marks et al. (2001) posited that team process behavior is fundamentally essential to enhancing team effectiveness. Similarly, the central framing of this dissertation was predicated on the notion that process sociomateriality behaviors will also improve team effectiveness. Results from the between subjects study found that effective teams engaged in more process facilitation behavior, and less process impairment behavior. The within subjects findings reaffirmed these results in demonstrating that effective teams engaged in more facilitation and expansion behavior, and less impairment behavior. Taken together, these findings suggest that facilitation and expansion behaviors improve team effectiveness by enhancing teamwork. Process impairment, on the other hand, likely captures instances in which teams are struggling to overcome obstacles that arise from technology use; thus, prominence of these behaviors may actually be a marker of team ineffectiveness.

The final principle contribution of this work was exploratory in nature, yet informative for future research. The team effectiveness condition manipulation enabled this study to examine the possibility that team members may evaluate the behavioral process of a particular team differently if they evaluate a team of differing quality first. The underlying proposition that informs this inquiry is that, for example, evaluating an ineffective team will shape one’s cognitive schema regarding process criteria in a specific way that would impact evaluations of effective teams later (and vice versa). Findings from the within subjects sample revealed that this effect was not manifested within the effective team sample. Participants who first evaluated an ineffective team, and then an effective team did not produce significantly differing patterns of response compared to individuals who evaluated the effective team first. However, results revealed some support for this phenomenon within the ineffective team sample. In particular, participants who first evaluated an ineffective team more strongly endorsed process facilitation and expansion behaviors in that team than participants who rated an effective team before evaluating the ineffective team. These findings imply that perhaps participants were more lenient when depicting the process sociomateriality behaviors of their ineffective team when doing so in isolation, but were relatively less likely to endorse process sociomateriality behaviors in ineffective teams when they were able to contrast this evaluation with the behavioral process of an effectively functioning team.

Summary. This study has contributed to the literature on team process by enhancing our assessment of the enmeshment of team process behaviors and technology. By developing and validating a measure of process sociomateriality, this work has introduced an instrument designed to gauge the frequency of behaviors that convey the fundamental connection between behavioral process and materiality. Moreover, this work has further established the construct space of process sociomateriality though demonstrating its convergent and discriminant validity. Taken together, these outcomes lay the groundwork for future investigations aimed at better understanding the process factors that contribute to team success and failure in modern organizations.

CHAPTER 7

STUDY 3 – QUASI FIELD STUDY

Teams researchers have long heralded the I-P-O model as the definitive framework for understanding team functioning. Through this lens, the literature has posited that member interaction processes play a pivotal role in team functioning, converting inputs like composition and leadership into valued performance and affective outcomes (Mathieu, Maynard, Rapp, & Gilson, 2008). Despite the prominence of this perspective, empirical work has historically struggled to produce the expected robust relationship between teams process and outcomes (Hackman, 1968; 1987).

Initial investigations of the process-outcome relationship were conducted through the lens of the IPO model (e.g. McGrath, 1964). Perhaps the most notable early empirical work in this area was that of Morris (1966) and Hackman (1968). Both studies investigated the impact of a variety of team process indicators on team performance. Each effort succeeded in establishing significant links between inputs and processes, and input and outcomes. However, analyses revealed "uninterpretable" patterns of relations between team process and outputs (Hackman, 2012, p. 431).

Despite this initial lack of support, the literature persisted in the belief that behavioral processes significantly (and positively) impact team outcomes. For instance, Kaplan (1979a; 1979b) utilized both field and controlled experimental settings to further investigate this foundational relationship. However, findings for this work did not yield substantive support for the team process-outcome relationship. In fact, Kaplan (1979b) demonstrated that group interaction hindered team performance in a field setting. A number of other efforts produced similarly weak or inconsistent findings (e.g. Bachrach, Bendoly, & Podsakoff, 2001; Chidambaram, 1996; Dirks, 1999; Isabella & Waddock, 1994; Mathieu & Schulze, 2006).

Nevertheless, the IPO model was too logical to the vast majority of researchers on teams to simply be discarded (Hackman, 2012). Recent theoretical efforts have focused upon developing a more fine-grained conceptualization of process (e.g. Marks et al., 2001). These efforts towards conceptual clarity seem to have coincided with more promising empirical findings regarding the process-outcome relationship. LePine et al. (2008) utilized the temporally-based process taxonomy developed by Marks et al. (2001) to frame their meta-analysis of this relationship. Findings revealed that, overall, behavioral process maintains a positive relationship with team performance across all dimensions of process. Effect sizes from this work range from .17 to .35, depending upon the specific behavioral process of interest.

These results do demonstrate improved support for the process-outcome link. However, given that behavioral process is considered by many to be the hallmark of team effectiveness, process should account for a more substantial portion of the variance in team performance. If there truly is a foundational relationship between process and performance, the aforementioned evidence suggests that research on teams has still not adequately captured this phenomena.

Thus far, this dissertation has attempted to establish process sociomateriality as a viable and informative construct that further captures the essence of team process (Study 1), and subsequently enhanced the measurement of team process by developing the PSS (Study 2). Study 3 builds upon these efforts, and positions process sociomateriality as a critical factor within the I-P-O model by testing how it shapes team outcomes. In order to accomplish this aim, this study will first investigate whether process sociomateriality impacts team states and performance, and will subsequently examine whether process sociomateriality impacts these outcomes beyond prior conceptualizations of the team process – communication tool use relationship. The central purpose of this study is to further strengthen our understanding of the link between processes and outcomes.

The Impact of Process Sociomateriality on Team Outcomes

A principal contribution of this dissertation is to demonstrate that process sociomateriality is an important aspect of team process that long been overlooked in the literature. In doing so, this work seeks to enhance our conceptualization of team process, and subsequently inform our understanding of how team process shapes team functioning. Put otherwise, this work has the potential to strengthen the process-outcome link in the I-P-O model. Therefore, a critical next step in this line of research is to examine how process sociomateriality shapes important aspects of team functioning.

Two essential aspects of current team effectiveness frameworks are team emergent states and team performance (Marks et al. 2001; Ilgen et al., 2005). Emergent states are a product of team experiences and reflect dynamic properties of the team (DeChurch & Mesmer-Magnus, 2010; Martins et al., 2004). Emergent states reflect how members think and feel about their teamwork. It follows that these states are indicators of the strength of teamwork processes and are critical aspects of team functioning. Likewise, team performance represents the degree to which a team effectively accomplishes a given task (Mathieu, Maynard, Rapp, & Gilson, 2008). Thus, both emergent states and team performance are frequently used as markers of the effectiveness of team functioning.

Therefore, in order to develop this line of research, it is essential to investigate the manner in which process sociomateriality shapes emergent states and team performance.

Process Sociomateriality → Team Performance

The manner in which technology use facilitates, enhances, or hinders teamwork is likely to shape a team's ability to accomplish a given task. For instance, teams that consistently and efficiently utilize technology to facilitate process behaviors such as brainstorming, idea evaluation, or activity synchronization are likely to be more effective than teams that do not effectively enact these behaviors. Likewise, teams that effectively enact process expansion behaviors will also perform better. For example, teams that are able to utilize technology to create visual representations of the collaboration process (e.g. create documents via Microsoft Word) or effectively switch between platforms to match task demands are more likely to succeed than teams that do not. Similarly, teams that experience high levels of process impairment will not be able to perform efficiently or effectively. Hindrances such as limited technological familiarity or mismatched technology preferences among members may slow down the collaboration process, or even disrupt team interaction altogether. In turn, these difficulties are likely to negatively impact a team's ability to carry out a given task. Therefore, this dissertation hypothesizes:

> H1: *Process facilitation and expansion positively predict team performance (H1a) and team viability (H1b).*
>
> H2: *Process impairment negatively predicts team performance (H2a) and team viability (H2b).*

Process Sociomateriality → Emergent States → Team Performance

Investigating the direct impact of process sociomateriality on team performance/viability provides insight into the importance of technologically embedded behaviors to team effectiveness. However, given the distal nature of the relationship between behavior and performance, it is important to examine the presence of any potential mechanisms that transmit the influence of process sociomateriality to team performance. Emergent states are defined as collective properties of a team (DeChurch & Mesmer-Magnus, 2010; Martins et al., 2004). Process sociomateriality is likely to shape emergent states given that these behaviors serve as an impetus for how team members feel about one another and how engaged they are in the task at hand. For instance, using technology to compliment member task contributions can invoke positive feelings towards the team and heighten motivation. Likewise, leveraging the unique capabilities of technology to increase work efficiency (e.g. by switching between platforms, setting up automatic task reminders) will also increase member engagement. Thus, using technology to engage in teamwork behaviors is likely to shape how the collective team feels (affective emergent states), and allocates effort (motivational emergent states).

Affective Emergent States. Affective emergent states are collective states of emotion or feeling (Curseu, 2006). The literature has demonstrated that affective emergent states play an essential role in shaping team success and failure (Curseu, 2006; Mathieu et al., 2008). Process sociomateriality is likely to impact affective emergent states given these behaviors shape the transmission of emotions and cultivate the emotional environment surrounding the team. This dissertation will focus on four prominently studied affective states: team cohesion, team identity, team satisfaction, and team trust. Table 38 depicts lists affective emergent states and their associated definitions. The literature has posited that these states are clear indicators of team affect, and play an important role in team effectiveness (Devine et al., 1999; Mathieu et al., 2008).

Table 38.

Emergent States Definitions

Emergent State	Definition
Team Identity	A psychological ‘merging’ of the self and group that leads individuals 1) to see the self as similar to other members of the collective, 2) to ascribe group-defining characteristics to the self, and 3) to take the collective’s interest to heart (Tajfel & Turner, 1985).
Team Satisfaction	The extent to which team members feel content about their jobs and the groups in which they work (Vegt, G., Emans, B., & Vliert, E., 2010).
Team Cohesion	A dynamic state that is reflected in the tendency of a group to stick together and remain united in the pursuit of its instrumental objectives and/or for the satisfaction of member affective needs (Mach et al., 2010).
Team Trust	The extent to which members have faith in each other in completing taskwork (McAllister, 1995).
Collective Efficacy	A group’s shared belief in its conjoint capabilities to organize and execute the course of action require to produce given levels of attainments (Bandura, 1997).
Motivation to Work on Behalf of the Team	Member’s allocation of personal and collective effort towards team goals, which may involve effort directed as performing their individual role within the team, as well as assisting the team in other ways (Chen, G., Kanfer, R., DeShon, R., Mathieu, J., & Kozlowski, K., 2009).

Process facilitation and process expansion reflect active behaviors that team members should engage in to maximize process effectiveness. In the case of process facilitation, team members use communication technology to act in ways that enable or constrain process behaviors that prior literature has been demonstrated to be essential determinants of team functioning (Fleishman & Zaccaro, 1992; Marks et al., 2001; Prince & Salas, 1993). For instance, utilizing communication technology to host a "get-to-know-you" meeting would reflect motivation and confidence building. This process behavior may is likely to positively shape the manner in which team members feel about one another and the team as a whole by enhancing team trust and satisfaction. Likewise, ensuring that all team members coordinate and synchronize their behavior via technology (e.g. activity synchronization) so that all member contributions fit together in a harmonized fashion will likely enhance the perceived identity and cohesiveness of the collective. Furthermore, utilizing technology to monitor member task progress and engage in backup behavior whenever necessary will likely improve team trust. Thus, process facilitation behaviors are likely to enhance team affective emergent states.

Likewise, process behaviors that uniquely arise out of the use of technology (e.g. process expansion) also positively shape team affective states. These behaviors can serve to invoke a sense of togetherness within the team while also enhancing perceptions of reliability amongst team members. For instance, team members may switch between multiple communication technology platforms so as to transmit different forms of communication (verbal, textual, etc.) between members. This interaction variability is likely to create a more comprehensive sense of interpersonal connection than if members we to interact entirely via one mode (e.g. email). Likewise, utilizing technology to interact across temporal and geographic boundaries is also likely to enhance the general sense of connectedness and perceived support amongst team members, thus cultivating positive affect. Moreover, team members may utilize technology to collaborate simultaneously so as to scaffold and coordinate taskwork in real-time. This synergy in work effort may again heighten perceptions of unity and increase trust amongst team members. Each of these circumstances reflects instances in which behaviors that uniquely arise out of the use of technology positively enhance team affect.

Affective emergent states have been shown to be important predictors of team outcomes (team performance: Chiocchio & Essiembre, 2009; Ng & Sorenson, 2008; Riketta & van Dick, 2005; Whitman, Rooy, & Viswesvaran, 2010; team viability: Barrick, Stewart, Neuber, & Mount, 1999). Affective emergent states serve to cultivate positive emotions towards the collective, resulting in improved collective performance. For instance, team cohesion reflects an interpersonal attraction within the group and commitment of team members to each other. These characteristics enhance positive affect about completing taskwork with group members, resulting in improved performance (Webber & Donahue, 2001). Other work has posited that team trust reflects a willingness to depend on each other to carry out taskwork; accordingly, increased levels of trust engender increased levels of productivity and team effectiveness (Erdem & Ozen, 2003). The literature has also demonstrated that team identity reflects the extent to which individual members define themselves as part of the collective, and internalize the objectives of the collective (van Knippenberg & van Schie, 2000); thus, teams that exhibit stronger team identity will perform more effectively (Riketta & van Dick, 2005).

Affective states have also been demonstrated to play an essential role in shaping team viability. Team viability is closely related to team affect, and reflects the extent to which team members would remain in the team. Logically, much literature has argued, and found, that positive feelings about the team heighten the likelihood that individuals would want to remain a part of the team in the future (Chang & Bordia, 2001; Foo, Sin, & Yiong, 2006).

Taken together, teams that utilize technology to engage in essential team process behaviors (e.g. process facilitation) will cultivate positive feelings about the team. Moreover, teams that leverage the capabilities of technology to interact in novel ways (e.g. process expansion) will also exhibit positive affective states. These collective feelings will, in turn, positively shape team performance and viability. Therefore, process facilitation and expansion will improve team effectiveness by enhancing team affect. Thus, this dissertation hypothesizes that:

> H3: *Affective emergent states mediate the relationship between process facilitation and expansion, and team performance (H3a: team satisfaction; H3b: team cohesion, H3c: team identity, & H3d: team trust) and viability (H3e: team satisfaction; H3f: team cohesion, H3g: team identity, & H3h: team trust).*

Whereas the use of communication technology may facilitate or even expand team process, it may also lead to many unique hindrances to team process. These difficulties are likely to negatively shape collective affect. For instance, if communication technology continuously breaks down or loses connection, members are likely to become frustrated with one another, which will negatively shape team affect. Moreover, if members possess different levels of familiarity with certain communication technology platforms, more experienced members may become impatient with less experienced members, again resulting in negative feelings towards the team. Similarly, members may exhibit different technology use preferences, resulting in uncertain team communication norms and overall interaction inefficiency. This ambiguity may engender negative affect within the team, resulting in decreased team satisfaction and hindering the development of cohesion and identity.

Given that emergent states are predictive of team effectiveness, it is expected that process impairment will negatively impact affective emergent states, which will in turn impact team performance. Thus, process impairment will hinder team performance by negatively impacting collective affect. Therefore, this dissertation hypothesizes that:

H4: *Affective emergent states mediate the relationship between process impairment and team performance (H4a: team satisfaction; H4b: team cohesion, H4c: team identity, & H4d: team trust) and viability (H4e: team satisfaction; H4f: team cohesion, H4g: team identity, & H4h: team trust).*

Motivational Emergent States. Motivational emergent states refer to the team's general level of investment and effort in both teamwork and taskwork (Mathieu et al., 2008). These states describe shared belief among members about the team's engagement and capability to perform tasks. Process sociomateriality is likely to shape team motivational emergent states. This dissertation will focus on two prominently studied motivational emergent states: collective efficacy and motivation to work on behalf of the team. Table 38 delineates the motivational emergent states and their associated definitions. The literature has indicated that these states are important markers of a team's motivational environment, and fundamentally shape team effectiveness (Chen et al., 2009; Mathieu et al., 2008).

Teams that utilize communication technology to enable process behaviors that are critical to team functioning (e.g. process facilitation) are likely to experience enhanced motivational states. For instance, members may use the "to-do list" function in a project management platform, such as Basecamp, to assign roles and tasks to each other. Role and task assignment can elicit motivational arousal from members by providing members with specific and tangible objectives. Moreover, members may review taskwork contributions via various technological platforms, and intervene when necessary. This monitoring behavior is also likely to motivate members to engage in teamwork. Likewise, teams that utilize technology to encourage and build confidence in one another are also more likely to work on behalf of the collective and to believe in the ability of the collective. Accordingly, process facilitation is likely to positively shape motivational emergent states.

Similarly, process behaviors that are enabled only by virtual of a material aspect of a technology (e.g. process expansion) also enhance team motivational states. For example, members may leverage unique communication technology capabilities to organize teamwork through the use of automated task reminders. These consistent and timely notifications can free up member resources, while enhancing team coordination and ensuring that team members remain engaged in taskwork; therefore, they are likely to improve member motivation. Moreover, teams may consistently switch between technological platforms in order to leverage their different capabilities to maximize interaction effectiveness (e.g. interaction variability). This efficient and proactive behavior is likely to cultivate member confidence in the team's ability to accomplish the task. Likewise, teams may frequently utilize technology to collaborate across temporal and geographic boundaries. This behavior serves to extend member reach across time and space, subsequently increasing collective engagement towards taskwork.

Motivational emergent states have been demonstrated to be essential determinants of team outcomes (Gully, Incalterra, Joshi, & Beaubien, 2002; Mathieu et al., 2008). For instance, teams that possess a stronger belief in their abilities to perform a given task (e.g. collective efficacy) are more likely to succeed at said task (Jung & Sosik, 1999) and may be more likely to retain their members (team viability). Likewise, teams that cultivate a more engaged atmosphere (e.g. motivation to work on behalf of the team) are more likely to perform effectively and want to remain together (van Knippenberg, 2000).

Taken together, teams that employ communication technology to facilitate critical team process behaviors are more likely to exhibit a strong motivational environment. Likewise, teams that utilize technology to expand their behavioral repertoire will also cultivate strong motivational states. Enhanced motivational states will, in turn, positively shape team performance and viability. Thus, process facilitation will improve team effectiveness by enhancing motivational emergent states. Therefore, this dissertation postulates that:

H5: *Motivational emergent states mediate the relationship between process F&E and team performance (H5a: collective efficacy; H5b: motivation) and viability (H5c: collective efficacy; H5d: motivation).*

Problems specific to communication technology use may also hinder team motivational states. If communication technology consistently breaks down, members are likely to become demotivated. This is due to the fact that members may feel an inability to contribute to the task, and may subsequently lose interest in participating. Likewise, if members frequently utilize communication technology platforms that are inappropriate for the task at hand, members may also lose focus and motivation. Moreover, if members are not familiar with certain essential technologies, team members may lose confidence in the ability of the team to perform effectively. Therefore, it is expected that process impairment will hinder team effectiveness by negatively impacting motivational emergent states. In particular, process impairment will hinder motivational emergent states, which will, in turn, impact team effectiveness. Thus, this dissertation hypothesizes:

H6: *Motivational emergent states mediate the relationship between process impairment and team performance (H6a: collective efficacy; H6b: motivation) and viability (H6c: collective efficacy; H6d: motivation).*

The Contribution of Process Sociomateriality Beyond Prior Conceptualizations

Current work on technology and teams has approached their relationship from one of three perspectives. The first perspective asserts that members and their social interactions are the primary determinants of performance (e.g. team process: Ilgen et al., 2005; Marks, et al., 2001; McGrath, 1964). The second perspective posits that communication technology platforms (and their associated capabilities) are the primary drivers of team effectiveness (e.g. virtuality: Gibson & Gibbs, 2006; Hertel, Geister, & Konradt, 2005; Kirkman & Mathieu, 2005; Olson & Olson, 2000). Finally, the third perspective postulates that communication technology impacts the relationship between member actions and team performance (e.g. virtuality-as-a-moderator: Bierly et al., 2009; Kirkman et al., 2004). This dissertation posits that communication technology use is embedded in team process, and has introduced the phenomenon of process sociomateriality to capture the constitutive entanglement between technology and process. Importantly, this dissertation argues that process sociomateriality better captures the construct space of teamwork than the three previously described perspectives. Given this novel ontological stance on the enmeshment of technology in teamwork, a central assertion of this work is that process sociomateriality will account for variance in team outcomes beyond each of these perspectives. The following will detail specific hypotheses relevant to this line of thought.

Team Process. Current conceptual frameworks of teamwork conceptualize behavioral process as devoid of and independent from materiality (e.g. Marks et al., 2001). This dissertation argues that materiality is actually a fundamental, omnipresent aspect of teamwork that has been long overlooked in studies of team process. In order to more appropriately capture the manner in which modern day teams interact and accomplish taskwork, researchers must consider how technology use may facilitation, expand, or impair the types of interactive behaviors that team members may engage in. Therefore, this dissertation asserts that process sociomateriality will account for additional variance in team performance and viability beyond team process as conceptualized by Marks et al. (2001). Therefore, the present study posits that:

H7: *Process sociomateriality shows incremental validity in team viability after controlling for the effects of team process.*

H8: *Process sociomateriality shows incremental validity in team performance after controlling for the effects of team process.*

Team Virtuality. The virtuality perspective posits that the capabilities of technology are the fundamental determinants of team effectiveness (Cramton, 2001; Hinds & Mortensen, 2005). Studies within this realm typically position virtuality as a primary input to team functioning, and leave little room considerations of human agency in how the technology is utilized. Team members have the ability to select how and when to employ various communication technologies to engage in team interaction (Leonardi, 2012). The lens of process sociomateriality acknowledges that, although communication technology may afford or constrain certain aspects of team interaction, members may choose to utilize these platforms in different ways. Therefore, process sociomateriality will account for incremental variance in team outcomes beyond team virtuality.

H9: *Process sociomateriality shows incremental validity in team viability after controlling for the effects of team virtuality.*

H10: *Process sociomateriality shows incremental validity in team performance after controlling for the effects of team virtuality.*

The Interaction Between Team Process and Team Virtuality. A final theoretical stance on teamwork and technology builds upon the prior two perspectives, and postulates that team virtuality shapes the relationship between team process and team outcomes (Bierly et al., 2009; Hakonen & Lipponen, 2008; Kirkman et al., 2004). This lens asserts that the capabilities of technology impact the manner in which member interactions shape team functioning. However, this lens still overlooks the manner in which social action is embodied in technology use, and, in particular, how technology use extends the realm of behavioral possibilities for teams. Put otherwise, communication technology doesn't just set boundary conditions on the manifestation of prior process routines, it can also expand the types of behaviors that teams can engage in. Therefore, process sociomateriality will also account for variance in team outcomes beyond the virtuality-as-a-moderator perspective.

H11: *Process sociomateriality shows incremental validity in team viability after controlling for the effects of the interaction between team virtuality and team process.*

H12: *Process sociomateriality shows incremental validity in team performance after controlling for the effects of the interaction between team virtuality and team process.*

Method

Sample

The sample was comprised of 219 undergraduate students from a northeastern university (n = 100) and a southern university (n = 119) who participated in a semester-long class project. Of the 219 participants, 52% were male. The sample was 47.9% American, 23.5% Mixed, 4.6% Indian, 4.1% Korean, and 19.9% other nationalities. The mean age of the participants was 20.82 years (range: 18-45).

Team Composition. The 219 participants were divided into 33 teams. Teams self-assembled using the My DreamTeam builder tool developed by SONIC Lab at Northwestern University. The tool was pre-populated with categories that participants could choose to help select their teammates (e.g. Leadership Skills; Cultural Background). In order to utilize this tool, participants first completed a demographic survey. This data was then loaded into the DreamTeam builder tool. Participants then logged into the DreamTeam builder to construct their own customized recommendation systems for choosing potential teammates.

Twenty full teams were formed through the My DreamTeam builder interface, 9 teams were formed by matching teams that had partially-formed in the interface, and 4 teams were formed entirely from individuals that did not log in to the interface. Teams were comprised of either 6 participants (3 psychology students; 3 ecology students) or 7 participants (4 psychology students; 3 ecology students). There were 11 6-person teams, 21 7-person teams, and 1 4-person team. The 4-person team was originally comprised of 6 members, but two individuals withdrew from class shortly after team composition; thus, that particular team was comprised of four members (2 psychology students, 2 ecology students). Given the likelihood that this four-person team experienced different workload distribution and interaction dynamics than the 6- and 7-person teams, it was removed from subsequent analysis. Therefore, the final sample was comprised of 32 teams (n = 213).

Procedure

The project teams were interdisciplinary; they were comprised of social psychology students from a southeastern university and ecology students from a northeastern university. These teams were tasked with integrating their respective expertise on human behavior and ecological issues to propose an advertising campaign designed to mitigate an ecological issue.

In order to accomplish this aim, the participants were instructed to create a proposal (presented in poster format) for an advertising campaign that could be funded and produced by an environmental group. An effective advertising campaign was framed as instrumental in changing individuals' attitudes about the behavior that are contributing to a particular ecological problem. Over the course of the 10-week project, the teams completed 4 sequential deliverables. The first was a topic selection paper, in which teams described their ecological issue of choice. The second was a behavioral observation study. The teams were instructed to observe and document individuals engaging in a specific behavior that contributes to a specific ecological problem, and then write up their findings in an APA-style report. The third deliverable was an attitudinal survey study. The purpose of the survey was to assess human attitudes about 1) the ecological problem and 2) behavior as it relates to this ecological problem. Students were instructed to distribute this survey to the general population, and then disseminate their findings in an APA-style write-up. Findings from these efforts were used to inform the final, central deliverable: the persuasive poster. The purpose of the poster was to convey to the advertising campaign, and convincingly discuss how it would improve the ecological issue.

Collaboration Tools. This was an appropriate sample for assessing the criterion-related validity of process sociomateriality given that distributed nature of the teams necessitated communication technology use. As with the sample utilized in Study 1, these project teams were provided with a suite of new media platforms including WebEx, Basecamp, and Google Docs (see Table 2). Given that this was a quasi-field study, teams were able to utilize tools outside of this suite to collaborate.

Measurement

This section describes the measures that will be used to assess Hypotheses 1-12. The measurement battery is included in Appendix C. These measures are grouped into affective emergent states, motivational emergent states, process, and performance. There were two measurement time-points during the project: Time 1 (T1), and Time 2 (T2). T1 was administered directly after the attitudinal survey study was completed. T2 was collected immediately following the completion of the final persuasive poster.

Aggregation & Reliability. Table 39 provides Cronbach alphas and aggregation indices for study variables.

Table 39.

Reliability and Agreement Indices for Study 3 Variables

Time	Scale	# Items	Alpha	ICC(1)	R_{wg}
1	Process Sociomateriality – Process Facilitation	20	.98	.98	.95
	Process Sociomateriality – Process Expansion	16	.97	.97	.94
	Process Sociomateriality – Process Impairment	14	.98	.98	.90
	Team Process – Transition Process	9	.95	.94	.92
	Team Process – Action Process	12	.95	.95	.92
	Team Process – Interpersonal Process	9	.96	.96	.91
	Team Cohesion	2	.92	.92	.73
	Team Identity	1	N/A	N/A	N/A
	Team Satisfaction	3	.96	.96	.77
	Motivation to Work on Behalf of the Team	3	.91	.90	.92
	Collective Efficacy	3	.96	.96	.94
2	Process Sociomateriality – Process Facilitation	20	.98	.98	.96
	Process Sociomateriality – Process Expansion	16	.96	.96	.95
	Process Sociomateriality – Process Impairment	14	.99	.99	.90
	Team Process – Transition Process	9	.95	.94	.92
	Team Process – Action Process	12	.95	.95	.93
	Team Process – Interpersonal Process	9	.96	.96	.92
	Team Cohesion	2	.94	.94	.76
	Team Identity	1	N/A	N/A	N/A
	Team Satisfaction	3	.97	.97	.79
	Team Trust	4	.93	.93	.84
	Motivation to Work on Behalf of the Team	3	.95	.95	.92
	Collective Efficacy	3	.98	.98	.94
	Team Virtuality	7	N/A	N/A	N/A
	Team Viability	4	.72	.71	.81

Note. Alpha ≥ .7 = acceptable internal consistency; $R_{wg} \geq .7$ = acceptable agreement

All measures indicated acceptable internal consistency across both time points. All measures were administered at the individual level. However, theoretical inquiry in this dissertation is at the level of the team. Therefore, all measures were aggregated to the team-level to facilitate appropriate analysis and examination of hypotheses. Analysis was conducted to support the aggregation to the team level. r_{wg} indices of within group agreement (James, Demaree, & Wolf, 1984) were calculated for each measure. Previous literature has indicated that a minimum r_{wg} of .7 reflects acceptable agreement (Bliese, 2000). The purpose of this analysis was to examine the extent to which team members agree enough on their evaluation of a particular construct to justify aggregation to the team level. r_{wg} requirements were satisfied (see Table 39), thus, composite variables were created for each measure through mean aggregation. Intraclass correlations ($ICC_{(1)}$) were calculated to further examine the extent to which aggregation is appropriate. $ICC_{(1)}$ provides an overall estimate of the consistency of ratings with a sample. A significant and positive $ICC_{(1)}$ value indicates that measure variance is attributable to group membership, which further justifies aggregation to the team level. $ICC_{(1)}$ requirements were satisfied as well.

It is important to note that both the Mathieu and Marks (2006) and the process sociomateriality measures are comprised of higher-order and lower-order dimensions. The Mathieu and Marks (2006) process scale contains three higher order factors (transition, action, interpersonal), each of which contains 3-4 lower order factors. The process sociomateriality scale also contains three higher order factors (facilitation, expansion, impairment), each of which is comprised of 4-6 lower order factors. The theoretical framework and subsequent hypotheses of the present manuscript are centered upon the higher-order factors for each of these scales. This perspective makes the assumption that the lower order factors (within a particular higher order factor) will maintain homologous relationships with the dependent variable of interest. This logic pertains to all hypotheses. Therefore, item responses were aggregated to the higher-order level for process sociomateriality and Marks et al. (2001) team process for each team.

Affective Emergent States. The following constructs were measured as indicators of team affective states: team cohesion, team identity, team satisfaction, and team trust. Team cohesion was measured using an adjusted two-item scale developed for this study. A sample item is “Our team likes working together.” Team satisfaction was assessed using a 3-item measure developed by Peeters, Rutte, van Tuijl, and Reyman (2006). A sample item is “Taken as a whole, I am satisfied with working in this team.” Team trust was measured via a four-item psychometric measure developed by McAllister (1995). A sample item is “Our team has a sharing relationship. We can freely share our ideas, feelings, and hopes.” Responses for the team cohesion, team satisfaction, and team trust measures were all rated on a 5-point Likert-type scale (1 = strongly disagree, 2 = disagree, 3 = neither disagree or agree, 4 = agree, 5 = strongly agree). Team identity was assessed using the pictorial measure developed by Hinds and Mortensen (2005). Responses were rated on a 6-item scale (1 = very different, 2 = somewhat different, 3 = a little different, 4 = a little close, 5 = somewhat close, 6 = very close), in which the scale points correspond to the extent to which two circles (representing the team and self) overlap. All affective measures were administered at T1 and T2, except for team trust, which was only administered at T2.

Motivational Emergent States. The following constructs were measured as indicators of team motivational states: motivation to work on behalf of the team and collective efficacy. Motivation to work on behalf of the team was assessed using a 3-item scale developed for this study. This scale uses a 7-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = neither disagree or agree, 5 = slightly agree, 6 = agree, 7 = strongly agree). A sample item is “While working with this team, I will persist until our goals are accomplished." Collective efficacy will be measured using the 3-item scale developed by Collins and Parker (2009). Participants were instructed to indicate the extent to which they are confident that their team could do specified tasks on a 10-point scale (0 = Not at all confident, 10 = Very confident). A sample item is "Resolve conflicts that have become personalized." All motivational measures were administered at T1 and T2.

Team Process/Process Sociomateriality. Process sociomateriality was measured using the items developed and validated in Study 2. The final scale is 50 items. These items were evaluated on a 5-point scale (1 = Not at all, 5 = To a Very Great Extent). A sample item is "To what extent did your team actively work to use new media to generate ideas?" Process content/timing was measured using the 30-item team process scale developed by Marks et al. (2001). These items were also evaluated on a 5-point scale (1 = Not at all, 5 = To a Very Great Extent). A sample item is "To what extent did your team actively work to identify our main tasks?" Both scales were administered at T1 and T2.

Team Virtuality. Virtuality was assessed via a constant sum item in which participants were instructed to indicate what percentage of their teamwork was conducted via a seven different types of communication technology platforms (videoconferencing, email, instant messaging), project management platforms, instant messaging, face-to-face, and other). This scale was adapted from the virtuality measure developed by Rapp, Ahearne, Mathieu, and Rapp (2010), and is reflective of the prominent conceptualizations and operationalizations of team virtuality (e.g. Bell & Kozlowski, 2002; Cohen & Gibson, 2003; Kirkman & Mathieu, 2005). Responses were constrained such that each member had to allocate exactly 100% across the different modalities. Consistent with

Rapp et al. (2010), degree of team virtuality was assessed by first subtracting the face-to-face interaction percentage from 100%, and then aggregating to the team level. As a result, each team exhibits a percentage reflective of how virtual they are; higher percentages indicate higher virtuality. The mean was 92.13 (SD = 6.20, range: 75.71 – 100). This scale was administered only at T2.

Team Viability. Team viability was assessed using a 4-item scale developed by Bayazit and Mannix (2003). These items are evaluated on a 5-point Likert scale (1=strongly disagree to 5=strongly agree). A sample item is "I wouldn't hesitate to participate on another task with the same team members." This scale was administered only at T2.

Team Performance. Team performance was assessed via behaviorally-anchored rating scales (BARS) of the final team product (persuasive poster). BARS were developed according to the recommendations of Smith and Kendall (1963). First, four subject matter experts (SMEs) assisted in the identification and definition of performance dimensions relevant to each team product. Two of the SMEs were full professors in industrial and organizational psychology, 1 SME was an assistant professor in industrial and organizational psychology, and 1 SME was an assistant professor in ecology.

Three performance dimensions were specified for the persuasive poster: solution effectiveness, solution implementability, and solution novelty. Solution effectiveness refers to the extent to which the proposed solution would successfully address the ecological issue. Implementability was defined as the extent to which the proposed solution could realistically be executed. Lastly, novelty referred to the demonstration of original thought or ideas. Given that each of these dimension capture a unique aspect of team performance, hypotheses that utilize ‘team performance’ as the dependent variable were tested with each respective performance dimension.

A second SME panel then assisted in developing examples of excellent, average, and poor indicators for each performance dimension within each team product. This SME panel was comprised of an assistant professor in ecology, and a doctoral candidate in industrial and organizational psychology. These examples were placed on a 5-point scale (1=poor; 5=excellent). The complete definitions of the performance dimensions and corresponding BARS scales are contained in Appendix D.

Four SMEs were then recruited to evaluate the persuasive poster according to these dimensions. The SMEs consisted of two doctoral candidates with extensive experience in ecology, and two doctoral candidates with extensive experience in social psychology. Each SME attended an initial meeting during which they received a project description and BARS training. Each SME then individually completed ratings for each performance dimension for the persuasive poster for each team. The SMEs exhibited acceptable agreement on all performance dimensions: Novelty r_{wg} = .75 (mean); .75 (median); Implementability r_{wg} = .71 (mean); .75 (median); and Solution Effectiveness r_{wg} = .70 (mean); .75 (median).

Qualitative Analysis

The use of communication technology has provided researchers with a unique opportunity to access behavioral data that can further inform our understanding of teams and how they function. This dissertation provided student project teams with a suite of new media platforms to enable their teamwork: Basecamp, GoogleGroups, and WebEx. Each of these tools can provide novel behavioral data that depicts teamwork. Basecamp (an project management tool) provides a repository of all team interaction via discussion threads, comments, and document sharing. GoogleGroups provides a catalogue of email correspondence among team members. Finally, WebEx provides descriptive information about meeting frequency, attendance, duration etc., as well as meeting recordings. This data can be used to provide informative, objective insights into the manner in which teams use technology to accomplish taskwork (e.g. Ahuja & Galvin, 2003; Ahuja, Galletta, & Carley, 2003; Gonzalez-Navarro, Orengo, Zornoza, Ripoll, & Peiro; Jimenez, 2012; Kossinets & Watts, 2009; Leonardi, Neeley, & Gerber, 2012; Maznevski & Chudoba, 2000). Thus, this dissertation utilized this data to attain illustrative examples of the embodiment of process sociomateriality in this sample of distributed teams.

In order to accomplish this aim, technology use dossier files were compiled for each team. These dossier files catalogued the content and descriptive information (e.g. time/date, individual who performed the action) for every member action that occurred in each of the three tools. For Basecamp, this included all discussion threads, file uploads, calendar events, to-do lists, and text docs. For GoogleGroups, this included each email chain. For Webex, this included all descriptive information about each meeting that each team held (e.g. duration, attendance, time/date, number of meetings per team). WebEx meetings were also recorded. This data was then separated into each of the 4 deliverable periods, depending on when the actions occurred.

The taxonomy developed in Study 1 was then utilized to identify and highlight instances of each of the three process sociomateriality factors for each deliverable period. The lower-order behaviors of the process sociomateriality taxonomy served as behavioral indicators of each high-order factor. For instance, the period 1 data was first examined for instances of process facilitation by looking for behavioral markers that were reflective of idea generation, idea evaluation, activity synchronization, role and task assignment, team monitoring and backup, and motivation and confidence building. This process was repeated for each process sociomateriality factor for each deliverable period. The central purpose of this effort was to highlight rich examples of each of the process sociomateriality factors to further illustrate the phenomenon; therefore, the findings from this effort are reported in the form of quotations and detailed descriptions.

Results

Overview of Results

The results from Study 3 are divided into two sections. The first section details regression results from Hypotheses 1 and 2. The subsequent section details findings from meditations tested in Hypotheses 3 through 6. Consistent with the introduction, this section first presents findings from Hypotheses 3 and 4, which postulate that the process sociomateriality factors indirectly shape team performance/viability through affective emergent states. This section then presents findings from Hypotheses 5 and 6, which posit that the process sociomateriality factors shape team performance/viability indirectly through motivational emergent states. The subsequent section details findings from the incremental validity hypotheses (Hypotheses 7 through 12). Tables 40 through 46 present the descriptive statistics and zero-order correlations among all study variables. Table 47 contains a summary of all hypotheses tested in Study 3.

Table 40.

Zero-order correlations Between Emergent States at T1 and T2

	Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10
1.	Team Sat. T1	3.84	0.49										
2.	Team Sat. (T2)	3.81	0.54	.79**									
3.	Team Identity T1	3.63	0.54	.64**	.50**								
4.	Team Identity T2	3.69	0.55	.42*	.58**	.69**							
5.	Team Cohesion T1	3.70	0.44	.89**	.78**	.74**	.45**						
6.	Team Cohesion T2	3.81	0.49	.73**	.87**	.62**	.61**	.80**					
7.	Team Trust (T2)	3.73	0.44	.69**	.86**	.58**	.66**	.73**	.85**				
8.	Collective Efficacy T1	7.68	0.97	.74**	.64**	.64**	.35*	.83**	.70**	.66**			
9.	Collective Efficacy T2	8.10	0.96	.73**	.87**	.51**	.58**	.78**	.83**	.88**	.78**		
10.	Team Mot. T1	6.10	0.36	.55**	.60**	.35	.35	.42**	.60**	.51**	.45*	.45*	
11.	Team Mot. T2	6.13	0.42	.44**	.55**	.20	.46**	.36**	.56**	.55**	.30	.57*	.74*

+$p \le .10$ (2-tailed),* $p \le .05$ (2-tailed), ** $p \le .01$ (2-tailed). $N = 32$

Table 41.

Zero-order correlations Between Process Sociomateriality Factors at Time 1 and Time 2

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. Facilitation (T1)	3.70	0.41								
2. Expansion (T1)	3.79	0.39	.87**							
3. Facilitation/Expansion (T1)	3.74	0.39	.97**	.97**						
4. Impairment (T1)	2.25	0.38	-.20	-.02	-.12					
5. Facilitation (T2)	3.62	0.40	.74**	.54**	.66**	-.36*				
6. Expansion (T2)	3.68	0.40	.74**	.59**	.69**	.32+	.94**			
7. Facilitation/Expansion (T2)	3.65	0.39	.75**	.57**	.69**	-.34+	.99**	.98**		
8. Impairment (T2)	2.22	0.39	-.44*	-.45*	-.46*	.21	-.18	-.20	-.19	-

+$p \leq .10$ (2-tailed), *$p \leq .05$ (2-tailed), ** $p \leq .01$ (2-tailed). $N = 32$.

Table 42.

Zero-order correlations Between Process Sociomateriality Variables and Emergent States

	Variable	*M*	*SD*	F/E (T1)	Imp (T1)	F/E (T2)	Imp (T2)
1.	Satisfaction (T1)	3.84	0.49	.55**	-.36*	.47**	-.20
2.	Cohesion	3.70	0.44	.53**	-.28	.49**	-.21
3.	Identity (T1)	3.63	0.54	.41*	-.20	.39*	-.05
4.	Collective Efficacy (T1)	7.68	0.97	.49**	-.22	.39*	-.26
5.	Motivation (T1)	6.10	0.36	.50**	-.11	.54**	-.07
6.	Cohesion (T2)	3.81	0.49	.54**	-.12	.58**	-.11
7.	Identity (T2)	3.69	0.55	.21	-.04	.42*	.12
8.	Collective Efficacy (T)	8.10	0.96	.54**	-.18	.53**	-.22
9.	Motivation (T2)	6.13	0.42	.32+	.08	.38*	-.07
10.	Satisfaction (T2)	3.81	0.54	.52**	-.28	.70**	-.12
11.	Trust (T2)	3.73	0.44	.59**	.17	.73**	-.16

+$p \leq .10$ (2-tailed), *$p \leq .05$ (2-tailed), ** $p \leq .01$ (2-tailed). $N = 32$.
F/E = Faciliation/Expansion; Imp = Impairment

Table 43.

Zero-order correlations Between Emergent States and Team Performance/Viability

	Variable	*M*	*SD*	Nov	Imp	SE	Via
1.	Cohesion (T1)	3.70	0.44	.01	$.33^{+}$	.22	$.76^{**}$
2.	Identity (T1)	3.63	0.54	$-.31^{+}$	.14	-.08	$.49^{**}$
3.	Collective Efficacy (T1)	7.68	0.97	.09	$.34^{+}$	$.31^{+}$	$.69^{**}$
4.	Motivation (T1)	6.10	0.36	-.09	$.44^{*}$	$.41^{*}$	$.58^{**}$
5.	Satisfaction (T1)	3.84	0.49	.06	$.35^{*}$	$.31^{+}$	$.78^{**}$
6.	Facilitation/Expansion (T1)	3.74	0.39	-.09	.29	.15	$.61^{**}$
7.	Impairment (T1)	2.25	0.38	-.14	$-.31^{+}$	-.17	$-.36^{*}$
8.	Cohesion (T2)	3.81	0.49	-.17	$.56^{**}$	$.30^{+}$	$.81^{**}$
9.	Identity (T2)	3.69	0.55	-.30	.25	.04	$.46^{**}$
10.	Collective Efficacy (T)	8.10	0.96	-.04	$.44^{**}$	.29	$.85^{**}$
11.	Motivation (T2)	6.13	0.42	-.15	$.37^{*}$	.31	$.50^{**}$
12.	Satisfaction (T2)	3.81	0.54	-.06	$.50^{**}$	$.34^{+}$	$.91^{**}$
13.	Trust (T2)	3.73	0.44	-.13	$.38^{*}$	.21	$.83^{**}$
14.	Facilitation/Expansion (T2)	3.65	0.39	-.18	$.36^{*}$	.22	$.74^{**}$
15.	Impairment (T2)	2.22	0.39	-.05	-.24	-.04	$-.36^{*}$

+$p \leq .10$ (2-tailed), *$p \leq .05$ (2-tailed), ** $p \leq .01$ (2-tailed). $N = 32$. Imp = Implementability; SE = Solution Effectiveness; Via = Viability

Table 44.

Zero-order correlations - Process Sociomateriality at T2 and Prior Conceptualizations of the Process-Technology Relationship at T2

Variable	*M*	*SD*	1	2	3	4
1. Facilitation/Expansion (T2)	3.65	0.39				
2. Impairment (T2)	2.22	0.39	-.19			
3. Process (T2)	3.53	0.40	.66**	-.03		
4. Virtuality (T2)	92.13	6.20	-.14	-.43*	-.17	
5. ProcessXVirtuality (T2)	-.40	2.00	-.12	-.02	-.34+	.14

+$p \leq .10$ (2-tailed), *$p \leq .05$ (2-tailed), ** $p \leq .01$ (2-tailed). $N = 32$.
F/E = Faciliation/Expansion.

Table 45.

Zero-order correlations - Emergent States at T2 with Process Sociomateriality at T2 and Prior Conceptualizations of the Process-Technology Relationship at T2

Variable	*M*	*SD*	F/E (T2)	Imp (T2)	Process (T2)	Virtuality (T2)	ProcessXVirtuality (T2)
1. Cohesion (T2)	3.81	0.49	.58**	-.11	.80**	.01	.00
2. Identity (T2)	3.69	0.55	.42*	.12	.64**	-.11	-.18
3. Collective Efficacy (T2)	8.10	0.96	.53**	-.22	.80**	.09	-.26
4. Motivation (T2)	6.13	0.42	.38*	-.07	.54**	-.11	-.12
5. Satisfaction (T2)	3.81	0.54	.70**	-.12	.82**	-.05	-.14
6. Trust (T2)	3.73	0.44	.73**	-.16	.88**	-.04	-.16

+$p \leq .10$ (2-tailed), *$p \leq .05$ (2-tailed), ** $p \leq .01$ (2-tailed). $N = 32$. F/E = Facilitation/Expansion; Imp = Impairment.

Table 46.

Zero-order correlations - Team Outcomes with Process Sociomateriality at T2 and Prior Conceptualizations of the Process-Technology Relationship at T2

Variable	*M*	*SD*	F/E (T2)	Imp (T2)	Process (T2)	Virtuality (T2)	ProcessXVirtuality (T2)
1. Scientific Rigor (T2)	3.17	0.90	.06	.26	-.10	.00	-.04
2. Integration (T2)	3.13	0.85	-.07	-.03	.09	-.16	-.08
3. Novelty (T2)	1.55	0.64	-.18	-.05	-.23	.04	-.05
4. Implementability (T2)	3.30	1.00	.36*	-.24	.40*	-.08	-.06
5. Solution Effectiveness (T2)	2.52	0.88	.22	-.04	.18	-.14	-.17
6. Viability (T2)	3.49	0.49	.74**	-.35+	.74**	.06	-.13

+$p \leq .10$ (2-tailed), *$p \leq .05$ (2-tailed), ** $p \leq .01$ (2-tailed). $N = 32$. F/E = Facilitation/Expansion; Imp = Impairment

Table 47.

Study 3 Hypotheses Summarized

Hypothesis Number	Hypothesis	Support?	Table/ Figure
1a	*Process facilitation/expansion (T1) positively predicts solution effectiveness.*	NS	Table 48
	Process facilitation/expansion (T2) positively predicts solution effectiveness.	NS	Table 48
	Process facilitation/expansion (T1) positively predicts solution implementability.	NS	Table 48
	Process facilitation/expansion (T2) positively predicts solution implementability.	S	Table 48
1b	*Process facilitation/expansion (T1) positively predicts team viability.*	S	Table 48
	Process facilitation/expansion (T2) positively predicts team viability.	S	Table 48
2a	*Process impairment (T1) negatively predicts solution effectiveness.*	NS	Table 48
	Process impairment (T2) negatively predicts solution effectiveness.	NS	Table 48
	Process impairment (T1) negatively predicts solution implementability.	NS	Table 48
	Process impairment (T2) negatively predicts solution implementability.	NS	Table 48
2b	*Process impairment (T1) negatively predicts team viability.*	S	Table 48
	Process impairment (T2) negatively predicts team viability.	S	Table 48
3a	*Team satisfaction mediates the relationship between process facilitation/expansion and solution effectiveness.*	S	Figure 4
	Team satisfaction mediates the relationship between process facilitation/expansion and solution implementability.	S	Figure 5
3b	*Team cohesion mediates the relationship between process facilitation/expansion and solution effectiveness.*	NS	Figure 6
	Team cohesion mediates the relationship between process facilitation/expansion and solution implementability.	NS	Figure 7
3c	*Team identity mediates the relationship between process facilitation/expansion and solution effectiveness.*	NS	Figure 8

Table 47. (ctd.)

Study 3 Hypotheses Summarized

Hypothesis Number	Hypothesis	Support?	Table/ Figure
3c	*Team identity mediates the relationship between process facilitation/expansion and solution implementability.*	NS	Figure 9
3d	*Team trust mediates the relationship between process facilitation/expansion and solution effectiveness.*	NS	Figure 10
	Team trust mediates the relationship between process facilitation/expansion and solution implementability.	S	Figure 11
3e	*Team satisfaction mediates the relationship between process facilitation/expansion and team viability.*	S	Figure 12
3f	*Team cohesion mediates the relationship between process facilitation/expansion and team viability.*	NS	-
3g	*Team identity mediates the relationship between process facilitation/expansion and team viability.*	NS	Figure 13
3h	*Team trust mediates the relationship between process facilitation/expansion and team viability.*	S	Figure 14
4a	*Team satisfaction mediates the relationship between process impairment and solution effectiveness.*	NS	Figure 15
	Team satisfaction mediates the relationship between process impairment and solution implementability.	NS	Figure 16
4b	*Team cohesion mediates the relationship between process impairment and solution effectiveness.*	NS	Figure 17
	Team cohesion mediates the relationship between process impairment and solution implementability.	NS	-
4c	*Team identity mediates the relationship between process impairment and solution effectiveness.*	NS	Figure 18
	Team identity mediates the relationship between process impairment and solution implementability.	NS	-
4d	*Team trust mediates the relationship between process impairment and solution effectiveness.*	NS	Figure 19
4d	*Team trust mediates the relationship between process impairment and solution effectiveness.*	NS	-
4e	*Team satisfaction mediates the relationship between process impairment and team viability.*	NS	-
4f	*Team cohesion mediates the relationship between process impairment and team viability.*	NS	-
4g	*Team identity mediates the relationship between process impairment and team viability.*	NS	-
4h	*Team trust mediates the relationship between process impairment and team viability.*	NS	-

Table 47 (ctd.)

Study 3 Hypotheses Summarized

Hypothesis Number	**Hypothesis**	**Support?**	**Table/ Figure**
5a	*Collective Efficacy mediates the relationship between process facilitation/expansion and solution effectiveness.*	S	Figure 20
	Collective Efficacy mediates the relationship between process facilitation/expansion and solution implementability.	S	Figure 21
5b	*Motivation to work on behalf of the team mediates the relationship between process facilitation/expansion and solution effectiveness.*	NS	Figure 22
	Motivation to work on behalf of the team mediates the relationship between process facilitation/expansion and solution implementability.	NS	Figure 23
5c	*Collective Efficacy mediates the relationship between process facilitation/expansion and team viability.*	NS	-
5d	*Motivation to work on behalf of the team mediates the relationship between process impairment and team viability.*	NS	Figure 24
6a	*Collective Efficacy mediates the relationship between process impairment and solution effectiveness.*	NS	Figure 25
	Collective Efficacy mediates the relationship between process impairment and solution implementability.	NS	Figure 26
6b	*Motivation to work on behalf of the team mediates the relationship between process impairment and solution effectiveness.*	NS	Figure 27
	Motivation to work on behalf of the team mediates the relationship between process impairment and solution implementability.	NS	-
6c	*Collective Efficacy mediates the relationship between process impairment and team viability.*	NS	-
6d	*Motivation to work on behalf of the team mediates the relationship between process impairment and team viability.*	NS	-
7	*Process sociomateriality will show incremental validity in team viability after controlling for the effects of team process.*	S	Table 49
8	*Process sociomateriality will show incremental validity in solution effectiveness after controlling for the effects of team process.*	NS	Table 49
	Process sociomateriality will show incremental validity in solution implementability after controlling for the effects of team process.	NS	Table 49

Table 47 (ctd.)

Study 3 Hypotheses Summarized

Hypothesis Number	**Hypothesis**	**Support?**	**Figure/ Table**
9	*Process sociomateriality will show incremental validity in team viability after controlling for the effects of team virtuality.*	S	Table 49
10	*Process sociomateriality will show incremental validity in solution effectiveness after controlling for the effects of team virtuality.*	NS	Table 49
	Process sociomateriality will show incremental validity in solution implementability after controlling for the effects of team virtuality.	NS	Table 49
11	*Process sociomateriality will show incremental validity in team viability after controlling for the effects of the interaction between team virtuality and team process.*	S	Table 49
12	*Process sociomateriality will show incremental validity in solution effectiveness after controlling for the effects of the interaction between team virtuality and team process.*	NS	Table 49
	Process sociomateriality will show incremental validity in solution implementability after controlling for the effects of the interaction between team virtuality and team process.	NS	Table 49
Supplemental	*Process sociomateriality will show incremental validity in team satisfaction after controlling for the effects of team process.*	S	Table 50
	Process sociomateriality will show incremental validity in team cohesion after controlling for the effects of team process.	NS	Table 50
	Process sociomateriality will show incremental validity in team identity after controlling for the effects of team process.	NS	Table 50
	Process sociomateriality will show incremental validity in team trust after controlling for the effects of team process.	S	Table 50
	Process sociomateriality will show incremental validity in collective efficacy after controlling for the effects of team process.	NS	Table 50
	Process sociomateriality will show incremental validity in motivation to work on behalf of the team after controlling for the effects of team process.	NS	Table 50
	Process sociomateriality will show incremental validity in team satisfaction after controlling for the effects of team virtuality.	S	Table 50

Table 47 (ctd.)

Study 3 Hypotheses Summarized

Hypothesis Number	**Hypothesis**	**Support?**	**Figure/ Table**
Supplemental	*Process sociomateriality will show incremental validity in team cohesion after controlling for the effects of team virtuality.*	S	Table 50
	Process sociomateriality will show incremental validity in team identity after controlling for the effects of team virtuality.	NS	Table 50
	Process sociomateriality will show incremental validity in team trust after controlling for the effects of team virtuality.	S	Table 50
	Process sociomateriality will show incremental validity in collective efficacy after controlling for the effects of team virtuality.	S	Table 50
	Process sociomateriality will show incremental validity in motivation to work on behalf of the team after controlling for the effects of team virtuality.	NS	Table 50
	Process sociomateriality will show incremental validity in team satisfaction after controlling for the effects of the team virtualityXprocess interaction.	S	Table 50
	Process sociomateriality will show incremental validity in team cohesion after controlling for the effects of the team virtualityXprocess interaction.	NS	Table 50
	Process sociomateriality will show incremental validity in team identity after controlling for the effects of the team virtualityXprocess interaction.	NS	Table 50
	Process sociomateriality will show incremental validity in team trust after controlling for the effects of the team virtualityXprocess interaction.	S	Table 50
	Process sociomateriality will show incremental validity in collective efficacy after controlling for the effects of the team virtualityXprocess interaction.	NS	Table 50
	Process sociomateriality will show incremental validity in motivation to work on behalf of the team after controlling for the effects of the team virtualityXprocess interaction.	NS	Table 50

Composite Variables. Two composite variables were created to due high factor intercorrelations. The first was a process facilitation/expansion composite. Consistent with the findings of Study 2, facilitation and expansion were very highly correlated (r = .86 at T1; r = .91 at T2). In order to avoid issues with multicollinearity and to test hypotheses in a parsimonious manner, facilitation and expansion were averaged to create a composite facilitation/expansion variable for each time point. This composite variable was used to test all relevant hypotheses.

The team process factors were also very highly correlated. The T1 intercorrelations were as follows: action-transition (r = .94), transition – interpersonal (r = .87), and action-interpersonal (r = .92). The T2 intercorrelations were as follows: action-transition (r = .90), transition – interpersonal (r = .92), and action-interpersonal (r = .88). Therefore, the action, transition, and interpersonal scores were averaged to created a composite "team process" variable at each time point. The team process composite variable was used as a control in the incremental validity hypotheses. The facilitation/expansion composite variable was also used to test the incremental validity hypotheses (instead of separate facilitation and expansion factors).

Solution Novelty. All key study variables were normally distributed, with the exception of solution novelty. Solution novelty displayed levels of skewness (1.85, *SE* = .41) and kurtosis (2.94, *SE* = .81) that fell outside of acceptable ranges (-1 to 1) (Bai & Ng, 2005). This variable did not display the presence of any outliers. Rather, this pattern is likely reflective of the fact that SME's judged the persuasive posters to be relatively low on novelty (M = 1.56, SD = .64, range = 1 to 3.5), resulting in a lower-bounded range restriction. Moreover, analysis of bivariate correlations revealed that none of the key study variables were related to solution novelty. Therefore, it was removed from subsequent hypothesis testing.

Analytic Approach: Hypotheses 1 & 2

Hypotheses 1 and 2 were examined through regression. These hypotheses posited that the process sociomateriality factors (H1: Facilitation/Expansion; H2: Impairment) would predict team performance and team viability. To test each hypothesis, the dependent variable (e.g. team performance; team viability) was regressed onto the independent variable (e.g. process facilitation/expansion & impairment). Given that process sociomateriality was measured at two time points (T1 and T2), these hypotheses were tested twice: by regressing the dependent variable onto the process sociomateriality factors at T1, and also by regressing the dependent variable onto the process sociomateriality factors at T2. This procedure examines whether sociomaterial process behaviors are more impactful to performance earlier or later in the team cycle. Theses hypotheses were evaluated by examining p-value for the standardized beta of the independent variables. The significance criterion was $p < .05$.

Hypotheses 1 & 2: Process Facilitation/Expansion, Impairment → Performance

Hypothesis 1a predicted that facilitation/expansion would positively predict team performance. This hypothesis was first tested with solution effectiveness as the dependent variable. Regression analyses revealed that neither facilitation/expansion at T1 ($\beta = .15$, ns) or T2 ($\beta = .22$, ns) predicted solution effectiveness. This hypothesis was then tested with solution implementability as the dependent variable. Regression analyses demonstrated that facilitation/expansion at T1 did not predict solution implementability ($\beta = .29$, ns); however, facilitation/expansion at T2 did positively predict solution implementability ($\beta = .36$, $p < .05$). Hypothesis 1b hypothesized that facilitation/expansion would positively predict team viability. Regression analyses revealed that facilitation/expansion at T1 (β = .61, $p < .01$) and T2 (β = .74, $p < .01$) positively predicted team viability.

Hypothesis 2a predicted that impairment would negatively predict team performance. This hypothesis was first tested with solution effectiveness as the dependent variable. Regression analyses revealed that neither impairment at T1 (β = -.17, ns) nor T2 (β = -.04, ns) predicted solution effectiveness. This hypothesis was then tested with solution implementability as the dependent variable. Regression analyses revealed that neither impairment at T1 (β = -.31, ns) nor T2 (β = -.24, ns) predicted solution implementability. Hypothesis 1b hypothesized that impairment would negatively predict team viability. Regression analyses revealed that impairment at T1 negatively predicted team viability (β = -.36, $p < .05$), as did impairment at T2 (β = -.36, $p < .05$). All findings for Hypotheses 1 and 2 are displayed in Table 48.

Table 48.

Regression Results Examining the Impact of Process Sociomateriality on Team Performance/Viability

Hypothesis	**DV**	**IV**	**β**	**SE**	***p***	***F***	R^2
1a	Solution Effectiveness	Facilitation/Expansion (T1)	.15	.18	*ns*	.69	.02
	Solution Effectiveness	Facilitation/Expansion (T2)	.22	.18	*ns*	1.57	.05
	Solution Implementability	Facilitation/Expansion (T1)	.29	.18	*ns*	2.71	.08
	Solution Implementability	Facilitation/Expansion (T2)	.36	.17	$p < .05$	4.52	.13
1b	Team Viability	Facilitation/Expansion (T1)	.61	.14	$p < .01$	17.34	.37
	Team Viability	Facilitation/Expansion (T2)	.74	.12	$p < .01$	36.27	.55
2a	Solution Effectiveness	Impairment (T1)	-.17	.18	*ns*	.90	.03
	Solution Effectiveness	Impairment (T2)	-.04	.19	*ns*	.05	.00
	Solution Implementability	Impairment (T1)	-.31	.18	*ns*	3.21	.07
	Solution Implementability	Impairment (T2)	-.24	.18	*ns*	1.90	.06
2b	Team Viability	Impairment (T1)	-.36	.17	$p < .05$	4.32	.13
	Team Viability	Impairment (T2)	-.36	.17	$p < .05$	4.11	.12

Analytic Approach: Mediation Hypotheses 3 – 6

This dissertation tested Hypotheses 3 through 6 using path-analysis. Path-analysis acts as an extension of multiple regression analysis, and enables researchers to examine the strength and magnitude of hypothesized effects within a causal system (Lleras, 2005). Path analysis is a specific case of structural equation modeling, in which models in path analysis contain only observed variables, each of which has only one indicator (Raykov & Marcoulides, 2000). Given its propensity for modeling causal linkages, path-analysis is a prominent analytic technique for modeling and testing for mediation (James, Muliak, & Brett, 2006).

An added benefit of path-analysis is that it can account for changes in a variable over time, and it enables a test of the causal ordering of study variables. This dissertation utilized cross-lagged panel analysis with autoregression to assess each of these factors (Cole & Maxwell, 2003; Kenny, 1975; Maxwell & Cole, 2007). The present study hypothesizes that process sociomateriality behaviors will impact team emergent states, which will in turn impact team performance. However, it is possible that emergent states may instead shape behavior (e.g. Mathieu et al., 2008; Marks et al., 2001). In order to examine these assertions, path models were constructed with two critical types of linkages. First, models were structured such that each process sociomateriality factor or emergent state (at T2) was predicted by the same variable at the previous time point at T1 (autoregression). Then, following the framework of cross-lagged panel analysis, time 1 variables (e.g. process facilitation/expansion) were positioned to predict time 2 variables (e.g. team cohesion), and vice versa. Examining these autoregressive, cross-lagged relationships allowed the present dissertation to test whether process sociomateriality occurs before team emergent states or vice versa, while also accounting for whether these variables related to themselves across the two time points.

It bears mention that the literature has indicated that path analysis can be an appropriate tool for small samples, particularly when the model contains only observed variables, there are fewer parameters than variables, and there are only a small number of variables (Bentler & Yuan, 1999; Tenenhaus, 2007; Wolf, Harrington, Clark, & Miller, 2013). These assertions, coupled with the previously describe analytic advantages of testing for mediation using cross-lagged panel analysis, support the use of path analysis in the present dissertation.

Testing for Mediation. This dissertation followed the criteria for testing for mediation detailed by James et al. (2006). First, the model must demonstrate acceptable fit. Model fit was assessed using the chi-square goodness of fit test, the root mean square error of approximation (RMSEA), comparative fit index (CFI), the standardized root mean square residual (SRMR), and the Akaike information criterion (AIC). A non-significant chi-square test indicates acceptable fit of the model to the data (Bentler, 1990). Values below .08 for RMSEA and SRMR, and above .90 for CFI indicate acceptable fit (Hu & Bentler, 1998; 1999). It is important to note that Kenny, Kaniskan, and McCoach (2014) indicate that RMSEA estimates can be unreliable for small models (e.g. low degrees of freedom) and small sample size models (e.g. low N). RMSEA is still reported for all path models given its prominence in the literature, but it should be interpreted with caution. Finally, the AIC enables comparisons of fit between non-nested models (Akaike, 1987; Haughton, Oud, & Jansen, 1997). This index was used to compare the relative of fit of the hypothesized mediation models (process sociomateriality →

emergent states → team performance) to an alternative mediation model (emergent states → process sociomateriality → team performance). Lower AIC values indicate better fit to the data. The relevance and use of the alternative models will be discussed in the subsequent paragraphs.

The second condition set forth by James et al. (2006) is that the path from the predictor to the mediator is significant (a-path) and that the path from the mediator to the dependent variable is significant (b-path). Thus, if the model fits the data, and the a- and b-paths are significant, there is potential for mediation. In the present study, given that sociomateriality and emergent states were collected twice, there was potential to test for mediation using two different a-paths. The first a-path positioned the predictor at time 1, and the mediator at time 2. This path offers the most robust test of causality given the temporal precedence of the predictor to the mediator. The second a-path positioned the predictor and mediator at time 2. In both instances, the b-path was comprised of the mediator at time 2 predicting team performance. This dissertation tested the meditation hypotheses using both variations of the a-path.

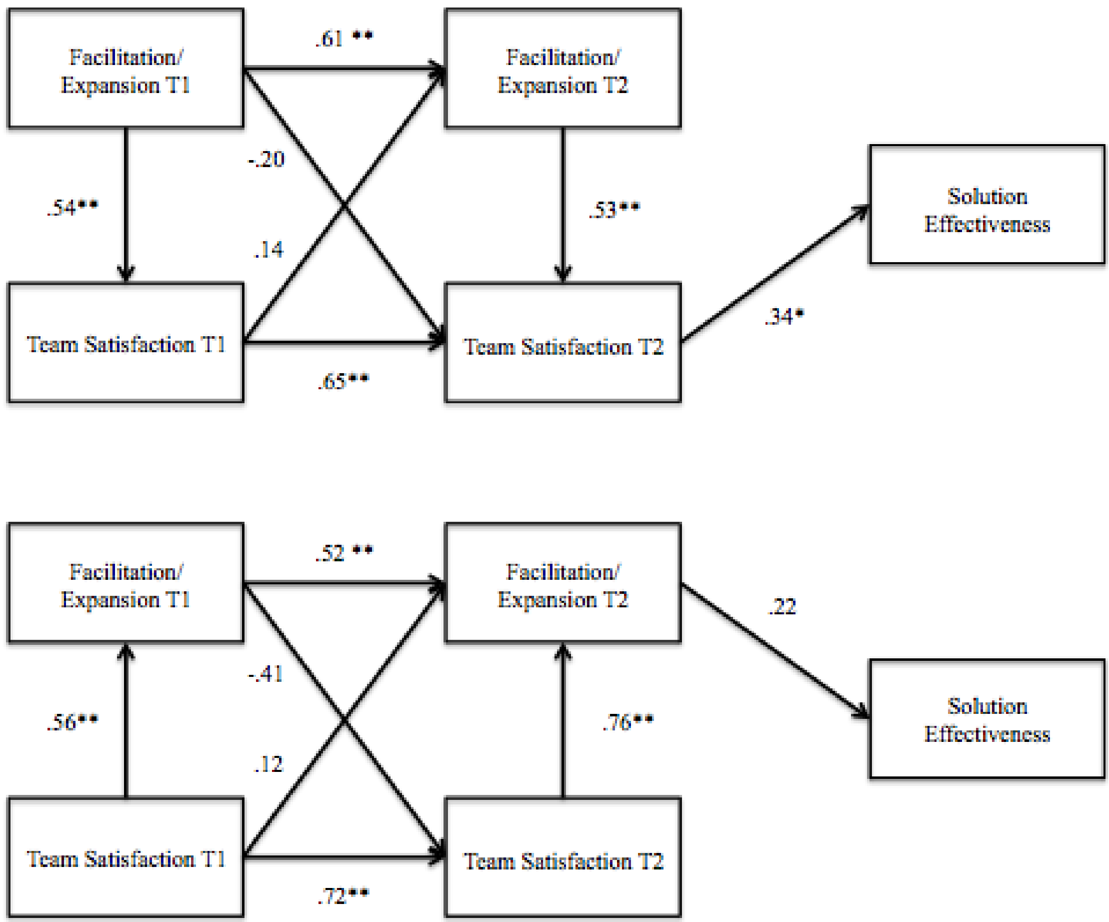
In order to test for the presence indirect effect, this dissertation utilized a bootstrapping procedure through the Lavaan package in R (Rosseel, 2015). Bootstrapping is a nonparametric technique that does not maintain assumptions about the distribution of the indirect effect (Hayes, 2009). This procedure provides a sample distribution of the indirect effect, and yields bias-corrected confidence intervals for the purpose of examining full mediation (Selig & Preacher, 2009). Mediation is present when the confidence interval around the indirect effect does not include zero (MacKinnon, Fairchild, & Fritz, 2007). In the current study, all tests of the indirect effect are based on 1,000 bootstrap samples, and a 95% bias-corrected confidence interval.

Alternate Model Testing. The present dissertation tested the hypothesized models against alternate models in which emergent states were positioned as a predictor of the process sociomateriality factors (at T1 and T2). Thus, there was potential to examine support for the emergent states → process sociomateriality linkage in the cross-lagged panel portion of the hypothesized models, and within the alternate models themselves. Mediation in the alternate models was examined using the same criteria utilized to test the hypothesized models.

Hypothesis 3a – 3d: Facilitation/Expansion → Affective Emergent States → Performance

Team Satisfaction as a Mediator. Hypothesis 3a predicted that team satisfaction would mediate the relationship between facilitation/expansion and team performance. This hypothesis was tested with two objective performance constructs: solution effectiveness, and solution implementability. This hypothesis was first tested with solution effectiveness as the dependent variable. The model fit well ($\chi^2_{(3)}$ = .28, ns; SRMR = .01; AIC = 389.29; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 4.

Figure 4. Path analysis results testing team satisfaction as a mediator between facilitation/expansion and solution effectiveness (Hypothesis 3a).



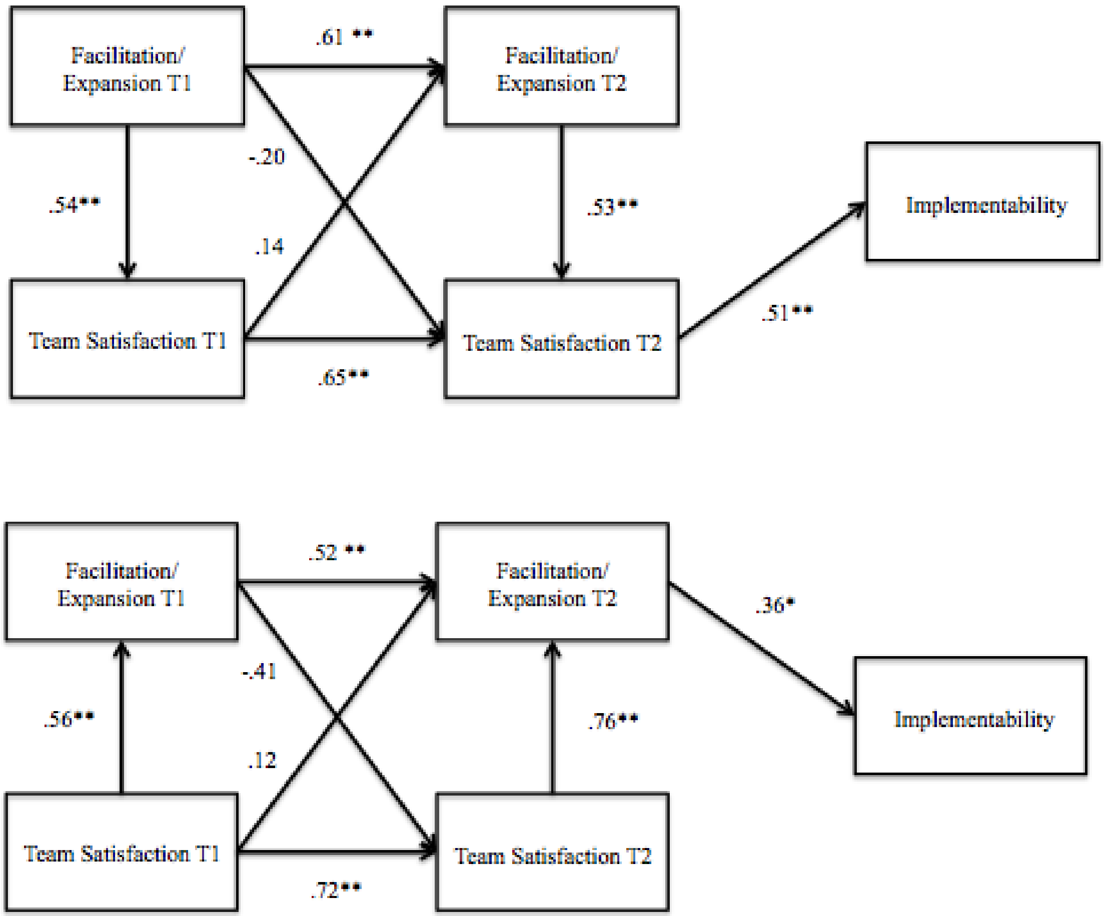
Note: * $p < .05$; ** $p < .01$. Top figure = hypothesized model ($\chi^2_{(3)} = .28$, ns; SRMR = .01; AIC = 389.29; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(3)} = 2.53$, ns; SRMR = .07; AIC = 391.54; CFI = 1.00; RMSEA = .00).

Focusing first on the autoregressions, the results indicated that facilitation/expansion at T1 significantly predicted facilitation/expansion at T2 ($\beta = .61$, $p \leq .01$), and team satisfaction at T1 significantly predicted team satisfaction at T2 ($\beta = .65$, $p \leq .01$). Regarding the cross-lagged relations, findings revealed that facilitation/expansion at T1 is not related to team satisfaction at T2 ($\beta = -.20$, ns), and that team satisfaction at T1 is not related to facilitation/expansion at T2 ($\beta = .14$, ns). Results did indicate that facilitation/expansion at T1 was positively related to team satisfaction at T1 (β = .54, $p \leq$ .01). Analysis of the T2 relationships revealed the potential for mediation. Facilitation/expansion at T2 was positively related to team satisfaction at T2 (β = .53, $p \leq$ .01), which in turn was positively related to solution effectiveness (β = .34, $p \leq$ .05). The bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution effectiveness did not include zero (.04 - .39), providing evidence that team satisfaction mediates the relationship between facilitation/expansion and solution effectiveness.

In order to further examine the causal linkage between the variables, an alternative model was tested with facilitation/expansion as a mediator between team satisfaction and solution effectiveness. Results revealed that the model did fit the data ($\chi^2_{(3)}$ = 2.53, ns; SRMR = .07; AIC = 391.54; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 4. However, the alternative model exhibited worse fit (AIC = 391.54) than the hypothesized model (AIC = 389.29). Further, analysis of the path coefficients revealed that although the a-path (team satisfaction at T2 → facilitation/expansion at T2) was significant (β = .76, $p \leq$ .01), the b-path (facilitation/expansion at T2 → solution effectiveness) was not (β = .22, ns). Thus, there is not statistical evidence that facilitation/expansion mediates the relationship between team satisfaction and solution effective, providing further support for the hypothesized model (facilitation/expansion → team satisfaction → solution effectiveness). Therefore, Hypothesis 3a was supported with solution effectiveness as the dependent variable.

Hypothesis 3a was then tested with solution implementability as the dependent variable. The model fit well ($\chi^2_{(3)}$ = .39, ns; SRMR = .01; AIC = 383.82; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 5.

Figure 5. Path analysis results testing team satisfaction as a mediator between facilitation/expansion and solution implementability (Hypothesis 3a).



Note: * p < .05; ** p < .01. Top figure = hypothesized model ($\chi^2_{(3)}$ = .39, ns; SRMR = .01; AIC = 383.82; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(3)}$ = 5.25, ns; SRMR = .08; AIC = 391.54; CFI = .97; RMSEA = .15).

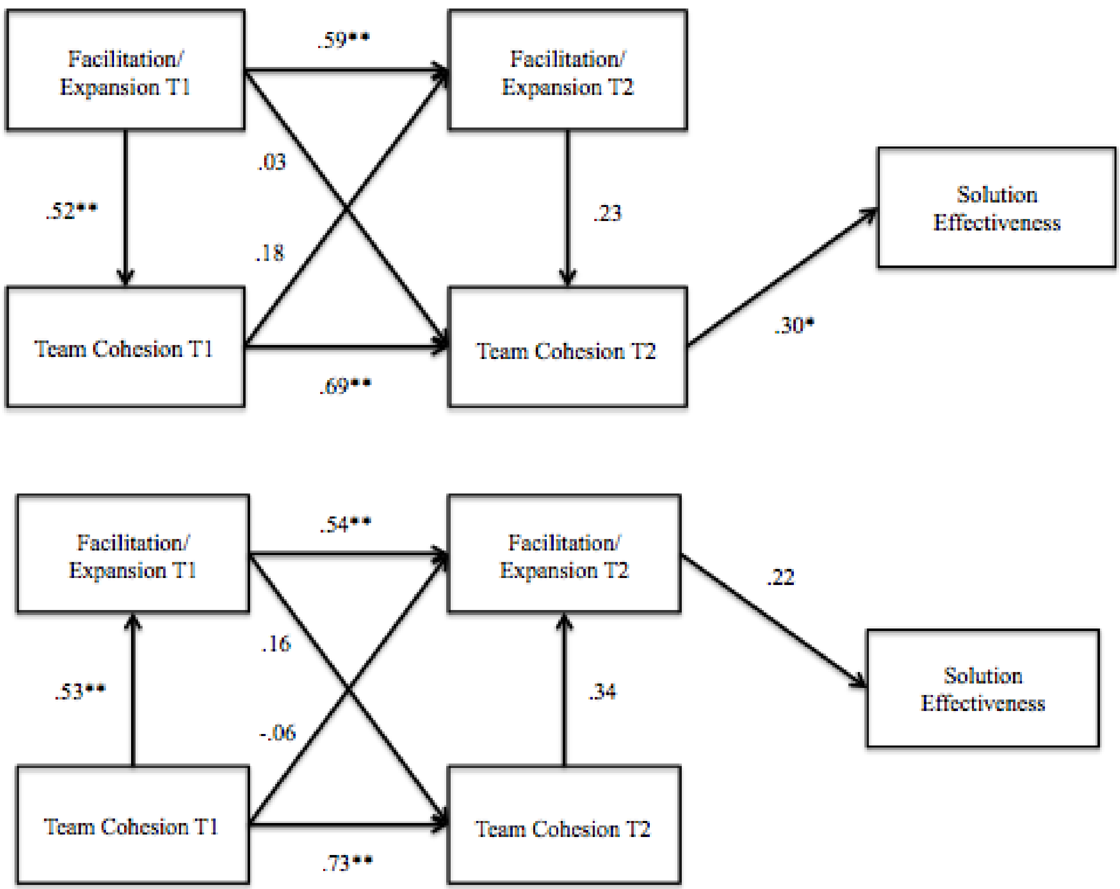
The autoregressive analyses and the cross-lagged analysis exhibited the exact same relationships revealed in the model with solution effectiveness as the dependent variable. Analysis of the T2 relationships revealed the potential for mediation. Facilitation/expansion at T2 was positively related to team satisfaction at T2 (β = .53, $p \leq$ .01), which in turn was positively related to solution implementability (β = .51, $p \leq$ .01).

The bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution implementability did not include zero (.10 - .46), providing evidence that team satisfaction mediates the relationship between facilitation/expansion and solution implementability.

The alternative model (team satisfaction → facilitation/expansion → solution implementability) demonstrated adequate fit to the data ($\chi^2_{(3)}$ = 5.25, ns; SRMR = .08; AIC = 391.54; CFI = .97; RMSEA = .15). The path model is depicted in Figure 5. Analysis of the path coefficients revealed that team satisfaction at T2 was positively related to facilitation/expansion at T2 (β = .76, $p \leq .01$), which in turn was positively related to solution implementability (β = .36, $p \leq .05$). Moreover, the bias-corrected 95% CI for the indirect effect of team satisfaction at T2 on solution effectiveness via facilitation/expansion did not include zero (.04 - .60). However, the alternative model exhibited worse fit (AIC = 391.54) than the hypothesized model (AIC = 383.82). Thus, although there is evidence for the alternate relationship, it is more plausible that team satisfaction mediates the relationship between facilitation/expansion and solution implementability. Therefore, Hypothesis 3a was supported with solution implementability as the dependent variable.

Team Cohesion as a Mediator. Hypothesis 3b predicted that team cohesion would mediate the relationship between facilitation/expansion and team performance. This hypothesis was first tested with solution effectiveness as the team performance dependent variable. The model fit well ($\chi^2_{(3)}$ = .27, ns; SRMR = .01; AIC = 402.71; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 6.

Figure 6. Path analysis results testing team cohesion as a mediator between facilitation/expansion and solution effectiveness (Hypothesis 3b).



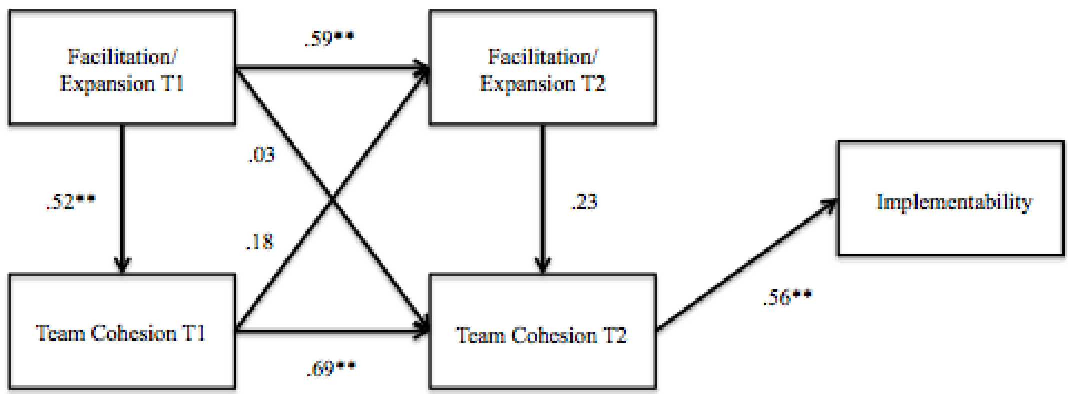
Note: * $p < .05$; ** $p < .01$. Top figure = hypothesized model ($\chi^2_{(3)} = .27$, ns; SRMR = .01; AIC = 402.71; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(3)} = 1.56$, ns; SRMR = .05; AIC = 404.01; CFI = 1.00; RMSEA = .00).

Focusing first on the autoregressions, the results indicated that facilitation/expansion at T1 significantly predicted facilitation/expansion at T2 ($\beta = .59$, $p \leq .01$), and team cohesion at T1 significantly predicted team cohesion at T2 ($\beta = .69$, $p \leq .01$). Regarding the cross-lagged relations, findings revealed that facilitation/expansion at T1 is not related to team cohesion at T2 ($\beta = .03$, ns), and that team cohesion at T1 is not related to facilitation/expansion at T2 ($\beta = .18$, ns). Results did indicate that facilitation/expansion at T1 was positively related to team cohesion at T1 (β = .52, $p \leq$ .01). Analysis of the T2 relationships did not provide the necessary support for mediation. Facilitation/expansion at T2 was not statistically related to team cohesion at T2 (β = .23, ns), although team cohesion was related to solution effectiveness (β = .30, $p \leq .05$). The lack of statistical significance of the a-path (facilitation/expansion → team cohesion) inhibits inferences of mediation. Therefore, Hypothesis 3b was not supported with solution effectiveness as the dependent variable.

Results also revealed that the alternate model (team cohesion → facilitation/expansion → solution effectiveness) fit the data ($\chi^2_{(3)}$ = 1.56, ns; SRMR = .05; AIC = 404.01; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 6. However, there was no support for mediation. Cohesion at T2 was not related to facilitation/expansion at T2 (β = .34, ns), and facilitation/expansion was not related to solution effectiveness (β = .22, ns).

This hypothesis was then tested with solution implementability as the team performance dependent variable. The model fit well ($\chi^2_{(3)}$ = 1.93, ns; SRMR = .03; AIC = 393.61; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 7.

Figure 7. Path analysis results testing team cohesion as a mediator between facilitation/expansion and solution implementability (Hypothesis 3b).

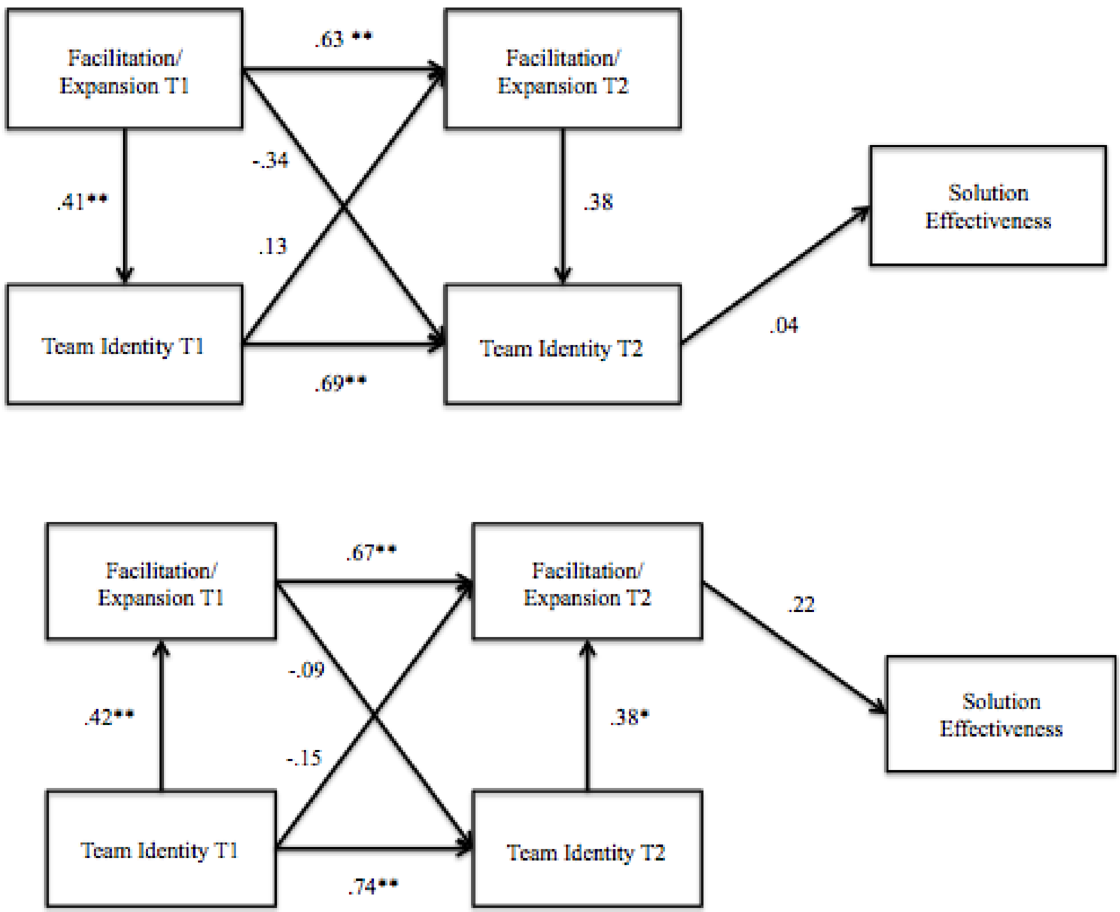


Note: * $p < .05$; ** $p < .01$. $\chi^2_{(3)} = 1.93$, ns; SRMR = .03; AIC = 393.61; CFI = 1.00; RMSEA = .00). Alternative model did not exhibit acceptable fit.

The autoregressive analyses and the cross-lagged analysis exhibited the exact same relationships revealed in the model with solution effectiveness as the dependent variable. Analysis of the T2 relationships did not demonstrate support for mediation. Facilitation/expansion at T2 was not related to cohesion at T2 ($\beta = .23$, ns), although cohesion at T2 was related to solution implementability ($\beta = .56$, $p \leq .01$). Again, the lack of statistical significance of the a-path (facilitation/expansion → team cohesion) inhibits inferences of mediation. The alternate model (team cohesion → facilitation/expansion → solution implementability) did not adequately fit the data ($\chi^2_{(3)} = 9.46$, $p \leq .05$; SRMR = .10; AIC = 401.14; CFI = .91; RMSEA = .26). Therefore, Hypothesis 3b was not supported with solution implementability as the dependent variable.

Team Identity as a Mediator. Hypothesis 3c predicted that team identity would mediate the relationship between facilitation/expansion and team performance. This hypothesis was first tested with solution effectiveness as the team performance dependent variable. The model fit the data ($\chi^2_{(3)}$ = 3.09, ns; SRMR = .07; AIC = 421.43; CFI = 1.00; RMSEA = .03). The path model is depicted in Figure 8.

Figure 8. Path analysis results testing team identity as a mediator between facilitation/expansion and solution effectiveness (Hypothesis 3c).



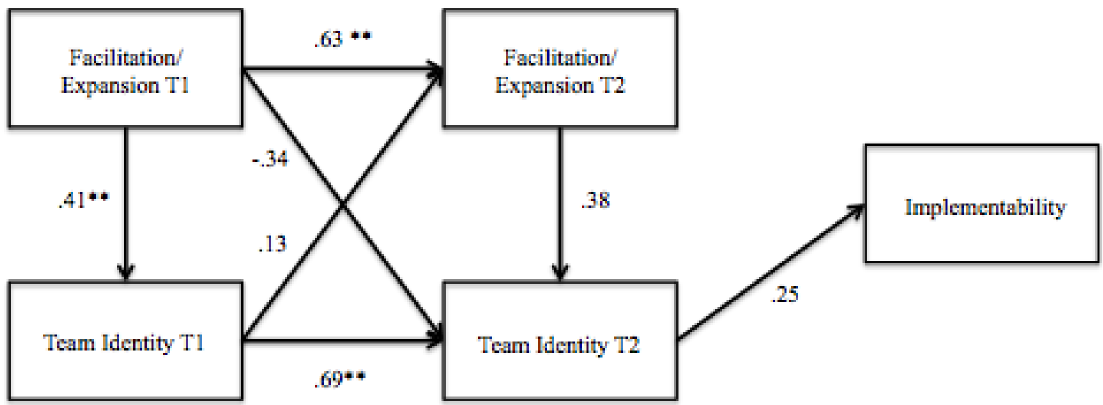
Note: * p < .05; ** p < .01. Top figure = hypothesized model ($\chi^2_{(3)}$ = 3.09, ns; SRMR = .07; AIC = 421.43; CFI = 1.00; RMSEA = .03); bottom figure = alternative model ($\chi^2_{(3)}$ = 1.50, ns; SRMR = .05; AIC = 419.84; CFI = 1.00; RMSEA = .00).

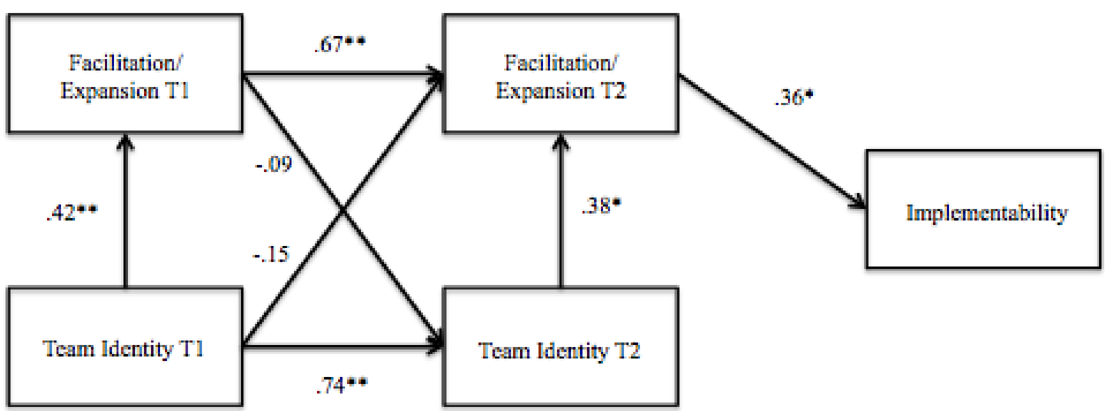
Results from the autoregressions revealed that facilitation/expansion at T1 significantly predicted facilitation/expansion at T2 (β = .63, $p \leq$ .01), and team identity at T1 significantly predicted team identity at T2 (β = .69, $p \leq$ .01). Regarding the cross-lagged relations, findings revealed that facilitation/expansion at T1 is not related to team identity at T2 (β = -.34, ns), and that team identity at T1 is not related to facilitation/expansion at T2 (β = .13, ns). Results did indicate that facilitation/expansion at T1 was positively related to team identity at T1 (β = .41, $p \leq .01$). Analysis of the T2 relationships did not provide the necessary support for mediation. Facilitation/expansion at T2 was not statistically related to team identity at T2 (β = .38, ns), and team identity was not related to solution effectiveness (β = .04, ns). The lack of statistical significance of these paths inhibits inferences of mediation. Therefore, Hypothesis 3c was not supported with solution effectiveness as the dependent variable.

Results also demonstrated that the alternate model (team identity → facilitation/expansion → solution effectiveness) fit the data ($\chi^2_{(3)}$ = 1.50, ns; SRMR = .05; AIC = 419.84; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 8. However, there was no support for mediation. Team identity at T2 was related to facilitation/expansion at T2 (β = .38, $p \leq .05$), but facilitation/expansion at T2 was not related to solution effectiveness (β = .22, ns).

This hypothesis was then tested with solution implementability as the team performance dependent variable. The model fit well ($\chi^2_{(3)}$ = 3.57, ns; SRMR = .09; AIC = 419.50; CFI = .99; RMSEA = .08). The path model is depicted in Figure 9.

Figure 9. Path analysis results testing team identity as a mediator between facilitation/expansion and solution implementability (Hypothesis 3c).





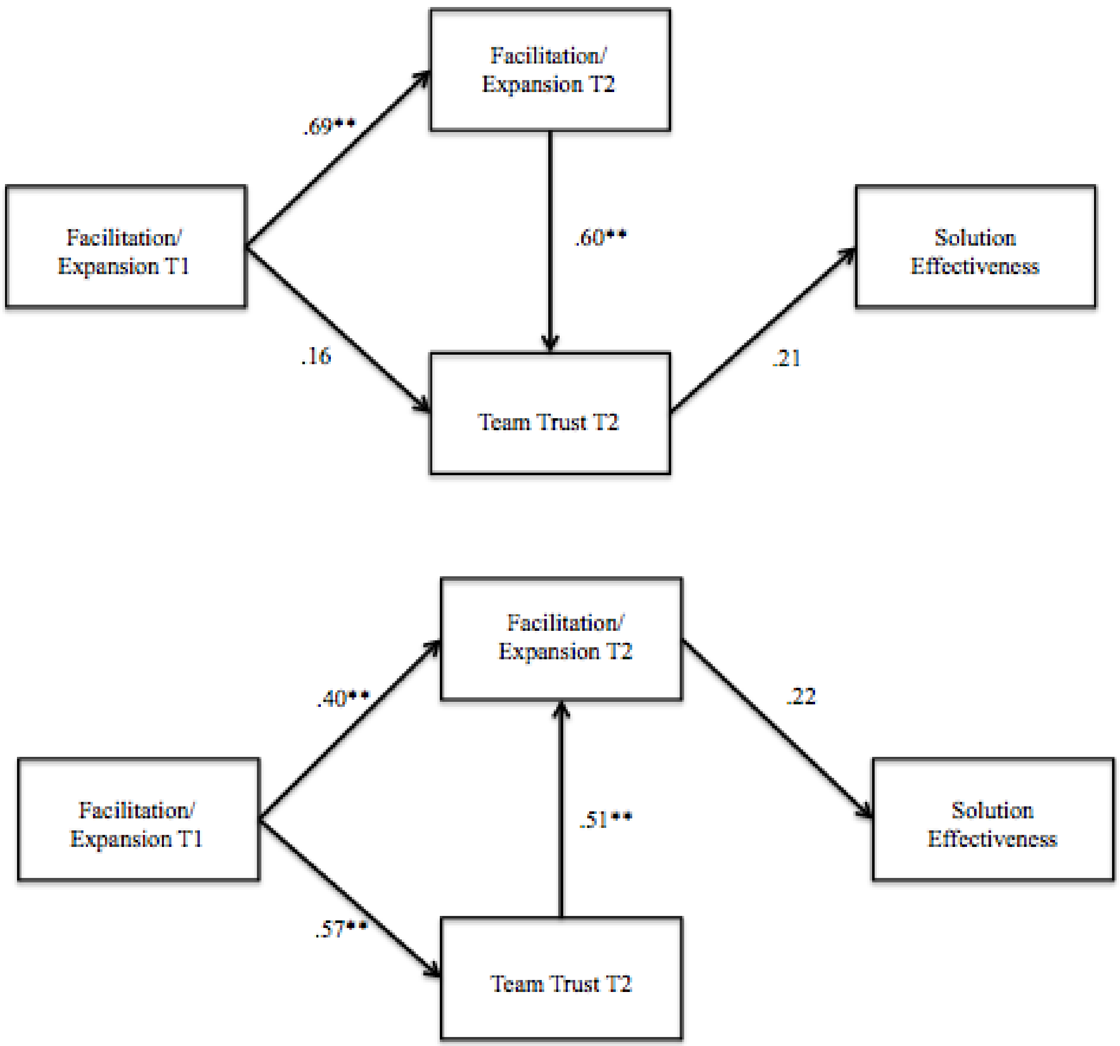
Note: * $p < .05$; ** $p < .01$. Top figure = hypothesized model ($\chi^2_{(3)} = 3.57$, ns; SRMR = .09; AIC = 419.50; CFI = .99; RMSEA = .08); bottom figure = alternative model ($\chi^2_{(3)}$ = 1.04, ns; SRMR = .03; AIC = 416.98; CFI = 1.00; RMSEA = .00).

The autoregressive analyses and the cross-lagged analysis exhibited the exact same relationships revealed in the model with solution effectiveness as the dependent variable. Analysis of the T2 relationships did not demonstrate support for mediation. Facilitation/expansion at T2 was statistically related to team identity at T2 ($\beta = .38$, $p \leq .05$), and team identity was not related to solution implementability ($\beta = .25$, ns). Thus, mediation is not supported. Therefore, Hypothesis 3c was not supported with solution implementability as the dependent variable.

The alternate model (team identity → facilitation/expansion → solution implementability) also adequately fit the data ($\chi^2_{(3)}$ = 1.04, ns; SRMR = .03; AIC = 416.98; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 9. Analysis of the T2 relationships provided support for mediation. Team identity at T2 was positively related to facilitation/expansion at T2 (β = .38, $p \leq .05$), which in turn was positively related to solution implementability (β = .36, $p \leq .05$). The bias-corrected 95% CI for the indirect effect of team identity at T2 on solution effectiveness via facilitation/expansion did not include zero (.01 - .37), providing support for the alternate model. Moreover, the alternate model demonstrated better fit (AIC = 416.98) than the hypothesized model (AIC = 419.50).

Team Trust as a Mediator. Hypothesis 3d predicted that team trust would mediate the relationship between facilitation/expansion and team performance. This hypothesis was first tested with solution effectiveness as the team performance dependent variable. The model fit the data ($\chi^2_{(2)}$ = .39, ns; SRMR = .03; AIC = 328.50; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 10.

Figure 10. Path analysis results testing team trust as a mediator between facilitation/expansion and solution effectiveness (Hypothesis 3d).



Note: * $p < .05$; ** $p < .01$. Top figure = hypothesized model ($\chi^2_{(2)}$ = .39, ns; SRMR = .03; AIC = 328.50; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(2)}$ = .15, ns; SRMR = .01; AIC = 328.26; CFI = 1.00; RMSEA = .00).

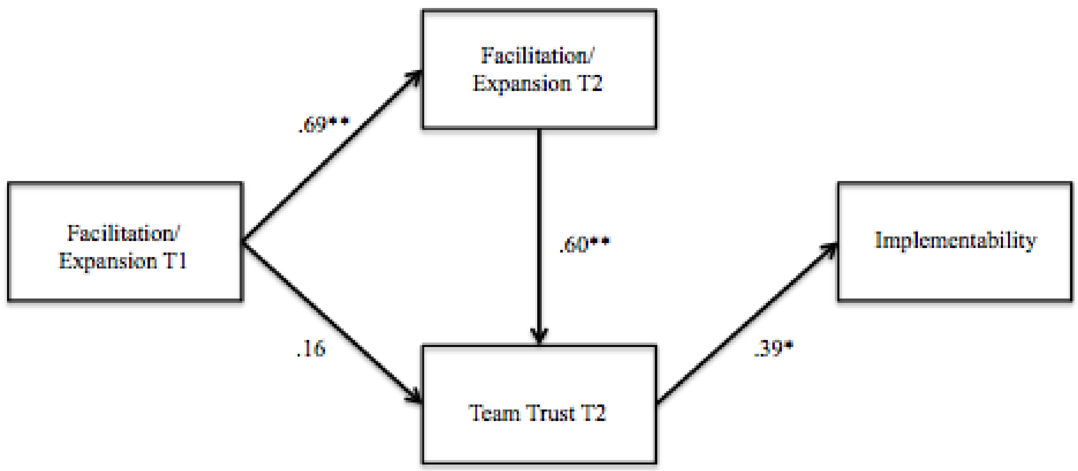
Results from the autoregressions revealed that facilitation/expansion at T1 significantly predicted facilitation/expansion at T2 ($\beta = .69$, $p \leq .01$); however, autoregressive effects for team trust could not be assessed given that the trust measure was not administered at T1. Cross-lagged analysis revealed that facilitation/expansion at

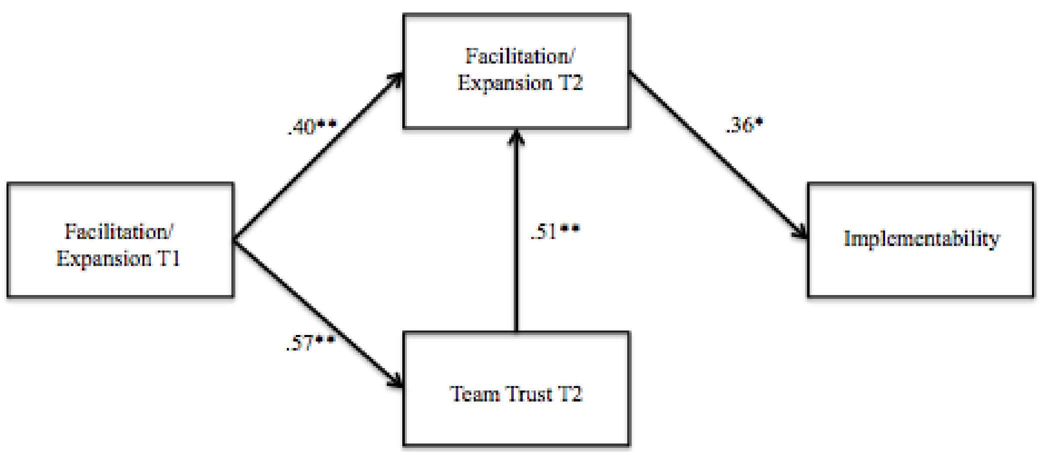
T1 did not significantly predict team trust at T2 (β = .16, ns). Given that team trust was not administered at T1, the cross-lagged analysis of team trust (T1) on facilitation/expansion (T2) could not be assessed. Analysis of the T2 relationships did not provide the necessary support for mediation. Facilitation/expansion at T2 was related to team trust at T2 (β = .60, $p \leq .01$), but team trust at T2 was not related to solution effectiveness (β = .21, ns). Thus, mediation is not supported. Therefore, Hypothesis 3d was not supported with solution effectiveness as the dependent variable.

The alternate model (team trust → facilitation/expansion → solution effectiveness) also fit the data ($\chi^2_{(2)}$ = .15, ns; SRMR = .01; AIC = 328.26; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 10. However, there was no support for mediation. Team trust at T2 was related to facilitation/expansion at T2 (β = .51, $p \leq .01$), but facilitation/expansion was not related to solution effectiveness (β = .22, ns). Therefore, mediation was not supported in the alternate model.

This hypothesis was then tested with solution implementability as the team performance dependent variable. The model fit the data ($\chi^2_{(2)}$ = .62, ns; SRMR = .03; AIC = 324.92; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 11.

Figure 11. Path analysis results testing team trust as a mediator between facilitation/expansion and solution implementability (Hypothesis 3d).





Note: * $p < .05$; ** $p < .01$. Top figure = hypothesized model ($\chi^2_{(2)} = .62$, ns; SRMR = .03; AIC = 324.92; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(2)} = 1.10$, ns; SRMR = .04; AIC = 325.40; CFI = 1.00; RMSEA = .00).

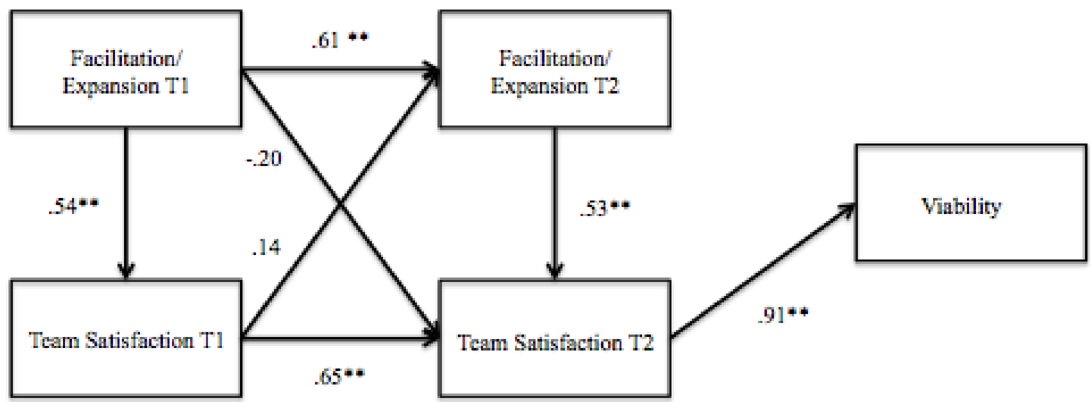
The autoregressive analyses and the cross-lagged analysis exhibited the exact same relationships revealed in the model with solution effectiveness as the dependent variable. Analysis of the T2 relationships revealed the potential for mediation. Facilitation/expansion at T2 was related to team trust at T2 ($\beta = .60$, $p \leq .01$), which was in turn related to solution implementability ($\beta = .39$, $p \leq .05$). The bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution implementability via team trust did not include zero (.04 - .51).

The alternate model also fit the data ($\chi^2_{(2)}$ = 1.10, ns; SRMR = .04; AIC = 325.40; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 11. Analysis of the T2 relationships also revealed the potential for mediation. Team trust at T2 was related to facilitation/expansion (β = .51, $p \leq .01$), which was then related to solution implementability (β = .36, $p \leq .05$). The bias-corrected 95% CI for the indirect effect of team trust at T2 on solution implementability via facilitation/expansion did not include zero (.02 - .37). Thus, these findings do not conclusively determine the direction of the causal relationship between facilitation/expansion and trust. However, it is important to note that the hypothesized model did demonstrate better fit to the data (AIC = 324.92) than the alternate model (AIC = 325.40). Therefore, Hypothesis 3d was supported with solution implementability as the dependent variable.

Hypotheses 3e – 3h: Facilitation/Expansion → Affective Emergent States → Viability

Team Satisfaction as a Mediator. Hypothesis 3e predicted that team satisfaction would mediate the relationship between facilitation/expansion and team viability. The model fit well ($\chi^2_{(3)}$ =7.75, ns; SRMR = .05; AIC = 335.14; CFI = .97; RMSEA = .22). The path model is depicted in Figure 12.

Figure 12. Path analysis results testing team satisfaction as a mediator between facilitation/expansion and team viability (Hypothesis 3e).



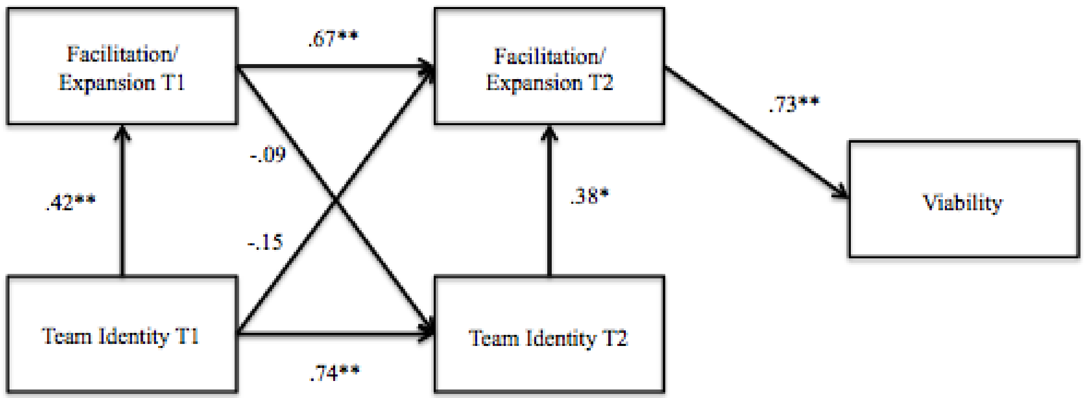
Note: * $p < .05$; ** $p < .01$. ($\chi^2_{(3)}$ =7.75, ns; SRMR = .05; AIC = 335.14; CFI = .97; RMSEA = .22). Alternative model did not exhibit acceptable fit.

As expected, the autoregressive analyses and the cross-lagged analysis exhibited the same relationships revealed in the models for Hypothesis 3a. Analysis of the T2 relationships revealed the potential for mediation. Facilitation/expansion at T2 was positively related to team satisfaction at T2 (β = .53, $p \leq .01$), which in turn was positively related to team viability (β = .91, $p \leq .01$). The bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on team viability did not include zero (.24 - .71), providing evidence that team satisfaction mediates the relationship between facilitation/expansion and team viability. The alternative model (team satisfaction → facilitation/expansion → team viability) demonstrated poor fit to the data ($\chi^2_{(3)}$ = 39.90, $p \leq .01$; SRMR = .08; AIC = 367.29; CFI = .73; RMSEA = .62), providing further support for the hypothesized model. Therefore, Hypothesis 3e was supported.

Team Cohesion as a Mediator. Hypothesis 3f predicted that team cohesion would mediate the relationship between facilitation/expansion and team viability. The model did not demonstrate adequate fit to the data ($\chi^2_{(3)}$ =17.19, $p \leq .01$; SRMR = .09; AIC = 371.42; CFI = .87; RMSEA = .38), thus removing the possibility of testing for mediation. The alternate model (team cohesion → facilitation/expansion → team viability) also did not demonstrate adequate fit to the data ($\chi^2_{(3)}$ =25.53, $p \leq .01$; SRMR = .15; AIC = 379.76; CFI = .80; RMSEA = .48). Therefore, Hypothesis 3f was not supported.

Team Identity as a Mediator. Hypothesis 3g predicted that that team identity would mediate the relationship between facilitation/expansion and team viability. The model exhibited poor fit to the data ($\chi^2_{(3)}$ = 22.27, $p \leq .01$; SRMR = .20; AIC = 413.24; CFI = .74; RMSEA = .45), thus removing the possibility of testing for mediation. However, the alternate model (team identity → facilitation/expansion → team viability) did adequately fit the data ($\chi^2_{(3)}$ = 4.62, ns; SRMR = .07; AIC = 395.59; CFI = .98; RMSEA = .13). The path model is depicted in Figure 13.

Figure 13. Path analysis results testing team identity as a mediator between facilitation/expansion and team viability (Hypothesis 3g).

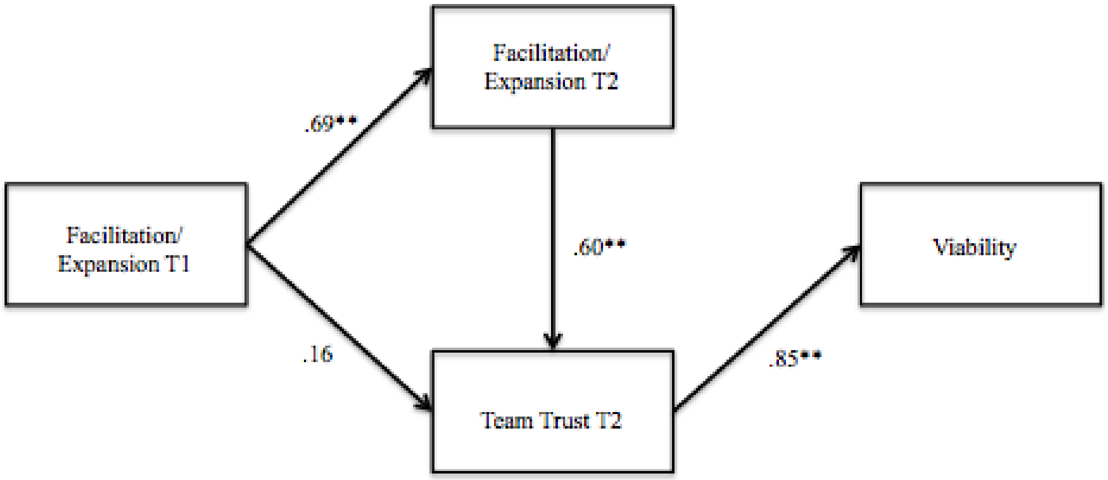


Note: * $p < .05$; ** $p < .01$. ($\chi^2_{(3)} = 4.62$, ns; SRMR = .07; AIC = 395.59; CFI = .98; RMSEA = .13). Hypothesized model did not exhibit acceptable fit.

Analysis of the T2 relationships provided support for mediation. Team identity at T2 was positively related to facilitation/expansion at T2 ($\beta = .38$, $p \leq .05$), which in turn was positively related to team viability ($\beta = .73$, p $\leq .01$). The bias-corrected 95% CI for the indirect effect of team identity at T2 on team viability via facilitation/expansion did not include zero (.05 - .52). This supports the alternate model that facilitation/expansion mediates the relationship between team identity and team viability. In addition, the alternate model demonstrated better fit to the data (AIC = 395.59) than the hypothesized model (AIC = 413.24), demonstrating further support for the alternate model. Therefore, Hypothesis 3g was not supported.

Team Trust as a Mediator. Hypothesis 3h predicted that that team trust would mediate the relationship between facilitation/expansion and team viability. The model fit the data ($\chi^2_{(2)} = 4.68$, ns; SRMR = .06; AIC = 291.56; CFI = .97; RMSEA = .21). The path model is depicted in Figure 14.

Figure 14. Path analysis results testing team trust as a mediator between facilitation/expansion and team viability (Hypothesis 3h).



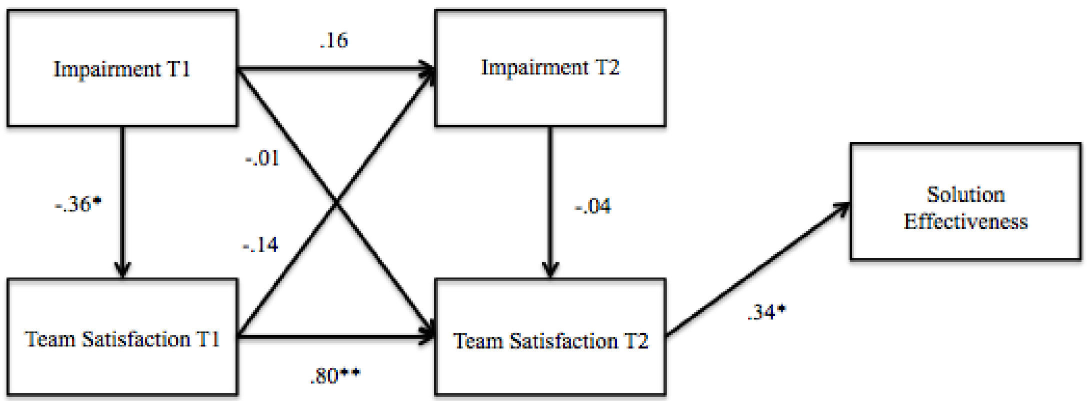
Note: * p < .05; ** p < .01. ($\chi^2_{(2)}$ = 4.68, ns; SRMR = .06; AIC = 291.56; CFI = .97; RMSEA = .21). Alternative model did not exhibit acceptable fit.

As expected, the autoregressive analyses and the cross-lagged analysis exhibited the exact same relationships revealed in the model for Hypothesis 3d. Analysis of the T2 relationships revealed the potential for mediation. Facilitation/expansion at T2 was positively related to team trust at T2 (β = .60, $p \leq$ .01), which in turn was positively related to team viability (β = .85, $p \leq$ .01). The bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on team viability did not include zero (.23 - .89). The alternate model did not fit the data ($\chi^2_{(2)}$ = 17.13, $p \leq$ .01; SRMR = .10; AIC = 304.01; CFI = .82; RMSEA = .49), demonstrating further support for the hypothesized model. Therefore, Hypothesis 3h was supported.

Hypothesis 4a - d: Impairment → Affective Emergent States → Performance

Team Satisfaction as a Mediator. Hypothesis 4a predicted that team satisfaction would mediate the relationship between process impairment and team performance. This hypothesis was first tested with solution effectiveness as the dependent variable. The model fit the data ($\chi^2_{(3)}$ = .33, ns; SRMR = .02; AIC = 430.44; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 15.

Figure 15. Path analysis results testing team satisfaction as a mediator between facilitation/expansion and solution effectiveness (Hypothesis 4a).



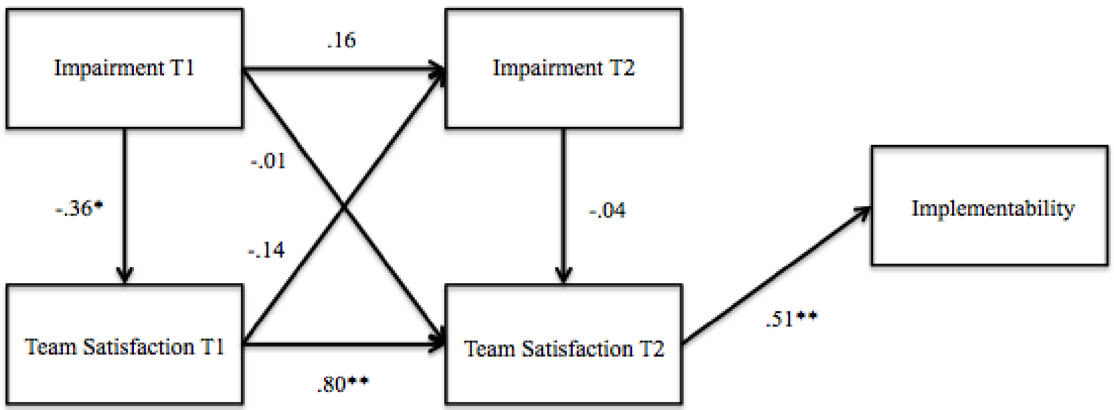
Note: * p < .05; ** p < .01. ($\chi^2_{(3)}$ = .33, ns; SRMR = .02; AIC = 430.44; CFI = 1.00; RMSEA = .00). Alternative model did not exhibit acceptable fit.

Focusing first on the autoregressions, the results indicated that impairment at T1 did not predict impairment at T2 (β = .16, ns), but team satisfaction at T1 significantly predicted team satisfaction at T2 (β = .80, $p \leq .01$). Regarding the cross-lagged relations, findings revealed that impairment at T1 is not related to team satisfaction at T2 (β = -.01, ns) and that team satisfaction at T1 is not related to impairment at T2 (β = -.14, ns). Impairment at T1 was significantly related to team satisfaction at T1 (β = -.36, $p \leq .05$). Analysis of the T2 relationships did not reveal support for mediation. Impairment at T2 was not related to team satisfaction at T2 (β = .04, ns); although, team satisfaction at T2 was related to solution effectiveness (β = .34, $p \leq .05$). The lack of significance of the a-path (impairment → team satisfaction) indicates that mediation is not supported. The alternate model (team satisfaction → impairment → solution effectiveness) did not demonstrate adequate fit to the data ($\chi^2_{(3)}$ = 4.17, ns; SRMR = .12; AIC = 432.27; CFI = .96; RMSEA

= .11). Therefore, Hypothesis 4a was not supported with solution effectiveness as the dependent variable.

This hypothesis was then tested with solution implementability as the dependent variable. The model fit the data ($\chi^2_{(3)}$ = 3.32, ns; SRMR = .07; AIC = 430.44; CFI = .99; RMSEA = .06). The path model is depicted in Figure 16.

Figure 16. Path analysis results testing team satisfaction as a mediator between facilitation/expansion and solution implementability (Hypothesis 4a).



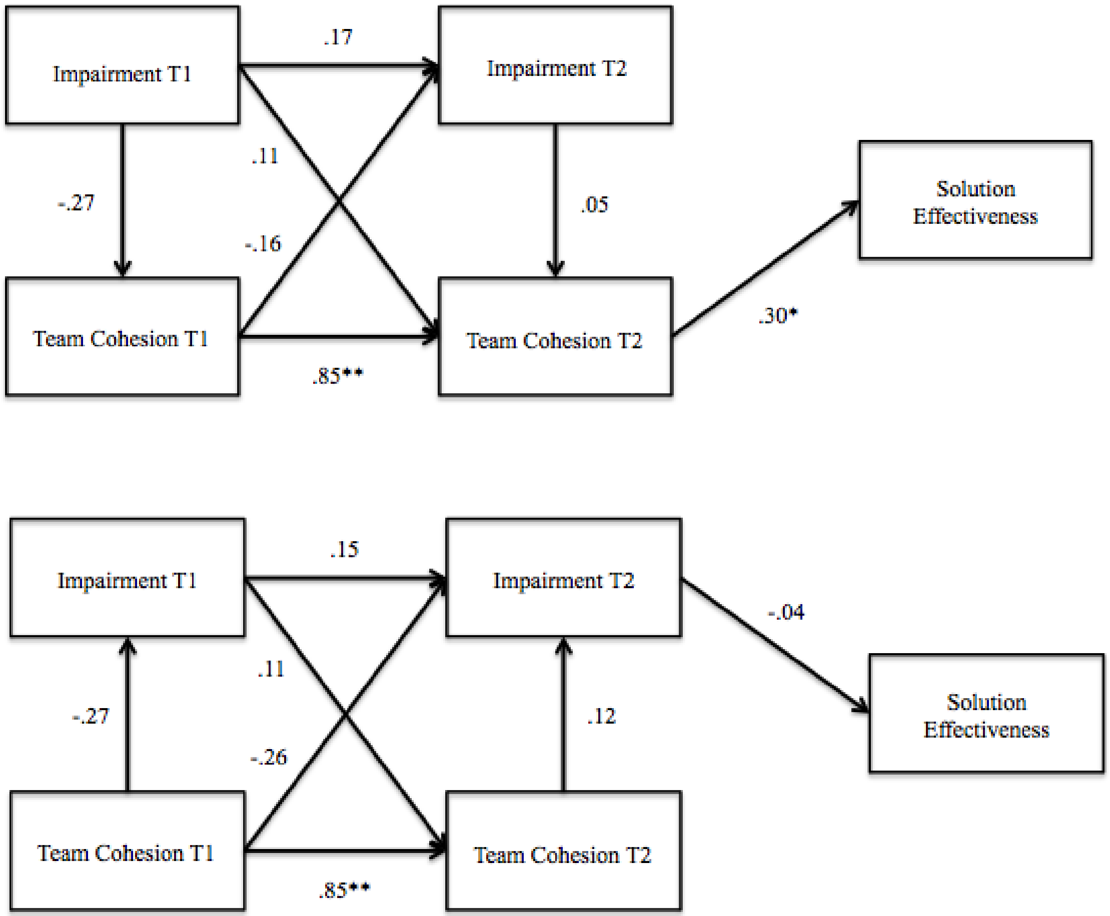
Note: * $p < .05$; ** $p < .01$. ($\chi^2_{(3)}$ = 3.32, ns; SRMR = .07; AIC = 430.44; CFI = .99; RMSEA = .06). Alternative model did not exhibit acceptable fit.

The autoregressive analyses and the cross-lagged analysis exhibited the exact same relationships revealed in the model with solution effectiveness as the dependent variable. Analysis of the T2 relationships did not demonstrate support for mediation. Impairment at T2 was not related to team satisfaction at T2 (β = -.04, ns); however, team satisfaction at T2 was related to solution implementability (β = .51, $p \leq .05$). Thus, mediation is not supported. The alternate model (team satisfaction → impairment → solution implementability) did not demonstrate adequate fit to the data ($\chi^2_{(3)}$ = 10.71, $p \leq .05$;

SRMR = .16; AIC = 432.35; CFI = .81; RMSEA = .28). Therefore, Hypothesis 4a was not supported with solution implementability as the dependent variable.

Team Cohesion as a Mediator. Hypothesis 4b predicted that team cohesion would mediate the relationship between process impairment and team performance. This hypothesis was first tested with solution effectiveness as the dependent variable. The model demonstrated adequate fit to the data ($\chi^2_{(3)}$ = .85, ns; SRMR = .04; AIC = 430.64; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 17.

Figure 17. Path analysis results testing team cohesion as a mediator between facilitation/expansion and solution effectiveness (Hypothesis 4b).



Note: * $p < .05$; ** $p < .01$. Top figure = hypothesized model ($\chi^2_{(3)} = .85$, ns; SRMR = .04; AIC = 430.64; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(3)} = 3.73$, ns; SRMR = .10; AIC = 433.61; CFI = .98; RMSEA = .09).

Analysis of the autoregressions revealed that impairment at T1 did not predict impairment at T2 ($\beta = .17$, ns); however, team cohesion at T1 was predictive of team cohesion at T2 ($\beta = .85$, $p \leq .01$). The cross-lagged relationships were not significant. Impairment at T1 did not predict team cohesion at T2 ($\beta = .11$, ns), and team cohesion at T1 did not predict impairment at T2 ($\beta = -.16$, ns). Analysis of the T2 relationships did not revealed support for mediation. Impairment at T2 was not related to team cohesion at

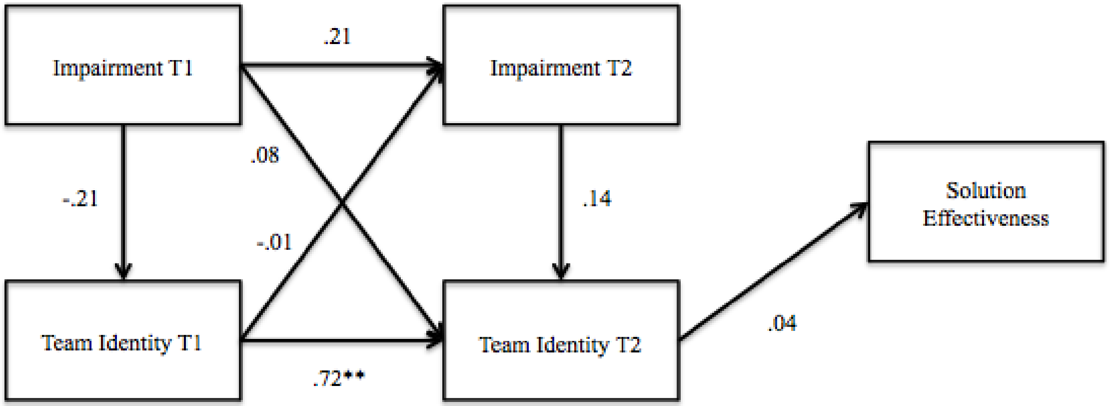
T2 (β = .05, ns); although, team cohesion was related to solution effectiveness (β = .30, $p \leq .05$). Therefore, Hypothesis 4b was not supported with solution effectiveness as the dependent variable.

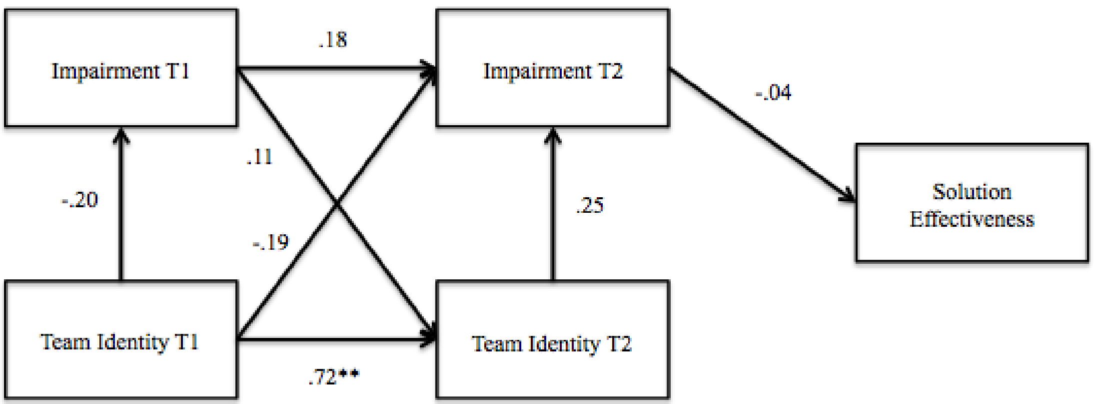
The alternate model (team cohesion → impairment → solution effectiveness) demonstrated acceptable fit to the data ($\chi^2_{(3)}$ = 3.73, ns; SRMR = .10; AIC = 433.61; CFI = .98; RMSEA = .09). The path model is depicted in Figure 17. Analysis of the path coefficients did not reveal support for mediation. Team cohesion at T2 was not related to impairment at T2 (β = .12, ns), and team cohesion was not related to solution effectiveness (β = -.04, ns).

This hypothesis was then tested with solution implementability as the dependent variable. The model did not adequately fit the data ($\chi^2_{(3)}$ = 9.29, $p \leq .01$; SRMR = .08; AIC = 421.63; CFI = .88; RMSEA = .26), thus removing the possibility of examining mediation effects. Therefore, Hypothesis 4b was not supported with solution implementability as the dependent variable. The alternate model (team cohesion → impairment → solution implementability) did not fit the data ($\chi^2_{(3)}$ = 19.35, $p \leq .01$; SRMR = .17; AIC = 431.70; CFI = .68; RMSEA = .41).

Team Identity as a Mediator. Hypothesis 4c predicted that team identity would mediate the relationship between process impairment and team performance. The hypothesis was first tested with solution effectiveness as the dependent variable. The model fit the data ($\chi^2_{(3)}$ = 2.29, ns; SRMR = .05; AIC = 447.05; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 18.

Figure 18. Path analysis results testing team identity as a mediator between facilitation/expansion and solution effectiveness (Hypothesis 4c).





Note: * $p < .05$; ** $p < .01$. Top figure = hypothesized model ($\chi^2_{(3)}$ = 2.29, ns; SRMR = .05; AIC = 447.05; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(3)}$ = 2.29, ns; SRMR = .05; AIC = 447.05; CFI = 1.00; RMSEA = .00).

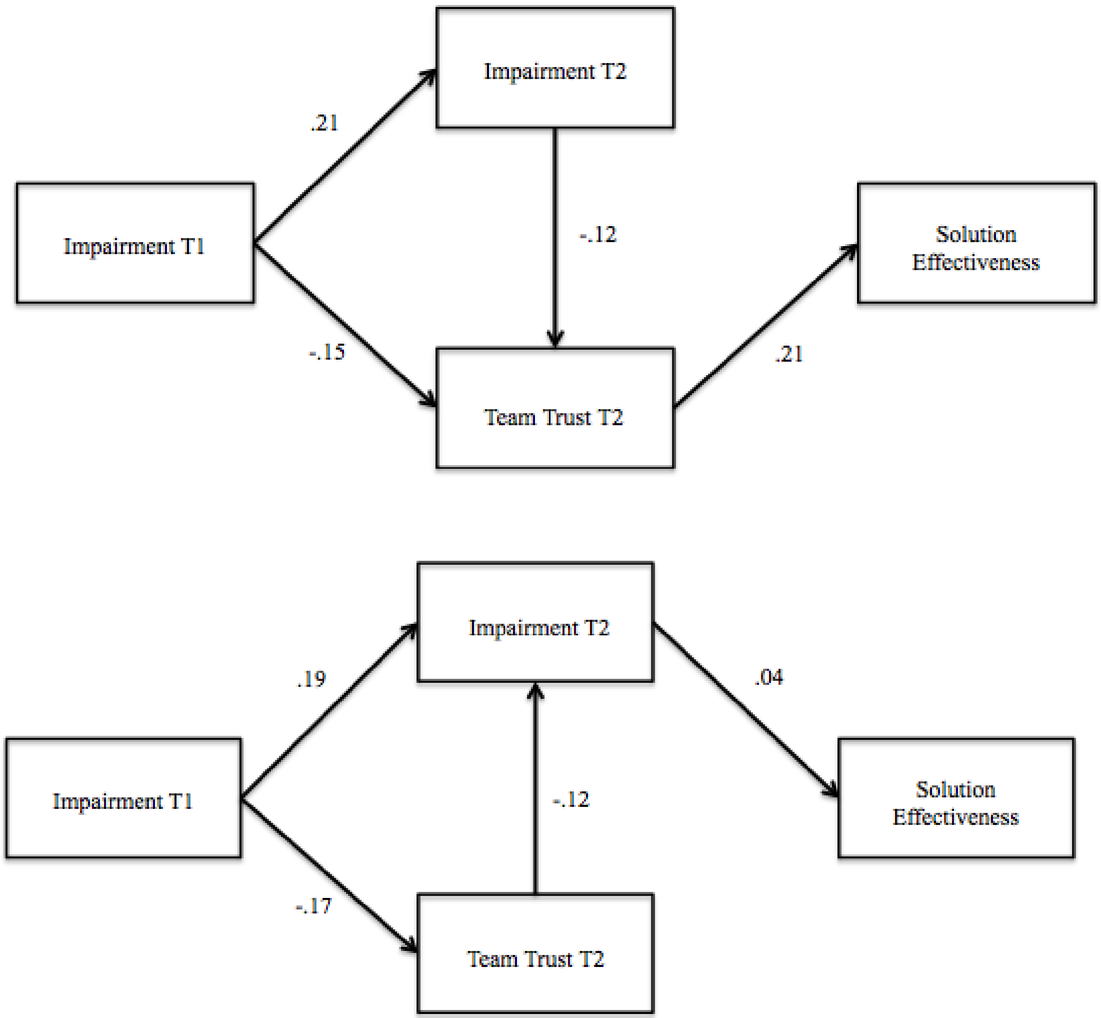
Focusing first on the autoregressions, the results indicated that impairment at T1 did not predict impairment at T2 (β = .21, ns), but team identity at T1 significantly predicted team identity at T2 (β = .72, $p \leq .01$). Regarding the cross-lagged relations, findings revealed that impairment at T1 is not related to team identity at T2 (β = .08, ns) and that team identity at T1 is not related to impairment at T2 (β = -.01, ns). Moreover, impairment at T1 was not related to identity at T1 (β = -.21, ns). Analysis of the T2 relationships does not reveal the potential for mediation. Impairment at T2 was not significantly related to team identity (β = .14, ns), and team identity was not related to solution effectiveness (β = .04, ns). Thus, Hypothesis 4c was not supported with solution effectiveness as the dependent variable. The alternate model also demonstrated adequate fit to the data ($\chi^2_{(3)}$ = 2.29, ns; SRMR = .05; AIC = 447.05; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 18. However, analysis of the T2 relationships did not demonstrate evidence of mediation. Team identity was not related to impairment (β = .25, ns), and impairment was not related to solution effectiveness (β = -.04, ns).

This hypothesis was then tested with solution implementability as the dependent variable. The model did not demonstrate adequate fit to the data ($\chi^2_{(3)}$ = 5.82, ns; SRMR = .11; AIC = 445.12; CFI = .88; RMSEA = .17). Thus, Hypothesis 4c was not supported with solution implementability as the dependent variable. The alternate model (team identity → impairment → solution implementability) did not demonstrate acceptable fit ($\chi^2_{(3)}$ = 5.83, ns; SRMR = .10; AIC = 445.13; CFI = .88; RMSEA = .17).

Team Trust as a Mediator. Hypothesis 4d predicted that team trust would mediate the relationship between process impairment and team performance. This hypothesis was first tested with solution effectiveness as the dependent variable. The model fit the data ($\chi^2_{(2)}$ = .64, ns; SRMR = .04; AIC = 368.83; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 19. Focusing first on the autoregressions, the results indicated that impairment at T1 did not predict impairment at T2 (β = .21, ns). Autoregressive effects for team trust could not be assessed given that the trust measure was not administered at T1. Cross-lagged analysis revealed that impairment at T1 did not significantly predict team trust at T2 (β = -.15, ns). Given that team trust was not administered at T1, the cross-lagged analysis of team trust (T1) on facilitation/expansion (T2) could not be assessed. Analysis of the T2 relationships did not provide the necessary support for mediation. Impairment at T2 was not related to team trust at T2 (β = -.12, ns), and team trust was not related to solution effectiveness (β = .21, ns). Thus, Hypothesis 4d was not supported with solution effectiveness as the dependent variable.

The alternate model (team trust → impairment → solution effectiveness) demonstrated adequate fit to the data ($\chi^2_{(2)}$ = 1.99, ns; SRMR = .08; AIC = 370.18; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 19.

Figure 19. Path analysis results testing team trust as a mediator between impairment and solution effectiveness (Hypothesis 4d).



Note: * $p < .05$; ** $p < .01$. Top figure = hypothesized model ($\chi^2_{(2)} = .64$, ns; SRMR = .04; AIC = 368.83; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(2)} = 1.99$, ns; SRMR = .08; AIC = 370.18; CFI = 1.00; RMSEA = .00).

However, analysis of the T2 relationships did not reveal support for mediation. Team trust at T2 was not related to impairment at T2 ($\beta = -.12$, ns), and team trust was not related to solution effectiveness ($\beta = .04$, ns).

This hypothesis was then tested with solution implementability as the dependent variable. The model did not demonstrate adequate fit to the data ($\chi^2_{(2)}$ = 3.24, ns; SRMR = .10; AIC = 365.25; CFI = .76; RMSEA = .14). The alternate model did not fit the data ($\chi^2_{(2)}$ = 6.26, $p \leq .05$; SRMR = .14; AIC = 368.26; CFI = .17; RMSEA = .26). Thus, Hypothesis 4d was not supported with solution implementability as the dependent variable.

Hypothesis 4e - h: Impairment → Affective Emergent States → Viability

Team Satisfaction as a Mediator. Hypothesis 4e predicted that team satisfaction would mediate the relationship between impairment and team viability. The model did not fit the data ($\chi^2_{(3)}$ = 15.17, $p \leq .01$; SRMR = .07; AIC = 376.29; CFI = .88; RMSEA = .36). Moreover, the alternate model did not fit the data ($\chi^2_{(3)}$ = 68.57, $p \leq .01$; SRMR = .30; AIC = 429.69; CFI = .35; RMSEA = .83). Therefore, Hypothesis 4e was not supported.

Team Cohesion as a Mediator. Hypothesis 4f predicted that team cohesion would mediate the relationship between impairment and team viability. The model did not demonstrate acceptable fit to the data ($\chi^2_{(3)}$ = 13.83, $p \leq .01$; SRMR = .10; AIC = 399.44; CFI = .86; RMSEA = .34). The alternate model (team cohesion → impairment → team viability) did not fit the data ($\chi^2_{(3)}$ = 43.42, $p \leq .01$; SRMR = .28; AIC = 429.03; CFI = .47; RMSEA = .65). Therefore, Hypothesis 4f was not supported.

Team Identity as a Mediator. Hypothesis 4g predicted that team identity would mediate the relationship between impairment and team viability. The model did not fit the data ($\chi^2_{(3)}$ = 11.63, $p \leq .01$; SRMR = .14; AIC = 438.87; CFI = .75; RMSEA = .30). The alternate model (team identity → impairment → team viability) did not fit the data ($\chi^2_{(3)}$ =

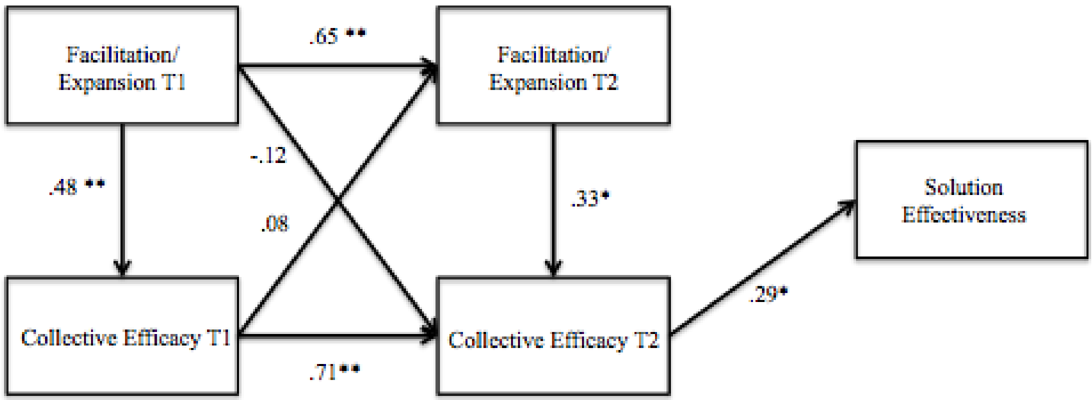
15.24, $p \leq .01$; SRMR = .19; AIC = 442.47; CFI = .65; RMSEA = .36). Thus, Hypothesis 4g was not supported.

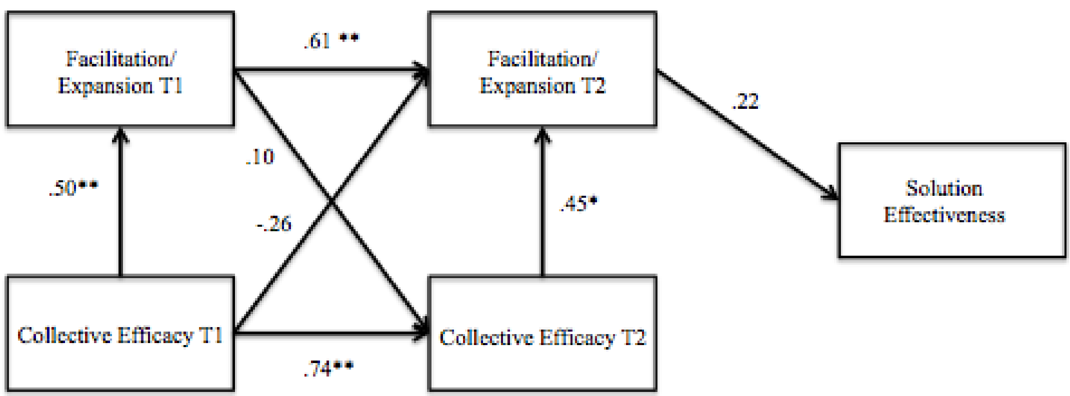
Team Trust as a Mediator. Hypothesis 4h predicted the team trust would mediate the relationship between impairment and team viability. The model did not fit the data ($\chi^2_{(2)} = 9.63$; $p \leq .01$; SRMR = .10; AIC = 331.89; CFI = .83; RMSEA = .35). Thus, hypothesis 4d was not supported. The alternate model did not fit the data ($\chi^2_{(2)} = 43.33$, $p \leq .01$; SRMR = .26; AIC = 365.60; CFI = .07; RMSEA = .80). Thus, Hypothesis 4h was not supported.

Hypothesis 5a- b: Facilitation/Expansion → Motivational Emergent States → Performance

Collective Efficacy as a Mediator. Hypothesis 5a predicted that collective efficacy would mediate the relationship between facilitation/expansion and team performance. This hypothesis was first tested with solution effectiveness as the dependent variable. The model demonstrated acceptable fit to the data ($\chi^2_{(3)} = 1.09$, ns; SRMR = .03; AIC = 407.35; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 20.

Figure 20. Path analysis results testing collective efficacy as a mediator between facilitation/expansion and solution effectiveness (Hypothesis 5a).





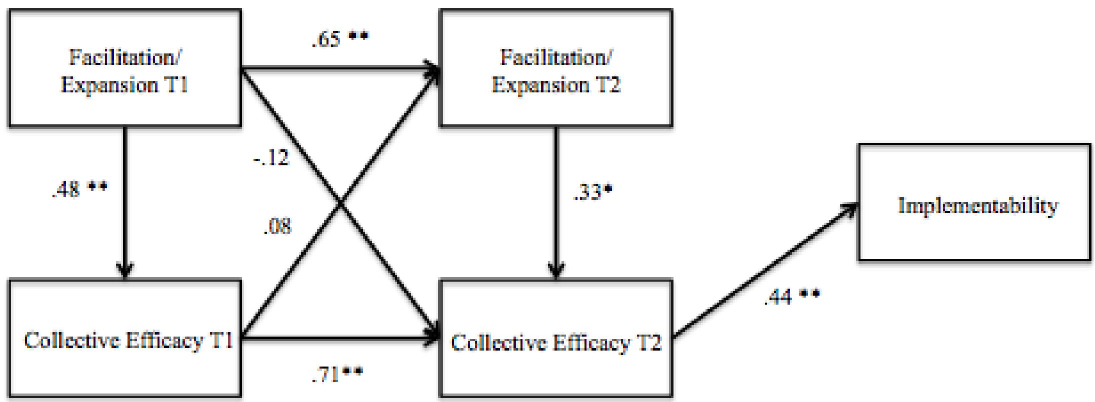
Note: * $p < .05$; ** $p < .01$. Top figure = hypothesized model ($\chi^2_{(3)} = 1.09$, ns; SRMR = .03; AIC = 407.35; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(3)} = 2.25$, ns; SRMR = .07; AIC = 408.52; CFI = 1.00; RMSEA = .00).

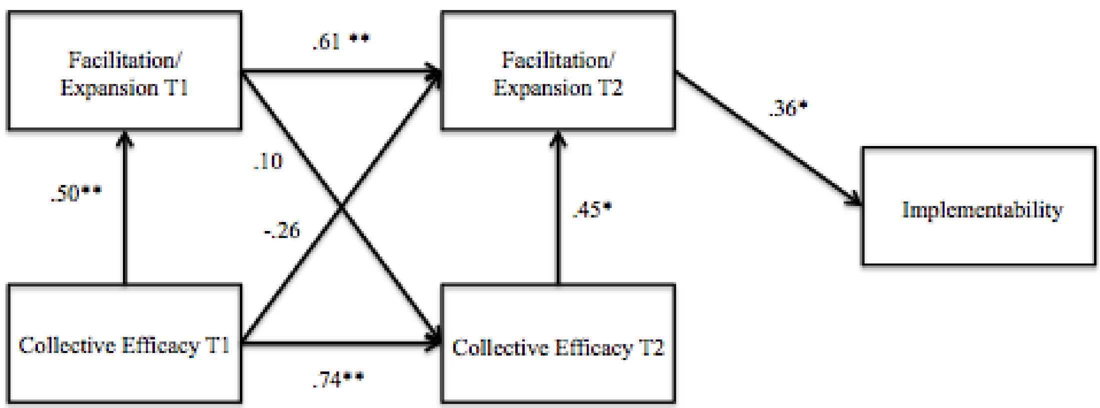
Focusing first on the autoregressions, the results indicated that facilitation/expansion at T1 significantly predicted facilitation/expansion at T2 ($\beta = .65$, $p \leq .01$), and collective efficacy at T1 significantly predicted collective efficacy at T2 ($\beta = .71$, $p \leq .01$). Regarding the cross-lagged relations, findings revealed that facilitation/expansion at T1 is not related to collective efficacy at T2 ($\beta = -.12$, ns), and that collective efficacy at T1 is not related to facilitation/expansion at T2 ($\beta = .08$, ns). Facilitation/Expansion at T1 predicted collective efficacy at T1 (β = .48, $p \leq .01$). Analysis of the T2 relationships revealed support for mediation. Facilitation/expansion at T2 was related to collective efficacy at T2 (β = .33, $p \leq .05$), and collective efficacy was related to solution effectiveness (β = .29, $p \leq .05$). The bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution effectiveness did not include zero (.01 - .27), providing evidence that collective efficacy mediates the relationship between facilitation/expansion and solution effectiveness.

The alternate model (collective efficacy → facilitation/expansion → solution effectiveness) demonstrated acceptable fit to the data ($\chi^2_{(3)}$ = 2.25, ns; SRMR = .07; AIC = 408.52; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 20. Analysis of the path coefficients at T2 revealed that collective efficacy at T2 was related to facilitation/expansion at T2 (β = .45, $p \leq .05$), but that facilitation/expansion at T2 was not related to solution effectiveness (β = .22, ns). Thus, mediation was not supported in the alternate model. Thus, Hypothesis 5a was supported with solution effectiveness as the dependent variable.

This hypothesis was then tested with solution implementability as the dependent variable. The model demonstrated adequate fit to the data ($\chi^2_{(3)}$ = .95, ns; SRMR = .04; AIC = 403.28; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 21.

Figure 21. Path analysis results testing collective efficacy as a mediator between facilitation/expansion and solution implementability (Hypothesis 5a).





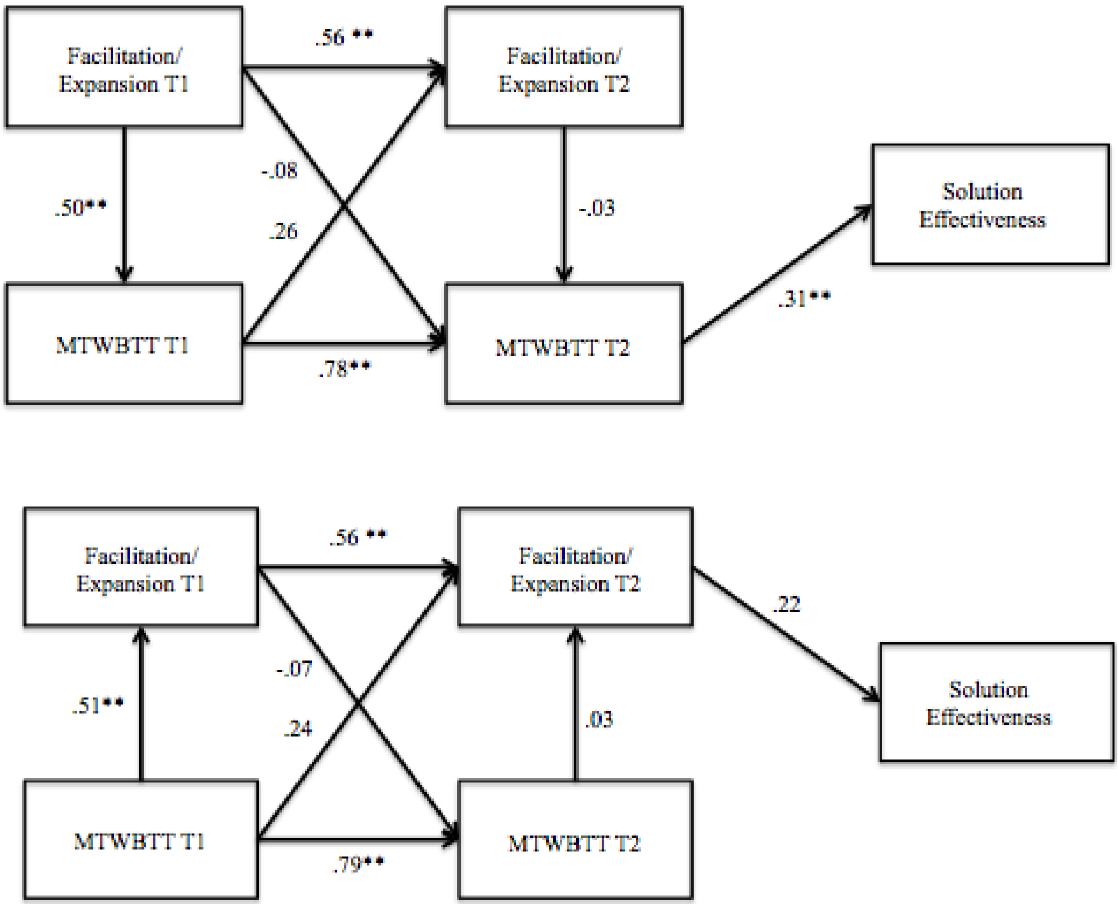
Note: * $p < .05$; ** $p < .01$. Top figure = hypothesized model ($\chi^2_{(3)} = .95$, ns; SRMR = .04; AIC = 403.28; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(3)} = 3.32$, ns; SRMR = .08; AIC = 405.65; CFI = 1.00; RMSEA = .06).

The autoregressive analyses and the cross-lagged analysis exhibited the exact same relationships revealed in the model with solution implementability as the dependent variable. Analysis of the T2 relationships revealed the potential for mediation. Facilitation/expansion at T2 was positively related to collective efficacy at T2 ($\beta = .33$, $p \leq .05$), which in turn was positively related to solution implementability ($\beta = .44$, $p \leq .01$). The bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution implementability did not include zero (.03 - .40), providing evidence that collective efficacy mediates the relationship between facilitation/expansion and solution implementability.

The alternate model (collective efficacy → facilitation/expansion → solution implementability) fit the data ($\chi^2_{(3)}$ = 3.32, ns; SRMR = .08; AIC = 405.65; CFI = 1.00; RMSEA = .06). The path model is depicted in Figure 21. Analysis of the T2 paths revealed potential for mediation. Collective efficacy at T2 was related to facilitation/expansion at T2 (β = .45, $p \leq .05$), and facilitation/expansion at T2 was related to solution implementability (β = .36, $p \leq .05$). However, the bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution implementability did include zero (.00 - .41), thus indicating that mediation is not present in the alternate model. Thus, Hypothesis 5a was supported with solution implementability as the dependent variable.

Motivation to Work on Behalf of the Team as a Mediator. Hypothesis 5b predicted that motivation to work on behalf of the team would mediate the relationship between facilitation/expansion and team performance. This hypothesis was first tested with solution effectiveness as the dependent variable. The model fit the data ($\chi^2_{(3)}$ = 2.88, ns; SRMR = .06; AIC = 412.91; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 22.

Figure 22. Path analysis results testing motivation to work on behalf of the team as a mediator between facilitation/expansion and solution effectiveness (Hypothesis 5b).



Note: * p < .05; ** p < .01. MTWBTT = Motivation To Work On Behalf of The Team. Top figure = hypothesized model ($\chi^2_{(3)}$ = 2.88, ns; SRMR = .06; AIC = 412.91; CFI = 1.00; RMSEA = .00); bottom figure = alternative model ($\chi^2_{(3)}$ = 4.44, ns; SRMR = .09; AIC = 414.47; CFI = .97; RMSEA = .12).

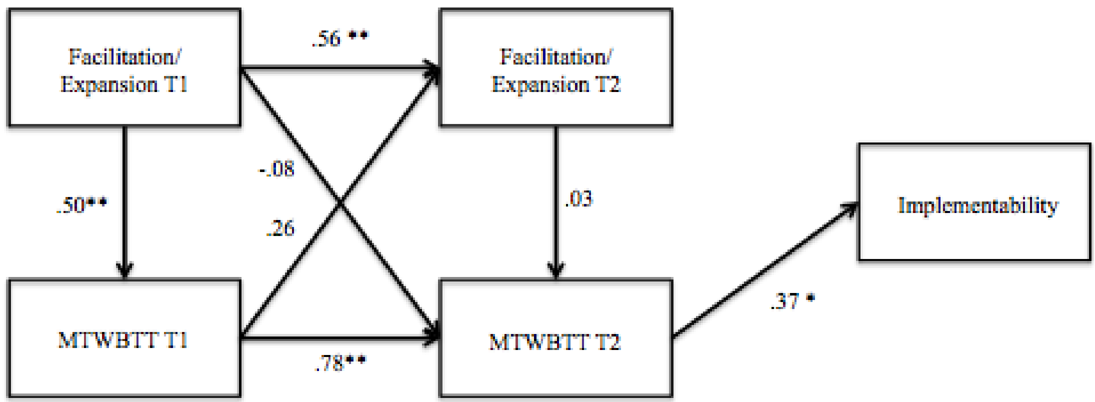
Analysis of the autoregressions revealed that facilitation/expansion at T1 predicted facilitation/expansion at T2 (β = .56, $p \leq .01$), and that motivation to work on behalf of the team at T1 predicted motivation to work on behalf of the team at T2 (β = .78, $p \leq .01$). Regarding the cross-lagged relations, findings revealed that facilitation/expansion at T1 is not related to motivation to work on behalf of the team at T2 (β = -.08, ns), and that motivation to work on behalf of the team at T1 is not related to facilitation/expansion at

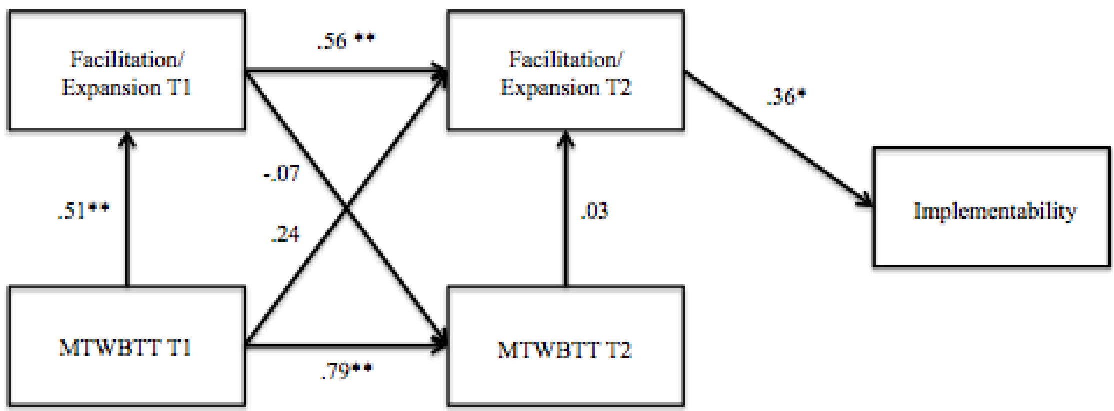
T2 (β = .26, ns). Facilitation/expansion at T1 is related to motivation to work on behalf of the team at T2 (β = .50, $p \leq .01$). Analysis of the T2 relationships did not reveal support for mediation. Facilitation/expansion at T2 was not related to motivation to work on behalf of the team at T2 (β = .03, ns), although motivation to work on behalf of the work at T2 was related to solution effectiveness (β = .31, $p \leq .01$). Therefore, Hypothesis 5b was not supported with solution effectiveness as the dependent variable.

The alternate model (motivation to work on behalf of the team → facilitation/expansion → solution effectiveness) demonstrated adequate fit to the data ($\chi^2_{(3)}$ = 4.44, ns; SRMR = .09; AIC = 414.47; CFI = .97; RMSEA = .12). The path model is depicted in Figure 22. However, analysis of the path relationships did not reveal support for mediation. Motivation to work on behalf of the team at T2 was not related to facilitation/expansion at T2 (β = .03, ns), and facilitation/expansion at T2 was not related to solution effectiveness (β = .22, ns).

This hypothesis was then tested with solution implementability as the dependent variable. The model demonstrated acceptable fit to the data ($\chi^2_{(3)}$ = 3.19, ns; SRMR = .08; AIC = 411.40; CFI = 1.00; RMSEA = .05). The path model is depicted in Figure 23.

Figure 23. Path analysis results testing motivation to work on behalf of the teams as a mediator between facilitation/expansion and solution implementability (Hypothesis 5b).





Note: * $p < .05$; ** $p < .01$. MTWBTT = Motivation To Work On Behalf of The Team. Top figure = hypothesized model ($\chi^2_{(3)} = 3.19$, ns; SRMR = .08; AIC = 411.40; CFI = 1.00; RMSEA = .05); bottom figure = alternative model ($\chi^2_{(3)} = 3.40$, ns; SRMR = .09; AIC = 411.60; CFI = .99; RMSEA = .06).

The autoregressive analyses and the cross-lagged analysis exhibited the exact same relationships revealed in the model with solution effectiveness as the dependent variable. Analysis of the T2 path coefficients did not reveal the presence of mediation. Facilitation/expansion at T2 was not related to motivation to work on behalf of the team at T2 ($\beta = .03$, ns); although, motivation to work on behalf of the team at T2 was related to solution implementability (β = .37, $p \leq .05$). Thus, Hypothesis 5b was not supported with solution implementability as the dependent variable.

The alternate model (motivation to work on behalf of the team → facilitation/expansion → solution implementability) demonstrated acceptable fit to the data ($\chi^2_{(3)}$ = 3.40, ns; SRMR = .09; AIC = 411.60; CFI = .99; RMSEA = .06). The path model is depicted in Figure 23. However, analysis of the path coefficients did not reveal the presence of mediation. Motivation to work on behalf of the team at T2 was note related to facilitation/expansion at T2 (β = .03, ns); although facilitation/expansion at T2 was related to solution implementability (β = .36, $p \leq .05$).

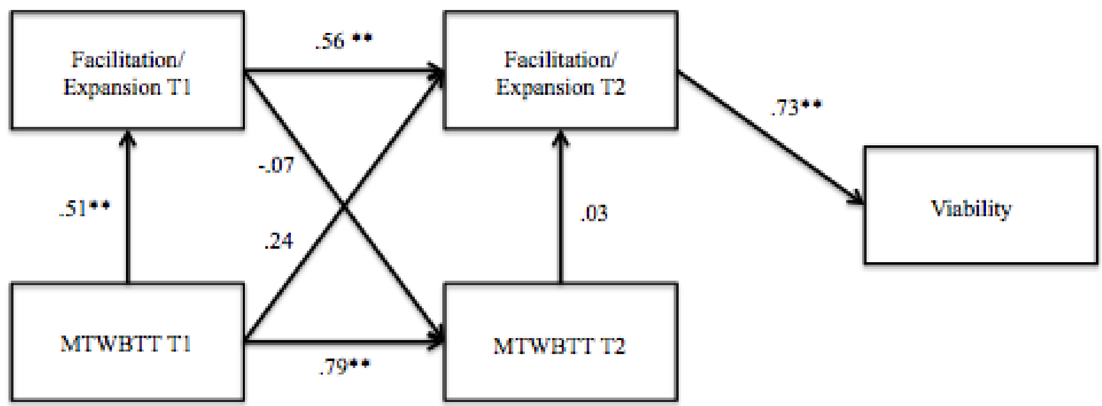
Hypothesis 5c – d: Facilitation/Expansion → Motivational Emergent States → Viability

Collective Efficacy as a Mediator. Hypothesis 5c predicted that collective efficacy would mediate the relationship between facilitation/expansion and team viability. The model did not fit the data ($\chi^2_{(3)}$ = 18.42, $p \leq .01$; SRMR = .10; AIC = 369.205; CFI = .86; RMSEA = .40). The alternate model (collective efficacy → facilitation/expansion → team viability) did not fit the data ($\chi^2_{(3)}$ = 33.49, $p \leq .01$; SRMR = .16; AIC = 384.27; CFI = .73; RMSEA = .56). Thus, Hypothesis 5c was supported.

Motivation to Work on Behalf of the Team as a Mediator. Hypothesis 5d predicted that motivation to work on behalf of the team would mediate the relationship between facilitation/expansion and team viability. The model did not fit the data ($\chi^2_{(3)}$ = 21.66, $p \leq .01$; SRMR = .19; AIC = 406.60; CFI = .77; RMSEA = .44). Thus, Hypothesis 6b was not supported. The alternate model (motivation to work on behalf of the team →

facilitation/expansion → team viability) did fit the data ($\chi^2_{(3)}$ = 5.28, ns; SRMR = .08; AIC = 390.22; CFI = .97; RMSEA = .15). The path model is depicted in Figure 24.

Figure 24. Path analysis results testing motivation to work on behalf of the teams as a mediator between facilitation/expansion and team viability (Hypothesis 5d).



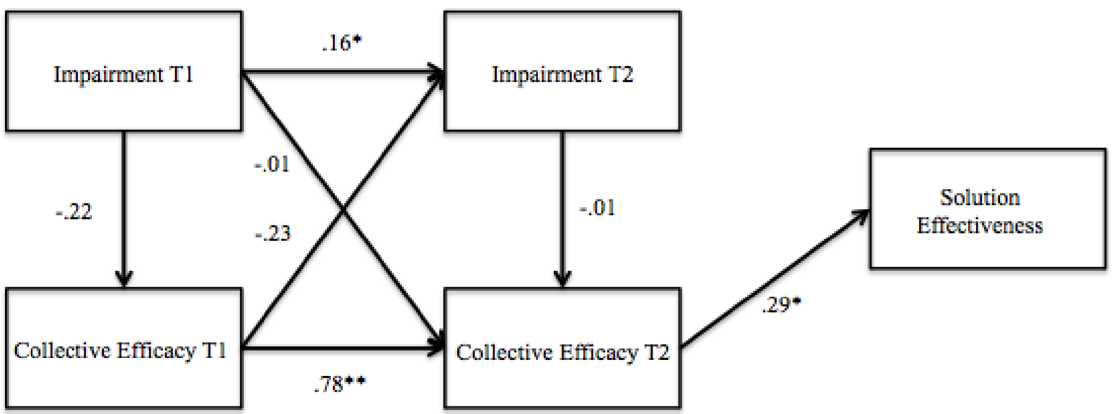
Note: * p < .05; ** p < .01. MTWBTT = Motivation To Work On Behalf of The Team. ($\chi^2_{(3)}$ = 5.28, ns; SRMR = .08; AIC = 390.22; CFI = .97; RMSEA = .15). Hypothesized model did not fit the data.

Focusing first on the autoregressions, the results indicated that facilitation/expansion at T1 significantly predicted facilitation/expansion at T2 (β = .56, $p \leq$ .01), and motivation to work on behalf of the team at T1 significantly predicted motivation to work on behalf of the team at T2 (β = .79, $p \leq$ .01). Regarding the cross-lagged relations, findings revealed that facilitation/expansion at T1 is not related to motivation to work on behalf of the team at T2 (β = -.07, ns), and that motivation to work on behalf of the team at T1 is not related to facilitation/expansion at T2 (β = .24, ns). Motivation to work on behalf of the team at T1 is related to facilitation/expansion at T1 (β = .51, $p \leq$ .01). Analysis of the T2 paths did not reveal support for mediation. Motivation to work on behalf of the team at T2 was not related to facilitation/expansion at T2 (β = .03, ns); although facilitation/expansion at T2 was related to team viability (β = .73, $p \leq$ .01). Thus, Hypothesis 5d was not supported.

Hypothesis 6a - b: Impairment → Motivational Emergent States → Performance

Collective Efficacy as a Mediator. Hypothesis 6a predicted that collective efficacy would mediate the relationship between impairment and team performance. This hypothesis was first tested with solution effectiveness as the dependent variable. The model fit the data ($\chi^2_{(3)}$ = 1.12, ns; SRMR = .04; AIC = 435.57; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 25.

Figure 25. Path analysis results testing collective efficacy as a mediator between impairment and solution effectiveness (Hypothesis 6a).

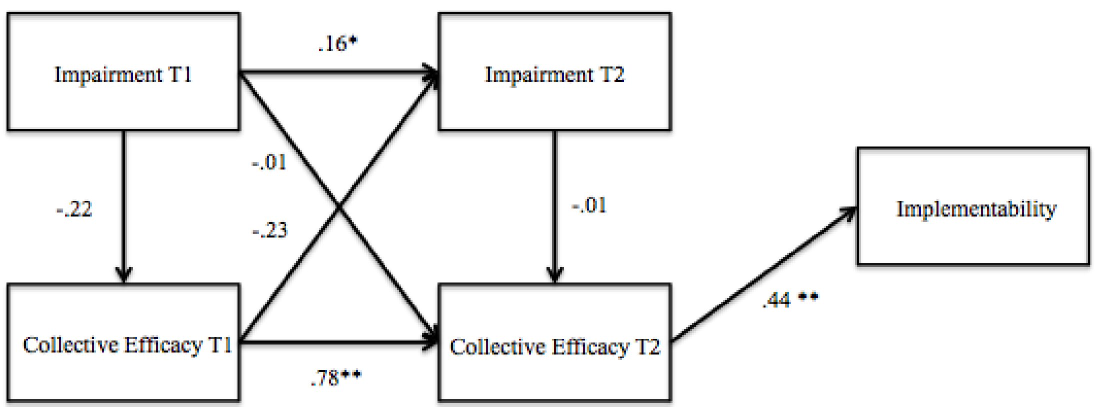


Note: * p < .05; ** p < .01. ($\chi^2_{(3)}$ = 1.12, ns; SRMR = .04; AIC = 435.57; CFI = 1.00; RMSEA = .00). Alternative model did not fit the data.

Analysis of the autoregressions revealed that impairment at T1 does not predict impairment at T2 (β = .16, ns); however, collective efficacy at T1 does predict collective efficacy at T2 (β = .78, $p \leq .01$). Analysis of the cross-lagged relations demonstrated that impairment at T1 is not related to collective efficacy at T2 (β = -.01, ns), and that collective efficacy at T1 is not related to impairment at T2 (β = -.23, ns). Additionally, impairment at T1 was not related to collective efficacy at T1 (β = -.22, ns). Impairment at T2 was related to collective efficacy T2 (β = -.22, ns). Analysis of the T2 path coefficients does not indicate the presence of mediation. Impairment at T2 is not related to collective efficacy at T2 (β = -.01, ns); although, collective efficacy is related to solution effectiveness (β = .29, $p \leq .05$). Therefore, Hypothesis 6a was not supported with collective efficacy as the dependent variable. The alternate model (collective efficacy → impairment → solution effectiveness) did not demonstrate acceptable fit to the data ($\chi^2_{(3)}$ = 3.87, ns; SRMR = .11; AIC = 407.35; CFI = .97; RMSEA = .10).

This hypothesis was then tested with solution implementability as the dependent variable. The model demonstrated acceptable fit to the data ($\chi^2_{(3)}$ = 2.97, ns; SRMR = .07; AIC = 431.50; CFI = 1.00; RMSEA = .00). The path model is depicted in Figure 26.

Figure 26. Path analysis results testing collective efficacy as a mediator between impairment and solution implementability (Hypothesis 6a).

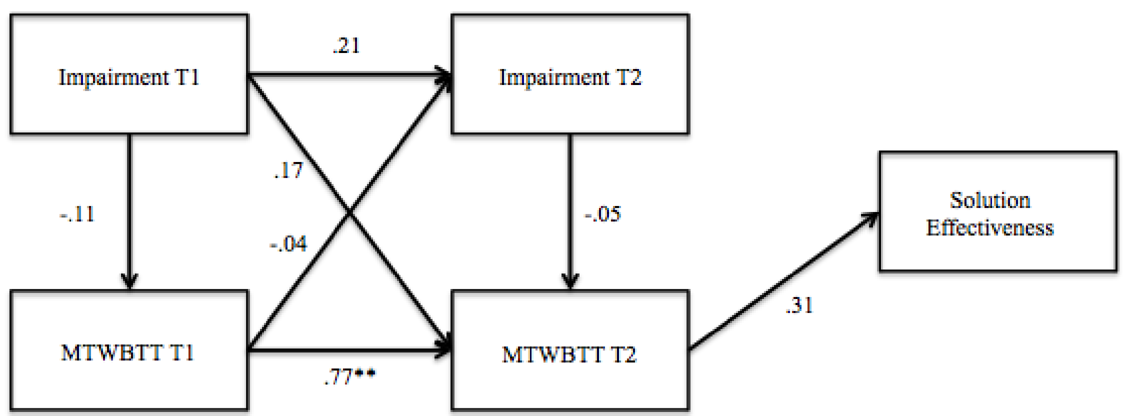


Note: * $p < .05$; ** $p < .01$. ($\chi^2_{(3)}$ = 2.97, ns; SRMR = .07; AIC = 431.50; CFI = 1.00; RMSEA = .00). Alternative model did not fit the data.

The autoregressions and cross-lagged analysis revealed the same pattern of relationships present in the model for with solution effectiveness as the dependent variable. Analysis of the T2 path coefficients did not reveal the presence of mediation. Impairment at T2 is not related to collective efficacy at T2 (β = -.01, ns); although collective efficacy at T2 is related to solution implementability (β = .44, $p \leq .01$). The alternate model did not fit the data ($\chi^2_{(3)}$ = 7.88, $p \leq .05$; SRMR = .14; AIC = 436.40; CFI = .86; RMSEA = .23). Thus, Hypothesis 6a was not supported with solution implementability as the dependent variable.

Motivation to Work on Behalf of the Team as a Mediator. Hypothesis 6b predicted that motivation to work on behalf of the team would mediate the relationship between process impairment and team performance. This hypothesis was first tested with solution effectiveness as the dependent variable. The model demonstrated acceptable fit to the data ($\chi^2_{(3)}$ = 3.34, ns; SRMR = .07; AIC = 440.02; CFI = .99; RMSEA = .06). The path model is depicted in Figure 27.

Figure 27. Path analysis results testing motivation to work on behalf of the team as a mediator between impairment and solution effectiveness (Hypothesis 6b).



Note: * $p < .05$; ** $p < .01$. ($\chi^2_{(3)}$ = 3.34, ns; SRMR = .07; AIC = 440.02; CFI = .99; RMSEA = .06). Alternative model did not fit the data.

Focusing first on the autoregressions, the results indicated that impairment at T1 does not predict impairment at T2 (β = .21, ns); however, motivation to work on behalf of the team at T1 significantly predicted motivation to work on behalf of the team at T2 (β = .77, $p \leq .01$). Regarding the cross-lagged relations, findings revealed that impairment at T1 was not related to motivation to work on behalf of the team at T2 (β = .17, ns), and that impairment at T1 was not related to motivation to work on behalf of the team at T2 (β = -.04, ns). Impairment at T1 was not related to motivation to work on behalf of the team at T1 (β = -.11, ns). Analysis of the T2 relationships did not reveal support for mediation. Impairment at T2 was not related to motivation to work on behalf of the team at T2 (β = -.05, ns), and motivation to work on behalf of the team was not related to solution effectiveness (β = .31, ns). Therefore, Hypothesis 7b was not supported with solution effectiveness as the dependent variable. The alternate model (motivation to work on behalf of the team → impairment → solution effectiveness) did not exhibit acceptable fit to the data ($\chi^2_{(3)}$ = 6.48, ns; SRMR = .14; AIC = 443.17; CFI = .87; RMSEA = .19).

This hypothesis was then tested with solution implementability as the dependent variable. The model did not demonstrate acceptable fit to the data ($\chi^2_{(3)}$ = 6.87, ns; SRMR = .11; AIC = 438.51; CFI = .88; RMSEA = .20). Thus, Hypothesis 6b was not supported with solution implementability as the dependent variable. The alternate model (motivation to work on behalf of the team → impairment → solution implementability) did not fit the data ($\chi^2_{(3)}$ = 9.61, $p \leq .05$; SRMR = .16; AIC = 441.25; CFI = .79; RMSEA = .26).

Hypothesis 6c - d: Impairment → Motivational Emergent States → Viability

Collective Efficacy as a Mediator. Hypothesis 6c predicted that collective efficacy would mediate the relationship between impairment and team viability. The model did not fit the data ($\chi^2_{(3)}$ = 7.83, $p \leq .05$; SRMR = .07; AIC = 397.41; CFI = .93; RMSEA = .22). The alternate model did not fit the data ($\chi^2_{(3)}$ = 44.16, $p \leq .05$; SRMR = .26; AIC = 433.74; CFI = .43; RMSEA = .66). Thus, Hypothesis 6c was not supported.

Motivation to Work on Behalf of the Team as a Mediator. Hypothesis 6d predicted that motivation to work would mediate the relationship between impairment and team viability. The model did not fit the data ($\chi^2_{(3)}$ = 13.98, $p \leq .01$; SRMR = .14; AIC = 433.71; CFI = .74; RMSEA = .34). Thus, Hypothesis 8b was not supported. The alternate model did not fit the data ($\chi^2_{(3)}$ = 18.65, $p \leq .01$; SRMR = .20; AIC = 438.59; CFI = .63; RMSEA = .41). Therefore, Hypothesis 6d was not supported.

Supplemental Analyses. Hypotheses 3-6 posited that the process sociomateriality factors impact performance/viability through shaping emergent states. This proposition asserts that process sociomateriality exhibits an indirect effect, but not direct, effect on performance. As such, the path models were constructed according to the recommendations of James et al. (2006), and did not include a direct linkage between the independent variable and dependent variable. However, in order to further examine alternative explanations for the relationship between process sociomateriality and team outcomes, this dissertation also incorporated a direct path between the independent variable and dependent variable into the path models in which mediation was present. This allows the present work to examine whether mediation persists after accounting for the relationship between the process sociomateriality factors and team performance/viability. Therefore, a direct linkage between the process sociomateriality factors (facilitation/expansion or impairment) at T2 and team performance/viability was added to each model that revealed support for mediation in the tests of Hypotheses 3 through 6.

Results from Hypothesis 3a provided evidence that team satisfaction mediates the relationship between facilitation/expansion and solution effectiveness. A direct path between facilitation/expansion at T2 and solution effectiveness was added to the model. This model fit the data ($\chi^2_{(2)}$ = .27, ns; SRMR = .01; AIC = 391.27; CFI = 1.00; RMSEA = .00). Findings revealed that the bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution effectiveness now included zero (-.02 - .52), indicating that mediation may not be present.

Results from Hypothesis 3a also provided evidence that team satisfaction mediates the relationship between facilitation/expansion and solution implementability. A direct path between facilitation/expansion at T2 and solution implementability was added to the model. This model fit the data ($\chi^2_{(2)}$ = .39, ns; SRMR = .01; AIC = 385.81; CFI = 1.00; RMSEA = .00). Findings revealed that the bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution effectiveness still did not include zero (.06 - .64), indicating that full mediation may be present.

Results from Hypothesis 3c revealed that facilitation/expansion mediated the relationship between team identity and solution implementability. A direct path between team identity at T2 and solution implementability was added to the model. The model fit the data ($\chi^2_{(2)}$ = 2.48, ns; SRMR = .04; AIC = 395.46; CFI = .99; RMSEA = .09). Findings revealed that the bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution effectiveness still did not include zero (.05 - .52), indicating that full mediation may be present.

Findings from Hypothesis 3d indicated that team trust mediate the relationship between facilitation/expansion and solution implementability. A direct path between facilitation/expansion at T2 and solution implementability was added to the model. The model fit the data ($\chi^2_{(2)}$ = .02, ns; SRMR = .01; AIC = 326.32; CFI = 1.00; RMSEA =

.00). Findings revealed that the bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution effectiveness now included zero (-.11 - .51), indicating that full mediation may not be present.

Results from Hypothesis 3e demonstrated that team satisfaction mediated the relationship between facilitation/expansion and team viability. A direct path between facilitation/expansion at T2 and team viability was added to the model. The model fit the data ($\chi^2_{(2)}$ = 3.80, ns; SRMR = .03; AIC = 333.18; CFI = .99; RMSEA = .17). Findings revealed that the bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on team viability still did not include zero (.23 - .60), indicating that full mediation may be present.

Findings from Hypothesis 3g revealed that team identity mediated the relationship between facilitation/expansion and team viability. A direct path between team identity at T2 and team viability was added to the model. The model fit the data ($\chi^2_{(2)}$ = 2.48, ns; SRMR = .04; AIC = 395.46; CFI = .99; RMSEA = .09). Findings revealed that the bias-corrected 95% CI for the indirect effect of team identity at T2 on team viability still did not include zero (.03 - .50), indicating that full mediation may be present.

Results from Hypothesis 3h found that team trust mediates the relationship between facilitation/expansion and team viability. A direct path between facilitation/expansion at T2 and team viability was added to the model. The model fit the data ($\chi^2_{(2)}$ = .42, ns; SRMR = .01; AIC = 289.30; CFI = 1.00; RMSEA = .00). Findings revealed that the bias-corrected 95% CI for the indirect effect of team identity at T2 on team viability still did not include zero (.16 - .71), indicating that full mediation may be present.

Findings from Hypothesis 5a revealed that collective efficacy mediates the relationship between facilitation/expansion and solution effectiveness. A direct path between facilitation/expansion at T2 and solution effectiveness was added to the model. The model fit the data ($\chi^2_{(2)}$ = .85, ns; SRMR = .02; AIC = 409.12; CFI = 1.00; RMSEA = .00). However, findings revealed that the bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution effectiveness now included zero (-.01 - .32), indicating that full mediation may not be present.

Finally, findings from Hypothesis 5a also indicated that collective efficacy mediates the relationship between facilitation/expansion and solution implementability. A direct path between facilitation/expansion at T2 and solution effectiveness was added to the model. The model fit the data ($\chi^2_{(2)}$ = .01, ns; SRMR = .00; AIC = 404.34; CFI = 1.00; RMSEA = .00). Findings revealed that the bias-corrected 95% CI for the indirect effect of facilitation/expansion at T2 on solution implementability still did not include zero (.02 - .38), indicating that full mediation may be present.

Incremental Validity

Hypotheses 7 through 12 were examined through the use of hierarchical regression. These hypotheses posited that process sociomateriality would incrementally predict team viability and team performance, respectively, beyond traditional conceptualizations of team process, (Marks et al., 2001), the virtuality perspective (e.g. Gibson & Gibbs, 2006; Kirkman & Mathieu, 2005), and the virtuality as a moderator framework (e.g. Bierly et al., 2009; Kirkman et al., 2004). The analytic procedure for Hypothesis 7 will be discussed as an illustration of the analytic technique. In Step 1, team viability was regressed onto team process from the Marks et al. (2001) process scale. In

Step 2, team viability was regressed onto the process sociomateriality factors (facilitation/expansion, impairment). This hypothesis was evaluated by examining p-value for the standardized beta of the IV. The significance criterion was $p < .05$. The change in R-Square was examined to determine incremental variance accounted for by the process sociomateriality factors. Table 49 displays the results of these hypothesis tests.

Table 49.

Hierarchical Regression Results Examining the Incremental Validity of Process Sociomateriality on Team Outcomes

Hypothesis	DV	Step 1 Variable	β	SE	F	R^2	Step 2 Variable	β	SE	F	R^2	ΔR^2
7	Team Viability	Team Process	.74*	.15	35.86	.54	Team Process	.49*	.16	24.16	.72	.18
							F/E	.37*	.17			
							Impairment	-.26*	.13			
8	SE	Team Process	.17	.39	.87	.03	Team Process	.04	.54	.50	.05	.02
							F/E	.04	.54			
							Impairment	-.20	.56			
8	Implementability	Team Process	.40*	.42	5.60	.16	Team Process	.31	.56	2.59	.22	.06
							F/E	.11	.58			
							Impairment	-.21	.45			
9	Team Viability	Virtuality	.06	.01	.12	.00	Virtuality	.09	.01	.12	.60	.59
							F/E	.72**	.16			
							Impairment	-.17	.18			
10	SE	Virtuality	-.14	.03	.61	.02	Virtuality	-.14	.03	.65	.07	.05
							F/E	.19	.43			
							Impairment	-.06	.48			
10	Implementability	Virtuality	-.08	.03	.17	.00	Virtuality	-.14	.03	2.02	.18	.17
							F/E	.29	.63			
							Impairment	-.25	.51			
11	Team Viability	Team Process	.81**	.16	13.44	.59	Team Process	.52*	.18	14.35	.73	.14
		Virtuality	.18	.01			Virtuality	.10	.00			
		ProcessXVirtuality	.11	.03			ProcessXVirtuality	.07	.03			
							F/E	.38*	.18			
							Impairment	-.21	.15			
12	SE	Team Process	.11*	.43	.53	.05	Team Process	-.04	.59	.47	.08	.03
		Virtuality	-.12	.03			Virtuality	-.12	.03			
		ProcessXVirtuality	-.12	.09			ProcessXVirtuality	-.14	.09			
							F/E	.20	.59			
							Impairment	-.06	.50			
12	Implementability	Team Process	.42*	.46	1.83	.16	Team Process	.61	.34	1.60	.24	.07
		Virtuality	.03	-.02			Virtuality	-.14	.03			
		ProcessXVirtuality	.09	.08			ProcessXVirtuality	.08	.09			
							F/E	.07	.61			
							Impairment	-.28	.52			

Note. † = p<.10, * = p<.05, ** = p<.01, N=32. SE = Solution Effectiveness; F/E = Facilitation/Expansion.

Hypothesis 7 predicted that process sociomateriality better predicts team viability than does team process. The standardized beta associated with facilitation/expansion was statistically significant ($\beta = .37$, $p \leq .05$), as was the standardized beta associated with impairment ($\beta = -.26$, $p \leq .05$). The change in R^2 from step 1 to step 2 was .18 ($p \leq .05$), indicating that the process sociomateriality factors account for variance in team viability after controlling for team process. Therefore, Hypothesis 7 was supported.

Hypothesis 8 postulated that process sociomateriality better predicts team performance than does team process. This hypothesis was first tested with solution effectiveness as the dependent variable. The standardized beta associated with facilitation/expansion was not significant ($\beta = .20$, ns), nor was the standardized beta associated with impairment ($\beta = .00$, ns). The change in R^2 from step 1 to step 2 was .02 (ns). Therefore, Hypothesis 8 was not supported with solution effectiveness as the dependent variable. This hypothesis was then tested with solution implementability as the dependent variable. The standardized beta associated with facilitation/expansion was not significant ($\beta = .11$, ns), nor was the standardized beta associated with impairment ($\beta = -.21$, ns). The change in R^2 from step 1 to step 2 was .06 (ns). Thus, Hypothesis 8 was not supported with solution implementability as the dependent variable.

Hypothesis 9 predicted that process sociomateriality would predict team viability better than team virtuality. The standardized beta associated with facilitation/expansion was statistically significant ($\beta = .72$, $p \leq .01$); however, the standardized beta associated with impairment was not significant ($\beta = -.17$, ns). The change in R^2 from step 1 to step 2 was .59 ($p \leq .05$), indicating that the process sociomateriality factors account for variance in team viability after controlling for team virtuality. Therefore, Hypothesis 9 was supported.

Hypothesis 10 postulated that process sociomateriality would predict team performance better than does team virtuality. This hypothesis was first tested with solution effectiveness as the dependent variable. The standardized beta associated with facilitation/expansion was not significant (β = .19, ns), nor was the standardized beta associated with impairment (β = -.06, ns). The change in R^2 from step 1 to step 2 was .05 (ns). Therefore, Hypothesis 10 was not supported with solution effectiveness as the dependent variable. This hypothesis was then tested with solution implementability as the dependent variable. The standardized beta associated with facilitation/expansion was not significant (β = .29, ns), nor was the standardized beta associated with impairment (β = -.25, ns). The change in R^2 from step 1 to step 2 was .17 (ns). Thus, Hypothesis 10 was not supported with solution implementability as the dependent variable.

Hypotheses 11 – 12 predicted that process sociomateriality would predict team performance/viability beyond the virtuality as a moderator perspective. In order to test this hypothesis, an interaction term between team virtuality and team process was created. Following the procedures outlined by Cohen, Cohen, West, and Aiken (2003), virtuality and process were first centered using their respective overall means, and then a multiplicative interaction term was created. Given that Hypotheses 11 – 12 involve an interaction term, it is important to control for the main effects of each variable that comprises the interactive term. Therefore, the analytic procedure for this set of hypotheses was: 1) regress the dependent variable onto team process, team virtuality, and their interaction term (processXvirtuality) in Step 1, and 2) regress the dependent variable onto the process sociomateriality factors (facilitation/expansion and impairment) in Step 2. Significance was determined by following the same procedure detailed for Hypotheses 7 through 10.

Hypothesis 11 stated that process sociomateriality better predicts team viability than does the interaction between team virtuality and team process. The standardized beta associated with facilitation/expansion was statistically significant (β = .38, $p \leq .05$); however, the standardized beta associated with impairment was not significant (β = -.21, ns). The change in R^2 from step 1 to step 2 was .14 ($p \leq .05$), indicating that the process sociomateriality factors account for variance in team viability after controlling for the processXvirtuality interaction term. Therefore, Hypothesis 11 was supported.

Hypothesis 12 postulated that process sociomateriality would predict team performance better than the interaction between team virtuality and team process. This hypothesis was first tested with solution effectiveness as the dependent variable. The standardized beta associated with facilitation/expansion was not significant (β = .20, ns), nor was the standardized beta associated with impairment (β = -.06, ns). The change in R^2 from step 1 to step 2 was .03 (ns). Therefore, Hypothesis 12 was not supported with solution effectiveness as the dependent variable. This hypothesis was then tested with solution implementability as the dependent variable. The standardized beta associated with facilitation/expansion was not significant (β = .07, ns), nor was the standardized beta associated with impairment (β = -.28, ns). The change in R^2 from step 1 to step 2 was .07 (ns). Thus, Hypothesis 12 was not supported with solution implementability as the dependent variable.

Supplemental Analyses. Analysis of Hypotheses 3 - 6 revealed some support that emergent states mediate the relationship between the process sociomateriality factors and team performance/viability. Therefore, it may be more appropriate to test the incremental validity hypotheses with emergent states as a more proximal team outcome of process sociomateriality, rather than the more distal construct team performance. Therefore, Hypotheses 7 through 12 were also tested with emergent states as the dependent variable. The same analytic procedure was followed in testing these relationships. However, given that emergent states are the outcome of interest for this analysis, emergent states at T1 were also included as a control variable in Step 1. Table 50 displays the results of these hypothesis tests.

Table 50.

Hierarchical Regression Results Examining the Incremental Validity of Process Sociomateriality on Emergent States

DV	Step 1 Variable	β	SE	*F*	R^2	Step 2 Variable	β	SE	*F*	R^2	Δ R^2
Team Satisfaction	Team Process	.52**	.18	44.34	.75	Team Process	.52**	.20	27.21	.80	.05
	Team Satisfaction	.42**	.15			Team Satisfaction	.43**	.14			
						F/E	.30*	.16			
						Impairment	.04	.13			
Team Cohesion	Team Process	.44**	.19	37.43	.71	Team Process	.36	.24	17.99	.73	.01
	Team Cohesion	.46**	.17			Team Cohesion	.48**	.18			
						F/E	.11	.17			
						Impairment	.03	.14			
Team Identity	Team Process	.32	.23	16.50	.53	Team Process	.26	.29	8.55	.56	.03
	Team Identity					Team Identity	.49**	.18			
						F/E	.08	.25			
						Impairment	.17	.19			
Team Trust	Team Process	.88**	.10	105.15	.78	Team Process	.73*	.12	43.15	.82	.04
						F/E	.23*	.12			
						Impairment	-.09	.09			
Collective Efficacy	Team Process	.53**	.26	51.87	.78	Team Process	.57**	.34	25.19	.79	.01
	Collective Efficacy	.46**	.11			Collective Efficacy	.43**	.12			
						F/E	-.03	.30			
						Impairment	-.03	.30			
Motivation	Team Process	.22	.15	20.39	.58	Team Process	.33	.18	10.43	.61	.02
	Motivation	.63**	.16			Motivation	.68**	.17			
						F/E	-.21	.19			
						Impairment	-.05	.14			

Note. † = *p*<.10, * = *p*<.05, ** = *p*<.01, N=32. F/E = Facilitation/Expansion; Motivation = Motivation to work on behalf of the team.

Table 50. (ctd.)

Hierarchical Regression Results Examining the Incremental Validity of Process Sociomateriality on Emergent States

DV	Step 1 Variable	β	SE	*F*	R^2	Step 2 Variable	β	SE	*F*	R^2	Δ R^2
Team Satisfaction	Team Virtuality	-.05	.01	24.04	.62	Team Virtuality	.06	.01	22.78	.77	.15
	Team Satisfaction	.79**	.13			Team Satisfaction	.60**	.12			
						F/E	.45**	.15			
						Impairment	.12	.15			
Team Cohesion	Team Virtuality	-.03	.01	26.12	.64	Team Virtuality	.06	.01	15.39	.70	.05
	Team Cohesion	.80**	.12			Team Cohesion	.69**	.14.			
						F/E	.27*	.16			
						Impairment	.11	.16			
Team Identity	Team Virtuality	-.13	.01	13.98	.49	Team Virtuality	-.02	.01	7.75	.54	.04
	Team Identity	.69**	.14			Team Identity	.62**	.15			
						F/E	.21	.21			
						Impairment	.18	.22			
Team Trust	Team Virtuality	-.04	.01	.05	.00	Team Virtuality	.07	.01	10.67	.53	.53
						F/E	.74**	.15			
						Impairment	.02	.17			
Collective Efficacy	Team Virtuality	-.03	.02	21.87	.60	Team Virtuality	.04	.02	13.21	.66	.06
	Collective Efficacy	.78**	.12			Collective Efficacy	.67**	.13			
						F/E	.28*	.31			
						Impairment	.03	.33			
Motivation	Team Virtuality	.07	.01	17.90	.55	Team Virtuality	.07	.01	8.34	.55	.00
	Motivation	.76**	.15			Motivation	.77**	.18			
						F/E	-.02	.17			
						Impairment	.01	.16			

Note. † = *p*<.10, * = *p*<.05, ** = *p*<.01, N=32. F/E = Facilitation/Expansion; Motivation = Motivation to work on behalf of the team

Table 50. (ctd.)

Hierarchical Regression Results Examining the Incremental Validity of Process Sociomateriality on Emergent States

DV	**Step 1 Variable**	**β**	**SE**	***F***	***R*²**	**Step 2 Variable**	**β**	**SE**	***F***	***R*²**	**Δ *R*²**
Team Satisfaction	Team Virtuality	.02	.01	23.46	.78	Team Virtuality	.06	.01	18.80	.82	.04
	Team Process	.58**	.19			Team Process	.38*	.21			
	ProcessXVirtuality	.16	.03			ProcessXVirtuality	.12	.03			
	Team Satisfaction	.42**	.15			Team Satisfaction	.43**	.14			
						F/E	.29*	.17			
						Impairment	.07	.14			
Team Cohesion	Team Virtuality	.03	.01	29.61	.81	Team Virtuality	.05	.01	18.69	.82	.00
	Team Process	.54**	.17			Team Process	.49**	.21			
	ProcessXVirtuality	.32**	.02			ProcessXVirtuality	.31**	.02			
	Team Cohesion	.48**	.15			Team Cohesion	.50**	.16			
						F/E	.07	.15			
						Impairment	.05	.13			
Team Identity	Team Virtuality	-.08	.01	7.99	.54	Team Virtuality	-.00	.01	5.36	.56	.02
	Team Process	.31	.25			Team Process	.29	.31			
	ProcessXVirtuality	.08	.04			ProcessXVirtuality	.07	.04			
	Team Identity	.51**	.18			Team Identity	.50*	.19			
						F/E	.07	.26			
						Impairment	.17	.22			
Team Trust	Team Virtuality	.10	.01	39.29	.81	Team Virtuality	.09	.01	27.65	.84	.03
	Team Process	.95**	.10			Team Process	.79**	.12			
	ProcessXVirtuality	.14	.02			ProcessXVirtuality	.12	.02			
						F/E	.23*	.12			
						Impairment	-.05	.10			

Note. † = p<.10, * = p<.05, ** = p<.01, N=32. F/E = Facilitation/Expansion.

Table 50. (ctd.)

Hierarchical Regression Results Examining the Incremental Validity of Process Sociomateriality on Emergent States

DV	Step 1 Variable	β	SE	*F*	R^2	Step 2 Variable	β	SE	*F*	R^2	ΔR^2
Collective Efficacy	Team Virtuality	.12	.01	26.52	.80	Team Virtuality	.10	.02	16.54	.80	.00
	Team Process	.59**	.28			Team Process	.60**	.35			
	ProcessXVirtuality	.05	.05			ProcessXVirtuality	.05	.05			
	Collective Efficacy	.43**	.11			Collective Efficacy	.41**	.12			
						F/E	-.02	.31			
						Impairment	-.05	.27			
Motivation	Team Virtuality	.10	.01	10.33	.61	Team Virtuality	.09	.01	6.90	.62	.02
	Team Process	.16	.16			Team Process	.26	.20			
	ProcessXVirtuality	-.14	.03			ProcessXVirtuality	-.13	.03			
	Motivation	.69**	.18			Motivation	.74**	.19			
						F/E	-.20	.19			
						Impairment	-.01	.16			

Note. † = *p*<.10, * = *p*<.05, ** = *p*<.01, N=32. F/E = Facilitation/Expansion.

The first set of supplemental analyses tested whether process sociomateriality predicted affective states better than team process. This proposition was first tested with team satisfaction as the dependent variable. Findings revealed that the standardized beta associated with facilitation/expansion was statistically significant (β = .30, $p \leq .05$); however, the standardized beta associated with impairment was not significant (β = .04, *ns*). The change in R^2 step 1 to step 2 was .05 ($p \leq .05$), indicating that the process sociomateriality factors account for variance in team satisfaction after controlling for team process.

This hypothesis was then tested with team cohesion as the dependent variable. Results revealed that the standardized beta associated with facilitation/expansion was not significant (β = .11, ns), nor was the standardized beta associated with impairment (β = -.03, ns). The change in R^2 step 1 to step 2 was .01 (ns), demonstrating that the process sociomateriality factors do not account for variance in team cohesion after controlling for team process.

This hypothesis was subsequently tested with team identity as the team outcome of interest. Results demonstrated that the standardized beta associated with facilitation/expansion was not significant (β = .08, ns), nor was the standardized beta associated with impairment (β = -.17, ns). The change in R^2 step 1 to step 2 was .03 (ns), indicating that the process sociomateriality factors do not account for variance in team cohesion after controlling for team process.

This hypothesis was then tested with team trust as the team outcome. Results indicated that the standardized beta associated with facilitation/expansion was statistically significant (β = .23, $p \leq .05$); however, the standardized beta associated with impairment was not significant (β = -.09, *ns*). The change in R^2 step 1 to step 2 was .04 ($p \leq .05$), indicating that the process sociomateriality factors account for variance in team trust after controlling for team process. It is important to note that team trust was not collected at T1, and was thus not included as a control variable.

The next set of analyses examined whether process sociomateriality better predicted motivational emergent states that team process. This proposition was first tested with collective efficacy as the outcome. Findings revealed that that the standardized beta associated with facilitation/expansion was not significant (β = -.03, ns), nor was the standardized beta associated with impairment (β = -.09, ns). The change in R^2 step 1 to step 2 was .01 (ns), demonstrating that the process sociomateriality factors do not account for variance in collective efficacy after controlling for team process.

This hypothesis was then tested with motivation to work on behalf of the team as the team outcome of interest. Results demonstrated that the standardized beta associated with facilitation/expansion was not significant (β = -.21, ns), nor was the standardized beta associated with impairment (β = -.05, ns). The change in R^2 step 1 to step 2 was .02 (ns), which indicates that the process sociomateriality factors do not account for variance in motivation to work on behalf of the team after controlling for team process.

Hypotheses 9 - 10 posited that process sociomateriality would predict team viability/performance better than team virtuality. These hypotheses were also tested with emergent states as the team outcome of interest. First, this assertion was tested with team satisfaction as the dependent variable. Findings demonstrated that the standardized beta associated with facilitation/expansion was statistically significant (β = .44, $p \leq .05$); however, the standardized beta associated with impairment was not significant (β = .09, ns). The change in R^2 step 1 to step 2 was .15 ($p \leq .05$), indicating that the process sociomateriality factors account for variance in team satisfaction after controlling for team virtuality.

This hypothesis was then tested with team cohesion as the team outcome of interest. Results indicated that the standardized beta associated with facilitation/expansion was statistically significant ($\beta = .27$, $p \leq .05$); however, the standardized beta associated with impairment was not significant ($\beta = .11$, ns). The change in R^2 step 1 to step 2 was .05 (ns), indicating that the process sociomateriality factors may account for variance in team satisfaction after controlling for team virtuality, although not at a statistically significant level.

Subsequently, this hypothesis was tested with team identity as the dependent variable. Findings revealed that the standardized beta associated with facilitation/expansion was not significant ($\beta = .21$, ns), nor was the standardized beta associated with impairment ($\beta = .18$, ns). The change in R^2 step 1 to step 2 was .04 (ns), which indicates that the process sociomateriality factors do not account for variance in team identity after controlling for team virtuality.

This hypothesis was then tested with team trust as the dependent variable. Results indicated that the standardized beta associated with facilitation/expansion was statistically significant ($\beta = .74$, $p \leq .05$); however, the standardized beta associated with impairment was not significant ($\beta = .02$, ns). The change in R^2 step 1 to step 2 was .53 ($p \leq .01$), indicating that the process sociomateriality factors account for variance in team trust after controlling for team virtuality.

This hypothesis was also tested with collective efficacy as the team outcome of interested. Findings demonstrated that the standardized beta associated with facilitation/expansion was statistically significant (β = .28, $p \leq .05$); however, the standardized beta associated with impairment was not significant (β = .03, ns). The change in R^2 step 1 to step 2 was .06 (ns), demonstrating may account for variance in collective efficacy after controlling for team virtuality, although not at a statistically significant level.

Finally, Hypothesis 9 - 10 was tested with motivation to work on behalf of the team as the dependent variable. Findings revealed the standardized beta associated with facilitation/expansion was not significant (β = -.02, ns), nor was the standardized beta associated with impairment (β = .01, ns). The change in R^2 step 1 to step 2 was .00 (ns), which indicates that the process sociomateriality factors do not account for variance in motivation to work on behalf of the team after controlling for team virtuality.

Hypotheses 11 - 12 stated that process sociomateriality would better predict team viability/performance than the interaction between virtuality and team process. These hypotheses were tested with emergent states as the team outcome. First, this postulation was tested with team satisfaction as the dependent variable. Results indicated that the standardized beta associated with facilitation/expansion was statistically significant (β = .29, $p \leq .05$); however, the standardize beta associated with impairment was not significant (β = .07, ns). The change in R^2 step 1 to step 2 was .04 (ns), demonstrating may account for variance in team satisfaction after controlling for the virtualityXprocess interaction, although not at a statistically significant level.

This hypothesis was then tested with team cohesion as the team outcome of interest. Findings revealed the standardized beta associated with facilitation/expansion was not significant (β = .07, ns), nor was the standardized beta associated with impairment (β = .05, ns). The change in R^2 step 1 to step 2 was .00 (ns), which indicates that the process sociomateriality factors do not account for variance in team cohesion after controlling for the virtualityXprocess interaction.

Subsequently, this hypothesis was tested with team identity as the dependent variable. Results demonstrated that the standardized beta associated with facilitation/expansion was not significant (β = .07, ns), nor was the standardized beta associated with impairment (β = .17, ns). The change in R^2 step 1 to step 2 was .02 (ns), which indicates that the process sociomateriality factors do not account for variance in team identity after controlling for the virtualityXprocess interaction.

This hypothesis was then tested with team trust as the dependent variable. Results indicated that the standardized beta associated with facilitation/expansion was statistically significant (β = .23, $p \leq .05$); however, the standardize beta associated with impairment was not significant (β = -.05, ns). The change in R^2 step 1 to step 2 was .03 (ns), demonstrating that process sociomateriality may account for variance in team trust after controlling for the virtualityXprocess interaction, although not at a statistically significant level.

This hypothesis was also tested with collective efficacy as the team outcome of interested. Results demonstrated that the standardized beta associated with facilitation/expansion was not significant (β = -.02, ns), nor was the standardized beta associated with impairment (β = -.05, ns). The change in R^2 step 1 to step 2 was .00 (ns), which indicates that the process sociomateriality factors do not account for variance in collective efficacy after controlling for the virtualityXprocess interaction.

Finally, this hypothesis was tested with motivation to work on behalf of the team as the dependent variable. Findings indicated that the standardized beta associated with facilitation/expansion was not significant (β = -.20, ns), nor was the standardized beta associated with impairment (β = -.01, ns). The change in R^2 step 1 to step 2 was .02 (ns), which demonstrates that the process sociomateriality factors do not account for variance in motivation to work on behalf of the team after controlling for the virtualityXprocess interaction.

Supplemental Analysis

A final supplemental consideration sought to examine the development of process sociomateriality over time. A first set of analyses examined the between-factor relations across the two study time points. Analysis of the bivariate correlations (see Table 40) revealed that facilitation/expansion at time 1 was negatively correlated with impairment at time 2 (r = -.46, p < .05). On the other hand, impairment at time 1 was not correlated with facilitation/expansion at time 2 at a statistically significant level (r = -.34, *ns*). These findings suggest that early impairment is not an indicator of later facilitation/expansion; teams that exhibit impaired process sociomateriality earlier in their project cycle may later experience high or low facilitation/expansion. However, when it comes to facilitation/expansion, teams that exhibit these process behaviors early on are likely to display fewer impairment behaviors later in their project cycle.

A second set of analyses examined within-factor changes over time. Thus, this dissertation examined mean differences in the process sociomateriality factors across time 1 and time 2. A paired samples t-test revealed that there was not a statistically significant difference between facilitation/expansion at time 1 (M = 3.75, SD = .39) and facilitation/expansion at time 2 (M = 3.65, SD = .39). A subsequent paired samples t-test also revealed that there was not a significant difference between impairment at time 1 (M = 2.25, SD = .38) and impairment at time 2 (M =2.21, SD = .39).

Qualitative Analysis

This dissertation had the opportunity to not only assess perceptions of process sociomateriality, but to also examine behavioral data to further elucidate this phenomenon. The following first presents descriptive information regarding overall patterns of tool use across the project. The subsequent section then provides qualitative examples of each of the process sociomateriality factors during each deliverable period by drawing from this repository of behavioral trace data.

Tool Descriptives. Participants were provided with three different new media platforms to enable team interaction: Webex, Googlegroups, and Basecamp. Webex is a videoconferencing platform, and enables synchronous interaction and social presence via webcameras. GoogleGroups is an email listserve, and allows team members to send communications to the entire team at once. Finally, Basecamp is an online project management tool. Basecamp enables a variety of collaboration functionalities including discussion boards, file sharing, to-do lists, text document creation, and shared calendar capabilities. Given that this was a quasi-field study, it is important to note that participants were free to use other communication platforms. The following section will provide descriptive statistics that depict tool use patterns across the sample of partially-distributed teams.

The 32 teams engaged in a total of 78 Webex meetings over the course of the project. The number of meetings per team ranged from 0 to 8 (Mean = 2.5; Median = 2); eight teams did not meet via Webex. The mean percentage for meeting attendance was 71.9% for the teams that utilized this tool. Average meeting time was 53.62 minutes.

A total of 617 emails were sent via the Googlegroups platform during the course of the project. One team did not use the tool, while 11 teams sent 5 emails or fewer using Googlegroups. The average number of emails sent was 19.28 per team (Median = 10).

Teams uploaded a total of 296 documents to their Basecamp account (Mean = 9.26, Median = 8). Teams posted a total of 2266 discussion comments, and started 237 discussion threads. The average number of discussion comments was 73.10 (Median = 35), and the average number of discussion threads was 6.28 (Median = 5). Teams used the calendar, text doc, and to-do list functionalities less frequently. Eight teams used the calendar functionality of Basecamp. These teams posted an average of 3.43 unique events on the Basecamp calendar. Seven teams used the text document functionality; these teams created an average of 3.86 text documents. Finally, eight teams used the to-do list function, and created an average of 5.88 unique “to-do’s”.

Qualitative Instances of Process Sociomateriality – Period 1

The first team deliverable was comprised of two parts: 1) team charter and 2) topic selection summary. The team charter served as team contract in which members documented their contact information, and established communication norms operating guidelines, and conflict management strategies. During this period, the teams also completed a topic selection summary in which they provided a 1 to 2-page synopsis of the team’s chosen ecological issue. The duration of this task period was 7 days. Table 51 displays exemplar instances of process sociomateriality behaviors that were displayed during period 1.

Table 51.

Sample Instances of Process Sociomateriality Behaviors Displayed during Period 1

Process Sociomateriality Dimension	**Behavioral Indicator**	**Instance/Quotation**	**Platform**
Facilitation	Idea Generation	"If you have any ideas for the research question, go ahead and post it here so we can discuss them!"	Basecamp Discussion Thread
Facilitation	Idea Evaluation	"I think this would be the most straight-forward research angle, especially considering that some people reuse disposable bottles!" "Sounds good to me! its super straight forward too which is nice. "	Basecamp Discussion Thread
Facilitation	Role and Task Assignment	"We {GT student] will write a paragraph, and you guys [GMU students] can add it to the doc."	WebEx Meeting
Facilitation	Activity Synchronization	“We need to upload the two assignments on Base camp as word documents, not google drive documents. I’ll go ahead and resubmit those now.”	GoogleGroups Email Thread
Facilitation	Team Monitoring and Backup Behavior	"Can I help with anything? Give any feedback?"	Basecamp Discussion Thread
Expansion	Simultaneous Collaboration	"We should do this in GoogleDocs, then everyone can type in the doc at the same time."	WebEx Meeting
Expansion	Bridging Space	Shared screen while completing team charter so everyone could see responses	WebEx Meeting
Expansion	Interaction Variability	Team completed a "WhenIsGood" poll on the share screen to coordinate member schedules.	WebEx Meeting
Expansion	Automated Coordination Facilitation	Webex meeting reminder email	GoogleGroups Email Thread
Expansion	Bridging Time	"We don't have to be together; we will be officially meeting Thursday at 9 pm on WebEx (which is recorded, and Aisana & whoever else who can't make it can watch :)"	Basecamp Discussion Thread
Impairment	Technology Breakdown	“I got kicked and can't quite figure out how to get back in”	GoogleGroups Email Thread
Impairment	Familiarity	“Hey guys! I am good with Thursday around 9 pm. How do we set up the whole WebEx meeting?”	Basecamp Discussion Thread
Impairment	Preference	"We need to establish a main mode of communication rather than switching between three constantly "	Basecamp Discussion Thread

Process Facilitation. This was the first task that teams completed as a collective. Thus, many teams utilized technology build rapport and to establish collaboration norms during this period. These actions are reflective of process facilitation behaviors, particularly *motivation and confidence building*, and *role and task assignment*. For instance, one team utilized the GoogleGroups form to send encouraging e-mail messages to the other members:

> "We need to do the document by tomorrow at 1. So ladies and gentlemen, we need to start ASAP or some voices won't be heard. I submitted a Doodle poll to each of you. Laura, I applaud you for your initiative."

Others utilized the discussion thread platform of Basecamp to create a motivational and engaged atmosphere for the team:

> "I'm Ashley, a biochemistry second year at Georgia Tech. I love social psychology, and I can't wait to start people watching. I might be getting a second job, but that should not affect this project. I look forward to working with you all!"

Another team held a "get-to-know-you" meeting via Webex. At the beginning of the meeting, team members utilized the videoconferencing platform to introduce themselves and discuss what skillsets they possess.

Teams also utilized these platforms to engage in *role and task assignment*. For instance, in a Basecamp discussion thread, one student stated: "I just thought I might send out the first email and see if we need to divide up tasks." This comment started a discussion thread in which this particular team allocated work for deliverable 1.

Given that teams were tasked with choosing an ecological problem space in period 1, many teams also utilized technology to engage in *idea generation* and *idea evaluation*. One team used the Basecamp discussion forum to brainstorm different ideas for their ecological problem:

> Student A: “If you have any ideas for the research question, go ahead and post it here so we can discuss them!"
>
> Student B: "What about comparing the use of reusable water bottles with the use of disposable bottles in the student center?"
>
> Student A: "That's a good idea! What if we did something on water and pollution to see   how much trash accumulates near major water ways?”

A final common process facilitation behavior was *activity synchronization*. Given that period 1 signified the beginning of the project, members wanted to ensure that they communicated and established norms for completed the project tasks. Many teams utilized the Webex platform to engage in a real-time conversation with the aim of institute these norms. For instance, one team spent six minutes discussing the need to use Basecamp as a central repository for all project-related information. During the conversation, one member noted: “It’s like GoogleDrive. It's where we will upload and share all project files.” In this way, this conversation served to synchronize member contributions to the project moving forward. Other teams demonstrated activity synchronization in discussing and determining how they planned to synchronize coordination across the different technology platforms that were available. On a GoogleGroups email thread, one member explained: “Also, we need to upload the two assignments on Base camp as word documents, not google drive documents. I’ll go ahead and resubmit those now.” Similarly, a member from a different team noted the following in a Basecamp discussion thread: “We need to establish a main mode of communication rather than switching between three constantly."

Each of these instances reflects team members utilizing technological means to engage in behaviors that are essential to team success. It is evident that process facilitation was commonly displayed in period 1; students used technology to facilitate process behaviors that have been established in the literature as critical aspects of team functioning.

Process Expansion. During period 1, teams also exhibited a variety of behaviors that demonstrate how technology uniquely extends the realm of possibility for team actions. These behaviors reflected instances in which the material capability of the tools enabled interactions that could not have been carried out without leveraging the capabilities of technology. These process expansion behaviors were quite prevalent in period 1.

Teams frequently engaged in *automated coordination facilitation*, typically via a variety of platforms. These behaviors enabled members to automate their coordination of processes, deadlines, and assignments. For instance, multiple teams scheduled Webex meetings, and subsequently set up automatic notification emails designed to remind team members that they had an upcoming meeting. Other teams utilized the “To-Do” list function in Basecamp to distribute automated reminders about the deliverable due dates for the reminder of the project. In each circumstance, teams used these automated coordination devices to free up resources to focus on other aspects of the task.

Teams also came to quickly leverage the asynchronous benefits of certain technology platforms. In particular, certain teams overtly recognized that technology allows team members to *bridge time*; that is, team members leveraged the fact that the functionality of particular platforms allowed them to work on and contribute to the project on their own time. For instance, while scheduling a Webex meeting in a Basecamp discussion thread, one member explained:

> "We don't have to be together [in the meeting]; we will be officially meeting Thursday at 9 pm on WebEx - which is recorded, and Aisana & whoever else who can't make it can watch on their own time:)"

Other teams exhibited similar bridging time behaviors by working according to their own schedules. During a Basecamp discussion thread, one member stated:

> "Here's the link for the team charter document. Some of us are working on it tonight. If anyone has time to work on it, please check to see if you can add anything when you can."

Other teams recognized the importance of being able to work together synchronously across geographic boundaries (e.g. *Bridging Space*). For instance, many teams hosted WebEx meetings in which all members contributed to the completion of the team chapter and topic selection summary in real-time.

Teams also frequently displayed *interaction variability* during period 1. Many teams switched between technological platforms so as to leverage their different capabilities to accomplish taskwork in an efficient manner. During a WebEx meeting, one team utilized the shared screen function so that all team members could complete a scheduling poll via the online platform whenisgood.com. This team recognized that

WebEx itself does not possess a schedule polling function, and accordingly incorporated another tool into their coordination process order to utilize this capability. In a Basecamp discussion thread, another team discussed the benefits of switching between tools so as to maximize collaboration efficiency. During this thread, one member suggested:

> "There is a good texting app called GroupMe that allows us to send messages to the group, but is a lot easier [than texting]. Instead of typing out everyone's number when texting to the group, you just need to text to one number and it sends to everyone. It is like google groups for texting."

Each of these examples reflects instances in which behavior and technology are intertwined in such a way that the technology is giving rise to unique and effective team process actions.

Process Impairment. Teams also experienced a fair amount of process impairment during period 1. This was likely due to the fact that it was the beginning of the project and many team members were not entirely familiar with the tools at their disposal. This lack of *familiarity* was evident particularly during the beginning of WebEx meetings. For example, one team spent over 16 minutes on figuring out how to utilize the tool itself and ensuring that everyone could hear and contribute to the meeting. This lack of familiarity was epitomized by quotations such as “Can you hear me?” and “It’s working, why can’t you see me?”

Teams also experienced some technological breakdowns in period 1. These issues seemed to be centered on the use of WebEx. For instance, one member wrote on a Basecamp discussion thread: “Is everyone on [WebEx]? I just got kicked out and can't log back on." Another noted: “Sorry I missed the meeting yesterday--my computer is having issues and it won't turn on anymore."

These circumstances reflect the fact that, particularly during this first period of work, technology also introduced hindrances to process. Teams were then forced to work to overcome these breakdowns in team coordination that were unique to the tools and how members utilized them.

Qualitative Instances of Process Sociomateriality – Period 2

The second team deliverable was a behavioral observation write-up. In order to accomplish the task, teams first conducted an unobtrusive observational study of individuals engaging in behavior that was detrimental their chosen ecological topic area. Then, teams disseminated their findings in an APA-style write up. The duration of this task period was 21 days. Table 52 displays exemplar instances of process sociomateriality behaviors that were displayed during period 2.

Table 52.

Sample Instances of Process Sociomateriality Behaviors Displayed during Period 2

Process Sociomateriality Dimension	**Behavioral Indicator**	**Instance/Quotation**	**Platform**
Facilitation	Activity Synchronization	"1) Do any of the Tech students have a car to get us to Home Depot? 2) When do we want to do the next Web Ex meeting because of spring breaks?"	Basecamp Discussion Thread
Facilitation	Team Monitoring and Backup Behavior	"So I saw on the google drive that georgia tech people observed people throwing away aluminum cans and plastic bottles. In our first paper we said we were only doing plastic bottles."	GoogleGroups Email Thread
Facilitation	Role and Task Assignment	"You guys should start on intro and method, and we'll contribute to results"	WebEx Meeting
Facilitation	Motivation and Confidence Building	Opened the meeting with 11 minutes of small talk before taskwork	WebEx Meeting
Expansion	Creating Artifacts	Uploaded multiple documents to basecamp containing notes on the data collection, write-up materials, drafts of deliverable 2	Basecamp
Expansion	Interaction Variability	"The meeting webex app is temporarily unavailable apparently. Things we can do without meeting: 1) GMU/George or Amen - can you write up the method section as outlined in the rubric? […]"	Basecamp Discussion Thread
Expansion	Interaction Variability	“"I'm going to go ahead a make a google doc for this [paper template], while we're still chatting so that we can make sure we're all on the same page."	WebEx Meeting
Expansion	Bridging Space	All team members shared their videos	WebEx Meeting
Expansion	Automated Coordination Facilitation	Created calendar event to distribute automatic reminder about Deliverable 2 deadline	Basecamp
Impairment	Familiarity	"To avoid any webex confusion, whoever opened up the meeting last time...please open it again this time. Thanks!"	Basecamp Discussion Thread
Impairment	Preference	"hey guys can we pls do a group me or something other than this? this is a terrible communication system!"	Basecamp Discussion Thread
Impairment	Technology/Process Mismatch	Team only used the chat function during a WebEx meeting – did not speak over audio	WebEx

Process Facilitation. Process facilitation behaviors were again quite prevalent throughout period 2 of the project. One of the most prominent indicators of process facilitation was *activity synchronization*. The behavioral observation task required that all team members across the two universities collect observational data at similar locations during the same time of day. This required members to utilize technology to ensure that all task behaviors were coordinated and synchronized. For instance, one team member wrote the following on a Basecamp discussion thread: “1) Do any of the Tech students have a car to get us to Home Depot? 2) When do we want to do the next WebEx meeting because of spring breaks?"

Another team engaged in a 20-message discussion thread concerned with setting up a meeting and place for the behavioral observation. Yet another team used a Basecamp discussion thread to coordinate the completion of deliverable two:

> "This thread was created for us to discuss the requirements of deliverable 2. It might be helpful if everyone goes through the whole list of questions and requirements and post their thoughts on them in this thread so the whole group can begin to decide on the best parameters."

Teams also frequently displayed *team monitoring and backup behavior* in period 2 as they carried out the behavioral observation and the associated write-up. In these instances, team members utilized technology to observe task progress, and leveraged this information towards enhancing process effectiveness. On a GoogleGroups email thread, one member wrote:

> “So I saw on the google drive that georgia tech people observed people throwing away aluminum cans and plastic bottles. In our first paper we said we were only doing plastic bottles.”

Similarly, a member of another team noted the following on a Basecamp discussion thread:

> “Hey guys, I haven't seen any progress on here with deliverable 2. We need to upload all the observation data so we can analyze it and write about it. I made a spreadsheet and added the link to the Google documents list, as well as a document where we can start writing the paper. We only have 2-ish more days to do this. :)"

Teams also utilized technology to engage in *role and task assignment*, particularly when it came to completing the final deliverable 2 write-up. For instance, one group member wrote the following on a GoogleGroups email thread:

> "We've [the Ecology students] started working on the paper and we've completed most of the introduction as well as the results and methods. We'll need to get you guys to write the methods and results for your observation to add to what we have. If you guys [the Social Psychology students] could also write about the social psychological stuff in the discussion that would be great!"

Likewise, a member from a different team also wrote the following on a GoogleGroups thread:

> “Okeydoke, I’ve made all my edits. My fair share I’d say. I moved one part that was in the results section to the discussion part since it seemed like more of an

analysis than concrete data. Anna or Daniela, Could you go through the discussion section further and incorporate more GT info?”

Yet another team held a discussion during a WebEx meeting that centered upon allocating work amongst the team members. For instance, during this interaction one participant suggested: “You guys should start on intro and method, and we'll contribute to results."

Motivation and confidence building was also quite evident during period 2. For instance, one team began their WebEx meeting by engaging in 11 minutes of small talk before actually discussing the task at hand. This activity allowed the team to establish a positive and supportive team atmosphere, which heighted subsequent task engagement. Each of these examples demonstrates that completing deliverable 2 required teams to engage in fundamental process behaviors that were be facilitated or constrained by technology.

Process Expansion. Process expansion behavior became increasingly prominent during period 2. A plausible explanation for this increase is that teams utilized period 1 to understand the functionality of the various technological platforms, and subsequently learned to leverage these capabilities to enhance their behaviors in period 2.

Simultaneous collaboration was quite common during period 2, particularly towards the end of the period. During this time, many teams used GoogleDocs to complete the deliverable 2 write-up. This platform enabled multiple members to contribute to the formation of their write-up in real time, rather than in a sequential fashion. This behavior allowed teams to construct their documents in a synthesized manner by drawing from and building upon each other’s ideas in real-time.

A central aspect of deliverable 2 is that it required the teams to document behavior relevant to their ecological issue by collecting observational data. In order to disseminate findings, many teams *created artifacts* of their data collection efforts. Multiple teams created a variety of documents to serve as visual representations of their observational data collection, such as notes from the data collection, spreadsheets containing findings, and other materials for the write-up, and uploaded them to their Basecamp account. This action enabled all team members to review and develop a shared understanding of the taskwork.

Interaction variability was also invoked as a common means of accomplishing taskwork in an efficient manner in period 2. During a WebEx meeting, a member from one team stated the following: “I'm going to go ahead a make a google doc for this [deliverable template] while we're still chatting so that we can make sure we're all on the same page." This action enabled this particular team to simultaneously leverage the real-time interaction capabilities of WebEx with the word processing capabilities of GoogleDocs so as to maximize collective productivity. Members of another team switched to a Basecamp discussion thread to engage in taskwork in order to avoid process loss:

> “The meeting webex app is temporarily unavailable apparently. Things we can do without meeting: 1) GMU/George or Amen - can you write up the method section as outlined in the rubric? The GA Tech members will need this asap for them to provide the proper human behavioral statistics and analysis portion of this deliverable...."

As in period 1, teams also persisted in capitalizing on the *automated coordination* capabilities of technology. Many teams set up WebEx meeting reminders to be distributed via email to ensure that all members were notified of upcoming meetings. Other teams also utilized the calendar functionality of Basecamp to set up automatic reminders about the observational data collection and deliverable 2 deadlines.

Finally, a more subtle indicator of process expansion could be observed in many teams' propensity to *bridge space*. Many teams recognized the geographic boundaries that separated the two subgroups of students that comprised each team, and thus took necessary steps to attempt to mitigate the impact of distributed collaboration. For instance, during a WebEx meeting, one team ensured that all team members activated their video-sharing capabilities to an effort to establish interpersonal presence.

Process Impairment. There were notably fewer instances of process impairment that arose from lack of familiarity with the technology in period 2. However, differences in technological preference did seem to engender some process difficulties. For instance, on a Basecamp discussion thread, one team member requested: “hey guys can we pls do a group me or something other than this? this is a terrible communication system!"

Additionally, a member from a different team noted the following in a GoogleGroup email thread:

> "Just to let you guys know you there are two separate Deliverable 2 google docs that are being worked in at the moment. Can we please consolidate to one to save some sanity and time? There is one that is in the Team 4 folder and one that was just created and is not in a special folder. I suggest we consolidate to the one that is in the Team 4 folder."

Each example indicates that, at times, team members may have acted according to differential technological use preferences, resulting in potential process loss. Thus, in these instances, teams needed to allocate their attentional resources towards overcoming these potential taskwork inefficiencies.

Qualitative Instances of Process Sociomateriality – Period 3

The third team deliverable was an attitude survey write-up. This task involved 1) constructing a 20-item survey designed to assess human attitudes about the ecological issue and relevant human behavior, 2) administering the survey to a minimum of 40 individuals from the general population, 3) analyzing and writing-up the findings in an APA-style paper. The duration of this task period was 16 days. Table 53 displays sample instances of process sociomateriality behaviors that were displayed during period 3.

Table 53.

Sample Instances of Process Sociomateriality Behaviors Displayed during Period 3

Process Sociomateriality Dimension	**Behavioral Indicator**	**Instance/Quotation**	**Platform**
Facilitation	Role and Task Assignment	"Intro: Allison (Me), Methods: Allison (Me), Results: Ben, Discussion: Danny, Antoine?So Chad, Marc, and Sarah just pick a section to double up on and let us know what you decide!"	Basecamp Discussion Thread
Facilitation	Activity Synchronization	32 message discussion about the structure of deliverable 3 paper	Basecamp Discussion Thread
Facilitation	Motivation and Confidence Building	"Hey Morgan, It looks good to me. Thanks for putting it together! Have a great day team!"	GoogleGroups Email Thread
Facilitation	Idea Evaluation	Discussion thread about evaluating different survey items for the attitude survey	Basecamp Discussion Thread
Facilitation	Motivation and Confidence Building	"Guys, please make your questions so I don't have to do all of them by myself! It'll be so much easier if everyone participates!"	Basecamp Discussion Thread
Expansion	Interaction Variability	"I agree. Do we want to start posting [the survey link] to our facebooks? I know I can also send mine out to my sorority email list as well."	Basecamp Discussion Thread
Expansion	Simultaneous Collaboration	While meeting on webex, shared a screen with the google doc containing deliverable 3 write-up so that everyone could edit and discuss their edits in real time. Wrote the whole paper this way.	WebEx Meeting
Expansion	Interaction Variability	Used the whiteboard capability on webex to view project notes and discuss them in real time	WebEx Meeting
Expansion	Automated Coordination Facilitation	Set up automatic webex emails containing meeting reminders and basecamp calendar event reminders	WebEx/Basecamp
Impairment	Familiarity	"Hey guys, Deliverable 3 is due next Wednesday. Should we be distributing the survey through Facebook? If so, how does one do this?"	Basecamp Discussion Thread
Impairment	Technological Breakdown	"There's lots of static, can you hear me?"	WebEx Meeting
Impairment	Familiarity	"I just realized I've been talking for a few minutes but was on mute."	WebEx Meeting

Process Facilitation. The patterns of process facilitation in period 3 were similar to that of period 2. This was likely due to the fact that the task itself was similar, in that students again had to collect data (this time via an attitudinal survey) and summarize their findings in an APA-style write up.

Team members frequently utilized technology to engaged in *role and task assignment*, particularly when constructing deliverable 3. For instance, one team allocated work via a Basecamp discussion thread:

> "Intro: Allison (Me), Methods: Allison (Me), Results: Ben, Discussion: Danny, Antoine? So Chad, Marc, and Sarah just pick a section to double up on and let us know what you decide! Also, if you pick the methods section, note that it is not entirely complete yet!"

Likewise, another team orchestrated a similar discussion via a GoogleGroups email chain:

> "So how are we going to split this up? Tech – Discussion section bc you guys did it last time so may have a better grasp at what to write and its mostly psych related Mason - Methods. Both Tech and Mason - Results How does that sound?"

Activity synchronization was also prominently displayed as teams orchestrated their efforts towards data collection and dissemination. Many teams utilized Basecamp discussion threads to update each other on their respective tasks to ensure that all efforts were coordinated appropriately. The following is an exchange between two team members reflecting the synchronization of their effort in completing the deliverable 3 write-up:

Student A: "Ok cool, I'm on it, I have it in a word Document that I'm making changes to. Let me know when you're done revising. "

Student B: "cool, I've got a few pages and about 5 sources for the discussion portion. I'm working to finalize it all in the next hour or so. With works cited it should be just about 8 "

Student A: "We are at 8 pages with the updated methods section that you just finished and the references section. I am going to tie together what I have and post it as a Word Doc. If you want to change it then you can down load it and up load as a FINAL again so we get credit."

Teams also utilized technology to engage in *idea evaluation*, particularly with regard to survey construction and administration. For instance, one team discussed survey administration options via a Basecamp discussion thread:

Student A: "should we survey electronically or physically? We would have a uniform survey to give out or send out, and I volunteer to combine all the data."

Student B: "I'm in favor of electronically, makes it easier to distribute and will (most likely) help with the data collection/assembly."

Likewise, another team evaluated the quality of different attitudinal survey items in a 32-message exchange via Basecamp. Yet another team held a WebEx meeting to evaluate the appropriateness and relevance of various social psychology theories as plausible explanations for their survey findings.

Process Expansion. Process expansion behaviors were readily implemented in period 3. To begin with, this period was marked by a significant amount of *interaction variability*. Many teams utilized different electronic survey platforms to administer their attitudinal surveys to the general population, and consequently switched between coordination platforms (e.g. Basecamp, GoogleGroups) and survey platforms on a consistent basis in order to maximize productivity. One team member utilized a Basecamp discussion thread to share a link to an online survey:

> "Hey everyone, I just made an online survey with the majority of our questions on there. I haven't launched the survey yet because I wanted all of you guys to see it and have the opportunity to edit it. To see and edit the survey: [link]"

This particular team member was aware that Basecamp lacked the functionality to build a survey, but leveraged its mass communication capabilities to direct team member to the survey platform.

Teams also displayed interaction variability when constructing deliverable 3. One team held a WebEx meeting to work on deliverable 3 in real time. During the meeting, all members developed and edited the deliverable in a GoogleDoc. Throughout the meeting, members discussed edits to the GoogleDoc over WebEx as they were occurring. In this circumstance, the team leveraged the synchronous communication capabilities of WebEx with the *simultaneous collaboration* capabilities of GoogleDocs to maximize efficiency.

Many teams also continued to use the *automated coordination* capabilities of the WebEx and Basecamp platforms. Teams frequently set up meeting reminder emails via WebEx, while others also used both the calendar and to-do functionality to generate repeated notifications about upcoming task demands for deliverable 3.

As with the previous two task periods, *bridging space and bridging time* behaviors were generally implicit in team interaction given that they frequently utilized a variety of technological platforms to interact across space and time. However, some teams overtly recognized these capabilities and embraced them to maximize teamwork. For instance, one team held a WebEx “meeting” in which the team members did not actually formally meet, but rather individually worked on separate tasks and asked questions over the WebEx call as they came up. Constructing such a work environment enabled team members to work together in real-time even though they were separated geographically.

Process Impairment. Process impairment was more prominent in period 3, compared to period 2, given that many teams incorporated new survey platforms into their technological repertoire in order to administer the attitude survey. Some teams were confronted with issues of technological *familiarity* as members learned how to use these new platforms. For instance, one member asked the following in a Basecamp discussion thread: "Hey guys, Deliverable 3 is due next Wednesday. Should we be distributing the survey through Facebook? If so, how does one do this?" Other teams did experience some *technology breakdowns* that hindered team process, particularly through WebEx. For instance, during a WebEx meeting one team member stated: “I’m getting lots of static, can you hear me?” The statement came occurred during an in depth discussion about the requirements of deliverable 3, and disrupted the conversation.

Qualitative Instances of Process Sociomateriality – Period 4

The final team deliverable was a persuasive poster. The poster was constructed to convey an advertising that could be funded and produced by an environmental group. The central objective of the poster was to frame the ecological issue persuasively while showing that the team’s research and ideas were creative and impactful. The duration of this task period was 12 days. Table 54 displays exemplar instances of process sociomateriality behaviors that were displayed during period 4.

Table 54.

Sample Instances of Process Sociomateriality Behaviors Displayed during Period 4

Process Sociomateriality Dimension	**Behavioral Indicator**	**Instance/Quotation**	**Platform**
Facilitation	Idea Evaluation	29 post chain about the design of a advertising campaign logo	Basecamp Discussion Thread
Facilitation	Motivation and Confidence Building	"Ushna, I like what you've done! I just think that maybe we should shorten what we put into the four sections. "	Basecamp Discussion Thread
Facilitation	Role and Task Assignment	Deliverable 4 is due Monday and I was wondering how we wanted to split it up. "	Basecamp Discussion Thread
Facilitation	Idea Generation	created a text doc for "brainstorming poster slogan and logo"	Basecamp
Facilitation	Activity Synchronization	Discussed what tasks relevant to the poster need to be finished and in what order	WebEx Meeting
Expansion	Simultaneous Collaboration	"Can you guys open the google document? I put everything for the poster in there. It would be good if we can all look at it and review it at the same time."	WebEx Meeting
Expansion	Creating Artifacts	Used whiteboard functionality to take notes about the persuasive poster	WebEx Meeting
Expansion	Interaction Variability	"I believe Kirby made a team logo, but he's not on this call." "Let me see if I can reach him through Groupme"	WebEx Meeting
Expansion	Interaction Variability	"karim and I are currently on google hangout and putting the poster together. please join”	Basecamp Discussion Thread
Impairment	Technology/Process Mismatch	Some individuals were using the chat functionality of Webex while others were talking in real time; two conversations were occurring independent of each other.	WebEx Meeting
Impairment	Preference	"Hi all, I've posted the survey on the Facebook page but I'm posting it here in case some of you don't check Facebook that often."	Basecamp Discussion Thread

Process Facilitation. A central aspect of period 4 was to develop an advertising campaign designed to mitigate detrimental ecological behavior (by drawing from the ideas gathered during the previous deliverables). Accordingly, many teams developed slogans and logos to help brand their respective campaigns. In order to accomplish this objective, these teams frequently utilized technology to engage in *idea generation* and *idea evaluation* to facilitate the development of their campaign ideas. For instance, one team engaged in a 29-message discussion thread via Basecamp in which members posted various ideas for their advertising campaign logo. Another team used a Basecamp discussion thread to choose between one of two slogan ideas:

> "As for the slogan, I don't know if "Every bit counts!" is set but I like it a lot better than "to hell with trash". Our project is about recycling and reusing trash rather than just banishing it."

Yet another team created a text document using Basecamp’s text doc functionality to brainstorm the poster slogan and logo.

Motivation and confidence building was also evident during period 4, as team members encouraged each other to remain engaged as the project was drawing to a close. One member used a Basecamp discussion thread to positively reinforce another member’s contributions while providing her feedback: “Ushna, I like what you've done! I just think that maybe we should shorten what we put into the four sections. " Similarly, at the beginning of period 4, a member of another used a Basecamp discussion thread to motivate other members to complete this final task: “Good Job Team on the third deliverable. We nailed it! Just one more to go!"

As with prior periods, teams also frequently used technology to engage in *role and task assignment* in an effort to complete the persuasive poster. For instance, at the beginning of the period, one team member wrote the following in a Basecamp discussion thread: "Hey team, Deliverable 4 is due Monday and I was wondering how we wanted to split it up. " Likewise, a member from a separate team utilized GoogleGroups to decide how the poster would be completed: "I'll volunteer to work on the logo and slogan and overall formatting of the poster. If you guys have any cool ideas, let me know!" Yet another team utilized WebEx to engage in role and task assignment. This particular team held a WebEx meeting to divide up tasks relevant to completing the final poster. The following is sample exchange from this discussion:

> Student A: "So how do we want to divide this up? Should someone develop the logo, and others can work on ideas for the slogan?"
>
> Student B: "I think it's a good idea to delegate those tasks, and then we should have one person put it all together."

Process Expansion. Process expansion was evident throughout period 4. Most teams designed and developed advertising campaign logos and slogans using various platforms, and utilized technology to create visual representations of their ideas (e.g. *artifacts*) that they then shared via Basecamp or GoogleGroups. Creating artifacts enabled others to view the current state of the logo, and offer their own suggestions towards improvement. Other teams created artifacts and offloaded ideas by documenting the collaborative process. For instance, one team used the whiteboard functionality in WebEx to take notes about the team’s progress on the persuasive poster during a WebEx meeting.

Simultaneous collaboration behaviors were more evident in periods 2 and 3 as teams frequently utilized GoogleDocs so that all team members could contribute to the formation of the behavioral observation write-up and the attitude survey write-up. However, despite this shift in task demands, simultaneous collaboration was still evident in certain teams during period 4. For instance, one team utilized GoogleDocs to simultaneously collaborate on the development of the persuasive poster: "Hey guys I've made a google doc where you can post the bullets for each section. Also feel free to contribute to the logo/slogan ideas." During a WebEx meeting, another team referenced the importance of simultaneously collaborating to effectively complete the persuasive poster: "Can you guys open the google document? I put everything for the poster in there. It would be good if we can all look at it and review it at the same time."

Interaction variability was also readily enacted during period 4. For instance, one team sought to switch between technologies in an effort to ensure that all members could contribute to a group meeting:

Student A: "I believe Kirby made a team logo, but he's not on this call."

Student B: "Let me see if I can reach him through Groupme"

In this example, team members utilized multiple forms of technological outreach in order to maximize the possibility of contacting a team member. A similar circumstance arose in another team, in which a team member used a Basecamp discussion thread to encourage other members to participate in poster edits in a GoogleDoc: "karim and I are currently on google hangout and putting the poster together. please join."

Process Impairment. There were relatively few instances of process impairment in period 4. However, there were some intriguing examples that bear mention. One team exhibited *technology/process mismatch* in which members were not utilizing technology in a manner that appropriately fit the demands of the task. In particular, this team attempted to hold a WebEx meeting to finalize the completion of the persuasive poster; however, one subgroup of team members utilized the instant message functionality of WebEx to communicate, while others engaged in a discussion in real-time via the WebEx audio channel. In order to maximize efficiency, the subgroup of individuals using the chat functionality should have engaged in the audio discussion to engender a rich discussion about the final deliverable rather than doing so via the less efficient instant message platform.

At this point in the project, the teams had worked together for approximately 6 weeks. However, issues surrounding member technological *preference* still arose. For instance, one team did not appear to have established salient technology use norms, resulting from ambiguity about member preferences. A member of this team noted the following in a Basecamp discussion thread: "Hi all, I've posted the survey on the Facebook page but I'm posting it here in case some of you don't check Facebook that often." This instance indicates that members of this particular team may have possessed different technology use preferences, resulting in unclear norms for communication.

Discussion

This study makes three principal contributions to the literature on team process. First, this work addresses recent claims that scholars must better acknowledge the role of materiality in team organizing principles (Leonardi, 2010; Orlikowski & Scott, 2008). This study sought to explicitly incorporate process sociomateriality behaviors into extant frameworks of team effectiveness (e.g. I-P-O model) by testing whether materially laden interactions impact team outcomes by shaping emergent states. Findings from the meditational analyses revealed support that process sociomateriality plays an important role in shaping team effectiveness. Results demonstrated that facilitation/expansion enhances team viability via team satisfaction and team trust. These findings lend support to the assertion that process facilitation and expansion behaviors cultivate positive collective affect, which in turn increases the extent to which individuals want to remain in the team. Findings also revealed that facilitation/expansion behaviors heighten team performance (solution effectiveness and solution implementability) via team satisfaction, team trust, and collective efficacy. These results indicate that process facilitation and expansion behaviors increase the degree to which individuals are satisfied with their team, trust each other, and believe in each other, each of which subsequently improve team performance. Taken together, these findings suggest that the manner in which teams utilize technology as part of their behavioral process can shape team effectiveness by impacting team satisfaction, trust, and collective efficacy.

Contrary to the hypotheses, results suggested that team identity shapes team viability and team performance (solution implementability) by positively enhancing facilitation/expansion. This intriguing finding suggests that team identity exhibits a more distal relationship with team performance, whereas the other affective states of team satisfaction and trust are more proximally related to team performance. Prior literature has indicated that distributed teams tend to base their team identity on team properties, such as goals or tasks (Ren, Kraut, & Kiesler, 2007; Rogers & Lea, 2005), rather than interpersonal interactions. Therefore, the teams in the present sample were more likely to form their team identity early in the project by drawing from these team properties. This objective/task-based collective identity then may have served as the foundation for subsequent team interactions. It follows that teams that exhibit stronger team identity (e.g. teams that more strongly internalize collective objectives) are more likely to utilize technology as part of their teamwork process given that it is an essential means of achieving collective objectives, which in turn will enhance team performance.

It bears mention that neither team cohesion nor motivation to work on behalf of the team acted as mediators between process sociomateriality and team effectiveness. It is evident that in each of the path models, both cohesion and motivation were positively related to team viability and team performance. This finding is consistent with prior research (e.g. Chiocchio & Essiembre, 2009; Van Knippenberg, 2000). However, facilitation/expansion did not significantly predict team cohesion or motivation to work on behalf of the team. This was likely due to the fact that these constructs exhibited strong relationships with themselves across Time 1 and Time 2, leaving little room for the predictive contribution of process sociomateriality.

The second principal contribution of this study was to demonstrate that, in many cases, process sociomateriality better predicts team outcomes than prior conceptualizations of the process-technology relationship. A key assertion of this work was that current frameworks of team process (e.g. Marks et al., 2001) overlook the role the materiality plays in shaping teamwork. Process sociomateriality explicitly addresses this limitation by embracing the inextricable linkage between member interactions and technological platforms, and asserting that team process is enmeshed with technology use. Findings revealed that, indeed, process sociomateriality better predicts team viability and team affective states (e.g. trust and satisfaction) than do Marks et al. (2001) team process measures.

This study also asserted that process sociomateriality would better predict team outcomes beyond the team virtuality perspective (e.g. de Guinea et al., 2012; Kirkman & Mathieu, 2005). Results demonstrated that process sociomateriality better predicts team viability, team affective states (e.g. team satisfaction, team trust, team cohesion), and motivation states (e.g. collective efficacy) than does team virtuality. Finally, empirical evidence also suggested that process sociomateriality better predicted these same team outcomes than the virtuality-as-a-moderator perspective (Bierly et al., 2009; Hakonen & Lipponen, 2008; Kirkman et al., 2004). These results lend credence to the assertions that each of these prior perspectives overlook key aspects of teamwork, and, as such, process sociomateriality better captures the team functioning of modern teams – particularly with regards to emergent states.

It is important to note that process sociomateriality did not account for incremental variance in team performance beyond team process, team virtuality, or the virtuality/process interaction. This implies that team performance is predicted equally well by these perspectives and process sociomateriality. The mediation analyses from this study revealed that, in general, process sociomateriality only indirectly impacted team performance by first shaping emergent states. Therefore, the fact that process sociomateriality does not account for incremental variance in team performance is not necessarily surprising given that process sociomateriality not generally exhibit a direct effect on team performance. Moreover, in many organizations, teams persist over time as they progress from one project to the next. While team performance will always be an important team outcome, team viability is highly relevant to those teams that endure over time. Thus, the significant findings regarding the positive impact of facilitation/expansion on viability are particularly insightful and relevant, as these insights can help inform and predict member stability and team durability over time.

An important insight from the meditational and incremental validity hypotheses was that process impairment appears to play a minimal role in shaping team functioning. Regarding the meditational hypotheses, process impairment did not impact team outcomes indirectly through emergent states. The relationships between process impairment and emergent states were weak, although typically negatively valenced. Moreover, very rarely did process impairment predict team outcomes at a statistically significant level after accounting for prior conceptualizations of the process-virtuality relationships. A possible explanation for these weaker effects (compared with the facilitation/expansion dimension) can be drawn from the qualitative analysis in Study 3. Although this analysis was illustrative in nature, the prominence of process impairment behaviors seemed to dissipate over the course of the project. This was likely due to the fact that team members became accustomed to using the various technological platforms, and the teams established effective technology use norms – thus minimizing the prevalence of process impairment over time. Process sociomateriality was only assessed later in the project (after deliverable's 3 and 4). However, it is possible that these effects may have been stronger early on the project. During the beginning phases of a project, teams seek to establish effective teamwork norms and may be more negatively impacted by process hindrances. Therefore, process impairment may be more predictive of team functioning during this time than in later stages of taskwork.

The final principal contribution of Study 3 was to highlight examples of the embodiment of process sociomateriality in data that was obtained from communication technology logs (e.g Basecamp, WebEx, GoogleGroups). This information was used to complement the perceptual data that was the focus of the primary hypotheses in Study 3, and provide objective behavioral insights into the manifestation of process sociomateriality. This effort highlighted qualitative instances of each of the process sociomateriality factors during each deliverable period. Examination of these qualitative examples revealed that the manner in which the process sociomateriality factors are embodied can shift depending on the task at hand, the technology that is used, and the placement of the interaction in the project timeline. The essential contribution of this effort was to demonstrate that process sociomateriality is a readily observable phenomenon, and can be investigated not only through perceptual data but also through communication technology trace data.

CHAPTER 8

GENERAL DISCUSSION

Team-based work has become a critical driver of organizational success. A substantial amount of research has therefore sought to uncover the factors that enhance and hinder team process. Despite its ubiquitous presence in the modern workplace, the use of communication technology (e.g. materiality) is notably absent from the conceptualization of team process. The present manuscript proposed that the use of communication technology is embedded in team process, and is fundamental aspect of team interaction. This work adopts the ontological lens of sociomateriality to suggest that communication technology use is an integral part of process. Consistent with the assertions of Poole and DeSanctis (1994), this ontological advancement asserts that team members appropriate technology to match their process needs, by using technology in ways that may or may not reflect the designer's original intentions. Embracing this conceptualization (*process sociomateriality*) will enable scholars on teams to closely examine how social interaction is embodied and enhanced through communication technology use, and how this phenomenon shapes team effectiveness.

Theoretical Contributions of the Program of Research

This program of research advanced knowledge on team process in three ways. First, this work advanced a theoretical framework that lays the foundation for the study of the inextricable linkage between technology and process. This effort advanced knowledge on modern teamwork beyond prior perspectives that have overlooked the role of materiality in teamwork (e.g. Marks et al., 2001), positioned the capabilities of technology as the primary determinant of team effectiveness (e.g. virtuality: Gibson &

Gibbs, 2006; Kirkman & Mathieu, 2005), or posited that communication technology use moderates the relationship between team interactions and team outcomes (Bierly et al., 2009; Hakonen & Lipponen, 2008; Kirkman et al., 2004). In particular, by adopting the sociomaterial lens, this work has asserted that modern teamwork is the result of the enmeshment of two forces. First, drawing from Adaptive Structuration Theory (DeSanctis & Poole, 1994; Poole & DeSanctis, 1990), team members exhibit agency by appropriating technology to engage in teamwork. This can occur in the form of accepting or rejecting technology, or via discovering varied uses for a particular technology. The second force is material affordance/constraint. Technologies possess certain structural and functional qualities that engender different types of member interactions. Taken together, this dissertation asserts that the constitutive entanglement of these two forces shapes the sociomateriality of modern teamwork processes.

Drawing from this lens, this dissertation found that process sociomateriality is embodied in three ways: 1) teams use technology to engage in processes that have been demonstrated to be important aspects of team functioning (e.g. process facilitation), 2) teams utilize technology to engage in behaviors that are uniquely enabled, scaffolded, and/or supported by technology (e.g. process expansion), and 3) teams engage in process behaviors to overcome impediments to process that arise out of the use of technology (e.g. process impairment). This taxonomy captures the manner in which member interactions and technology use are enmeshed, and can be used to inform future investigations of process in modern teams.

This framework builds upon the work of Poole and DeSanctis (1994), who advanced the framework of Adaptive Structuration Theory to posit that users may appropriate technology to engage in teamwork in two ways. Users may exhibit *faithful appropriation*, in which the tool is used in a manner that is consistent with the designer's original intentions. However, users may also display *ironic appropriation*, in which a tool is used in a way that deviates from the prescribed purpose of the tool. Similarly, this dissertation asserts that team members may exhibit agency by either using technology in a prescribed fashion or by using it to interact in novel ways. On the surface, it would appear that process facilitation behaviors closely align with the conservative nature of faithful appropriation, whereas process expansion behaviors align with the innovative aspects of ironic appropriation. However, this dissertation expands beyond this line of thought to assert that teams likely exhibit faithful or ironic appropriation in enacting both facilitation and expansion behaviors. Team members may exhibit agency in choosing from a variety of tools to engage in process facilitation behaviors, and in doing so, may appropriate these tools to match their process demands (e.g. brainstorming, activity synchronization, etc) in ways that may be consistent or inconsistent with the technology's original purpose. Similarly, members may faithfully appropriate tools to engage in process expansion behaviors (e.g. using a Google document to collaborate simultaneously), but they may also appropriate the tools in novel ways to engage in process expansion behaviors. For instance, teams may not actually host videoconferencing meetings to formally "meet" (even though that is the prescribed utility of such tools), but may instead use this tool to work on tasks on their own and ask each other questions as they arise in real time. Taken together, this dissertation has introduced the taxonomy of process sociomateriality to expand upon seminal perspectives on technology use (e.g. Adaptive Structuration Theory) to further elucidate our understanding of modern teamwork processes.

Second, this dissertation sought to improve the measurement of technology use in team settings. By drawing from the taxonomy developed in Study 2, this dissertation developed a reliable and valid psychometric measure of process sociomateriality that directly assesses the extent to which teams engage in sociomaterial process behaviors. This measure will allow researchers and practitioners alike to better capture the manner in which teams utilize technology to enable and augment teamwork. This advancement will enable researchers to better assess, and subsequent understand, the interactional dynamics within modern organization-based teams.

Finally, this dissertation demonstrated that the inextricable linkage between technology and process (as embodied by the construct of process sociomateriality) plays an important role in shaping team effectiveness. This effort has elucidated the manner in which process sociomateriality shapes important team outcomes. Moreover, this work has demonstrated that process sociomateriality better predicts team outcomes (particularly team emergent states) than prior perspectives on the team-technology relationship. The predictive insights gained from this dissertation can be used to better predict and understand team success and failure in modern organizations.

Practical Applications

This stream of research has developed a number of insights that are directly relevant to practitioners. To begin with, organizations are increasingly incorporating communication technology into the workplace in order maximize team efficiency and effectiveness. The technologies themselves are also constantly changing and evolving, resulting in a very dynamic and fast-paced teamwork requirements. Thus, it is in the best interest of practitioners and managers to comprehensively understand how technology use can help and hinder teamwork in modern settings.

This dissertation has highlighted that understanding the manner in which teams utilize communication technology as part of their teamwork is essential to understanding and predicting effectiveness. This work developed a taxonomy comprised of behavioral indicators that practitioners can use to identify the manner in which member interactions are tied to technology use. This taxonomy enumerates the different process behaviors that modern, technology-laden teams may exhibit. This framework provides managers with a catalogue of effective behaviors that they can teach their teams. Thus, insights gained from using this framework to identify process sociomateriality behaviors can be used to select content for team training modules designed to enhance teamwork. In particular, managers may leverage this information to train members on how to engage in various process facilitation and expansion behaviors in order to maximize team effectiveness. Likewise, managers can utilize the taxonomy to train members how to overcome the teamwork impediments that may arise from utilizing communication technology.

For instance, findings from this dissertation suggest that team managers should first take stock of the technologies and their associated functionalities available to the team. The manager should then use the taxonomy developed in Study 1 to select key sociomaterial behaviors that are critical to the task at hand, and develop training designed to teach these behaviors. For instance, such training could teach team members how and when to switch between communication platforms in order to maximize efficiency.

Drawing from the findings of this dissertation, managers may administer the overall scale, or they may administer a subset of the scale depending on their focal teamwork interest. In order to assess both positive and negative instances of technologically embedded behavior, managers should administer the full scale. In this circumstance, given their high correlation, the facilitation and expansion dimensions should be averaged, and the impairment scale may remain as a separate factor. Administering the overall scale can be an effective means of examining the technology use practices that are prevalent within a given team. However, managers with more targeted aims would be served to administer only one scale that assesses a particular process sociomateriality dimension. For instance, managers may wish to build trust within a distributed team. Given that the present study found that process facilitation/expansion shapes team trust, an important for step would be to gauge the frequency process facilitation and process expansion behaviors by administering the PSS. Likewise, managers may also administer the PSS to examine whether team members are struggling to use technology to interact, and if so, detect the specific sources of these hindrances.

Practitioners can leverage these insights towards understanding team interaction norms, and subsequently identify areas in need of improvement. For example, managers may wish to examine whether their teams are using technology to engage in effective, proactive behaviors (such as role and task assignment, simultaneous collaboration, interaction variability), or if they are spending the majority of their time attempting overcome issues that arise from technology use. In particular, managers can administer the process sociomateriality scale to examine the distribution or relative frequency of these behaviors, and subsequently train members how to better enact positive teamwork behaviors when interacting via technology.

Using this instrument will enable practitioners to provide practical recommendations to their teams designed to improve team communication and interaction. Moreover, these recommendations highlight the fact that, rather than simply focusing on training members about the functionality of technology, managers should take it a step further and teach members how to actually engage in teamwork by using a variety of tools. For example, if a team were provided with a suite of tools including WebEx, Basecamp, and GoogleGroups, training could focus on not only the functionality of these tools, but how team members can enact certain sociomaterial behaviors by using these tools – such as idea generation, automated coordination facilitation, and artifact creation. Thus, this dissertation asserts that technology training protocols should be adjusted to incorporate recommendations specific to sociomateriality process behaviors.

Limitations and Future Research Directions

This dissertation presented a program of research designed to develop and test the construct of process sociomateriality. In doing so, this work has shed light on a previously overlooked aspect of team process. However, despite the comprehensive nature of the research program, this work is not without its limitations.

Sample. Study 1 utilized a sample of distributed project teams comprised of undergraduates to inform the development of the process sociomateriality taxonomy. This effort marked a necessary first step towards unpacking the conceptual space that encompasses process sociomateriality. In examining the findings across the three studies, the construct of process sociomateriality appears to be theoretically robust, but could be further bolstered if examined in other samples. For instance, organization-based teams may demonstrate markedly different technology-relevant behaviors due to different environmental contingencies, as compared with the undergraduate teams. To this end, it would be appropriate to conduct a critical incident study (e.g. Study 1) in other settings to assess whether the construct emerges in a similar fashion.

Study 3 also utilized a sample of undergraduates to test the criterion-related validity of the process sociomateriality construct. This effort provided informative insights into the manner in which process sociomateriality relates to models of team effectiveness. However, it is possible that undergraduates may exhibit different technology use norms than other populations, particularly workers in modern organizations. Therefore, in order to strengthen the external validity of the Study 3 findings, future work should examine the criterion-related validity of process sociomateriality in samples of teams that operate within organizational settings.

Technological Platform. In addition, Study 1 gauged perceptions of process sociomateriality based on a relatively narrow form of communication technologies – new media. This helped focus the participants on a tangible set of technologies in order to closely examine the manner in which process sociomateriality was manifested. Moreover, the term ‘new media’ encompasses the majority of communication technologies that teams utilize to engender interaction. Given that this program of was cumulative in nature, Studies 2 and 3 also focused on new media as the principal technological platforms of interest. Thus, it is possible that certain technologies that modern teams utilize fell outside the scope of new media. In addition, Study 3 provided students with three platforms in enable their interaction (Basecamp, GoogleGroups, WebEx). Given that Study 3 was a quasi-field study, teams were able to use technologies outside this suite of tools. Future work should investigate the extent to which insights gathered from the present work apply to a variety of other technologies.

Process Facilitation/Process Expansion. A central assertion of this dissertation is that process sociomateriality is embodied in team in three primary ways: 1) teams used technology to enable process routines (process facilitation), 2) teams use technology to expand the types of behaviors they may exhibit (process expansion), and 3) teams work to overcome hindrances that are unique to the use of technology (process impairment). Findings from Studies 2 and 3 revealed that process facilitation and expansion are highly correlated phenomena.

There are three potential explanations for this finding. The first two are conceptual in nature. Leonardi (2012) suggested that material and social forces constantly shape each other through the process of imbrication. In particular, teams may first use a particular technology to accommodate prior social practices or routines (e.g. process facilitation), whereas this technology may also subsequently open the door to interacting in novel ways (e.g. process expansion). Thus, perhaps it is that each of these forces are highly related phenomena, and are so thoroughly enmeshed that they may be difficult to tease apart. In addition, LePine et al. (2008) found that team process factors are traditionally very highly correlated given that they are generally depict interactive behaviors that are beneficial for teamwork. Thus, there is theoretical and empirical precedent for the strong relationship between process facilitation and expansion.

The more methodological explanation for this finding is that the construction of the process sociomateriality measure did not enable participants to sufficiently discriminate between facilitation and expansion behaviors. This assertion is supported by the high scale reliability across all items and dimensions of the scale. However, findings from the exploratory qualitative analysis of the Study 3 communication data logs did reveal some support for the differential manifestation of facilitation and expansion behaviors. This would suggest that perhaps there is an observable difference in these factors, but that the process sociomateriality measure does not yet adequately capture this discrimination. Thus, future efforts could seek to refine the facilitation and expansion items such that they better differentiate from one another. Subsequent work could then attempt to tease apart and test these factors as relatively unique phenomena.

Mediation. Study 3 tested whether team emergent states mediate the relationship between process sociomateriality and team performance/viability. In many cases, findings revealed support that facilitation/expansion impact performance and viability via emergent states. However, significant mediation was only found within the time 2 variables (e.g. time 2 facilitation → time 2 emergent states → performance/viability). Researchers have asserted that mediation is most strongly supported when there is temporal precedent between the predictor, mediator, and outcomes (James & Brett, 1984). Unfortunately, results from the path analyses revealed that the cross-lagged relationships were not supported (e.g. time 1 facilitation/expansion → time 2 emergent states). This is likely due to the fact that emergent states were so strongly related to themselves across the two time points, leaving very little room for prediction in emergent states beyond their autoregressions. This dissertation argues that, although this does limit causal inference between the predictor and mediator, the incorporation of multiple measurement time points into the present does present advancement beyond traditional cross-sectional designs – thus strengthening inferences of mediation. Nonetheless, future research should further examine these mediation effects within longitudinal designs.

Study Setting. Studies 1 and 3 were carried out using quasi-field studies. The use of this study setting enabled this research to be implemented in an authentic team setting, which enhances the generalizability of these findings. Nonetheless, the field setting does limit the ability to control and manipulate key study variables. Teams in Study 3 were provided with a suite of communication technology platforms; however, students were ultimately free to utilize any tools they wanted. Thus, Study 3 could not directly control for technological platform choice when examining the effects of process sociomateriality. Future experimental research could constrain participant teams to a defined set of technological platforms, thus controlling for technology use differences across teams, which would enable a more robust understanding of the effects of process sociomateriality behaviors.

The Structure of Process Sociomateriality. This program of research centered upon the *content* of process sociomateriality, that is, the behaviors that comprise the phenomenon. This endeavor was a necessary first step to elucidating and establishing the phenomenon of process sociomateriality. However, recent work on teams has suggested that researchers must also consider the *structure* of team process. Crawford and LePine (2013) called for the study of patterns of team interaction by emphasizing the compilational nature of process. Their framework discusses the importance of considering the configurations of member-member interactions, in addition to the content of teamwork. The present dissertation aimed to capture the *content* of process sociomateriality via traditional psychometric methods; however, these efforts would be further complemented by also considering the *structure* of process sociomateriality.

The first critical step would be to examine process sociomateriality through a compilational lens by investigating whom members interact with via technological platforms. For instance, such items could ask “who do you brainstorm project ideas with via technology?” or “who do you simultaneously collaborate with in real time via technology?” Leveraging these items would allow researchers to analyze configurations of process sociomateriality behaviors in teams, and how these structures shape team functioning.

However, it would also be fruitful to examine the linkage between members and different technologies. The foundation of sociomateriality draws heavily from Actor-Network theory, which posits that social interaction involves both people and technology (Callon, 1986; Latour, 1991). This view suggests a move away from investigating the manner in which technologies influence teams, towards a more fine-grained investigation of the patterns of interaction between members and technologies (Leonardi, & Barley, 2010; Orlikowski, 2010). Similar to the social-network perspective embraced by Crawford and Lepine (2013), Actor-Network theory emphasizes systems of relationships between entities (e.g. networks: Contractor, Monge, & Leonardi, 2011). From both perspectives, a network is comprised of entities (nodes) and the relations (ties) among these entities (Wasserman & Faust, 1994). However, whereas the structural theory of process set forth by Crawford and LePine (2013) centers upon networks comprised of one type of entity (e.g. unimodal), Actor-Network theory seeks to capture networks comprised of humans and technologies (e.g. bimodal). The latter type of network is referred to as “multidimensional” due to the presence of multiple modes, or classes of entities, in the network (Borgatti & Everett, 1997).

Utilizing multidimensional networks that contain both members and technologies would allow teams researchers to improve our understanding of the ever-present role communication technology plays in member interactions. This conceptualization embraces the notion that technology is embedded in behavioral process by virtue of the fact that communication technology and team members are positioned as part of the same network. Moreover, the focal unit of interest is not team members or technology, but rather the tie between them. Therefore, this multidimensional framework supports the assertions of sociomateriality in that humans and technologies equivalently shape interactions (Contractor et al., 2011). This form of investigation would appropriately capture how multiple team members utilize multiple communication tools to facilitate process.

Importantly, this future research direction would enhance our understanding of the structure of the process-performance relationship. Capturing this aspect of process would allow us to account for: 1) the manner in which members spread interactions across multiple communication tools and 2) which tools are utilized to facilitate interaction. Such theory can posit that, given finite attentional resources and limitations in member ability to manage multiple communication tools, certain member-technology configurations may be more advantageous than others.

Trace Data. Teams researchers have long heralded the importance of gaining objective, longitudinally-driven insights into team functioning beyond that which is provided by perceptual measures. Unfortunately, the majority of work within the realm of psychology still heavily relies on cross-sectional, perceptual views of team process. However, the prevalence of communication technology in teams, paired with their subsequent digital traces (e.g. Williams, Contractor, Poole, Srivastava & Cai, 2011), has provided researchers with access to rich and longitudinal data that was not previously accessible. Insights gained from this trace data can complement those gained from perceptual assessments. Moreover, digital trace data represent discrete events as they occur over time, and such longitudinal data can help researchers to gain new insights into the interactions among groups.

Study 3 of this dissertation analyzed the digital traces of three tools (WebEx, Basecamp, and GoogleGroups) to gleam insight into behavioral process in novel and nuanced ways. However, this effort has only scraped the surface of using digital traces to understand team process. Future work should seek to leverage the inherent benefits of trace data to enhance our understanding of collective social behavior and organizing processes, and more importantly, to test theories of team processes (e.g. process sociomateriality) from a new angle.

A particularly informative advancement would be to leverage this information to develop a signature of process sociomateriality. In particular, this signature could reflect an index that captures the manner in which team members utilize different technological platforms and the fluidity of member switches between technological platforms. This index could be used to provide a more objective indicator of process sociomateriality behaviors, which could then be utilized as a predictor of essential team outcomes. This effort would also supplement the utility of the process sociomateriality scale.

Moderators. This dissertation developed the construct of process sociomateriality and sought to demonstrate that the construct shapes important team outcomes. Considering factors that may moderate the relationship between process sociomateriality and outcomes would further complement this work. First, future work should consider how the lifespan of the team shapes this relationship. In particular, analysis of the qualitative trace data logs from study 3 revealed that facilitation and impairment behaviors may have been more prominent at the beginning of the project, whereas expansion increased later on. Subsequent studies can examine and track exactly how these behaviors develop and manifest over the course of a team's lifespan.

Second, this line of thought can also be applied to specific performance episode. In Study 3 of this dissertation, teams completed four deliverables sequentially, each of which was completed within a defined performance period. It is plausible that the types of sociomaterial behaviors that teams exhibit change as teams shift from transition or planning processes to coordination or action processes within each performance episode. For instance, teams may utilize technology to engage in idea generation and evaluation during the planning phase, but shift to using technology to simultaneously collaborate in the action phase of the episode. Future work should examine the manner in which placement in performance episode shapes sociomaterial process.

Finally, future work should also consider how team type shapes the relationship between process sociomateriality and team outcomes. This dissertation tested the effects of process sociomateriality behaviors on team outcomes in a sample of science-based teams. Organization-based teams may engage in a variety of more applied tasks in which certain process sociomateriality behaviors (idea evaluation; simultaneous collaboration) may be less critical to team objectives. Thus, future work should examine how the nature of team impacts the manifestation of process sociomateriality behaviors, and how these behaviors impact performance.

Process Sociomateriality Factor Relations Over Time. This work examined how process sociomateriality shapes important team factors. However, it would also be fruitful to examine the interrelation of the process sociomateriality factors over time. For instance, does process expansion increase over the lifespan of a team as members become more comfortable implementing technology as part of their process? Does impairment decrease over time for the same reason? Moreover, how do the process sociomateriality factors shape each other across time? Perhaps, a prominent of process impairment at the beginning of the project would engender a hesitance in embracing technology, thus decreasing the propensity for process expansion behaviors later in the project. Likewise, perhaps embracing the novel capabilities of technology early on in the project through exhibiting process expansion behaviors will decrease impairment behaviors later in the project.

Individual Differences. An important consideration for future research is the role of individual differences in shaping process sociomateriality. This dissertation largely focused on the manifestation of process sociomateriality at the team-level; however, it is important to recognize that an individual team member initiates each sociomaterial behavior. As such, sociomaterial process behaviors are likely to be shaped by individual differences relevant to technology use. Participants in Study 3 of this dissertation were recruited from an undergraduate population, which is likely to possess a homogenous and high level of technological aptitude. However, in organizational settings, team members are more likely to differ in terms of age and technological use background. Future work should examine the extent to which this individual difference variability shapes member propensity to exhibit facilitation, expansion, and impairment behaviors.

Roles. Relevant to the topic of individual differences, it would also be interesting to examine how team members divide their project roles and how this classification impacts their technology appropriation. For instance, Carson and Tesluk (2007) posited that there appear to be four principle roles for team leadership: navigator, engineer, social integrator, and liaison. The navigator helps to establish the team's purpose and direction, and keeps the team focused on project goals; the engineer helps coordinate the team to accomplish project work effectively; the social integrator helps develop and maintain cohesiveness in the team, and helps manage conflict; and the liaison helps coordinate between the two teams in your taskforce. Given the prominence and ubiquity of technology in modern teamwork, it is logical that an additional role be added to this taxonomy: technology facilitator. This role encapsulates individuals who suggests technology tools for the team to use, and helps the team smoothly integrate their work and social interactions using technology. Future work should examine the emergence of these roles over time, and how they shape process sociomateriality behaviors.

Process vs. Outcomes. A central focus of this work was to capture how process sociomateriality is manifested. As such, the process sociomateriality measure was designed to gauge behavioral instances in which teams utilize technology to enable, expand, or overcome hindrances in their teamwork. However, it could be argued that the operationalization actually captures behavioral outcomes of process sociomateriality, rather than process sociomateriality itself. Put otherwise, does sociomateriality cause members to engage in these behaviors? Or are these behaviors reflective of sociomateriality itself? Future work should further investigate how can comprehensively capture process sociomateriality through leveraging a variety of data sources (e.g. psychometric, trace data).

Conclusion

Scholars have long placed ontological priority on either team interaction or technological capability as the primary driver of team functioning. This dissertation has asserted that technology is so ubiquitous in modern teamwork that team process cannot be fundamentally understood without considering how social action is embodied through, and expanded by, technological platforms. This work has introduced the construct of process sociomateriality to capture this inextricable linkage between technology and teamwork. The current program of research developed, validated, and tested this construct across three cumulative research studies. This novel line of inquiry sets the foundation for a number of promising avenues by which researchers and practitioners alike can better capture and understand teamwork in modern organizations.

APPENDIX A

STUDY 1 – CRITICAL INCIDENT STUDY PROMPT

Instructions: Please answer the following questions in paragraph format. Make sure to address each part (a, b, c, d) for each question.

Question 1: Please think about specific instances when the use of communication technology either helped or hurt the **teamwork within your [social analytics] team**.

1a. Think of an **instance** this semester when you and your teammates used a technology and it was EXTREMELY HELPFUL to the functioning of your team. Describe the following:

a) What was the technology? (Email, Webex, Basecamp, Facebook, etc.)
b) How did you/your teammates use the technology in this instance?
c) Why was the technology use HELPFUL to your team in this instance?
d) What did the technology allow your team to accomplish that would have been more difficult without the technology in this instance?

1b. Think of an **instance** this semester when you and your teammates used a technology and it was EXTREMELY HARMFUL to the functioning of your team. Describe the following:

a) What was the technology? (Webex, Basecamp, Facebook, Email etc.)
b) How did you/your teammates use the technology in this instance?
c) Why was the technology use HARMFUL to your team in this instance?
d) What did the technology prevent you from doing that you may have accomplished otherwise in this instance?

Question 2: Please think about specific instances when the use of communication technology either helped or hurt your **teamwork with the [business] team**.

2a. Think of an **instance** this semester when you and your teammates used a technology and it was EXTREMELY HELPFUL to the functioning of your team. Describe the following:

a) What was the technology? (Webex, Basecamp, Facebook, Email etc.)
b) How did you/your teammates use the technology in this instance?
c) Why was the technology use HELPFUL to your team in this instance?
d) What did the technology allow your team to accomplish that would have been more difficult without the technology in this instance?

2b. Think of an **instance** this semester when you and your teammates used a technology and it was EXTREMELY HARMFUL to the functioning of your team. Describe the following:

a) What was the technology? (Webex, Basecamp, Facebook, Email etc.)
b) How did you/your teammates use the technology in this instance?
c) Why was the technology use HARMFUL to your team in this instance?
d) What did the technology prevent you from doing that you may have accomplished otherwise in this instance?

APPENDIX B

MEASUREMENT BATTERY FOR STUDY 2

Consent and Demographics

CONSENT DOCUMENT FOR ENROLLING ADULT PARTICIPANTS IN A RESEARCH STUDY

Georgia Institute of Technology

Project Title: Teams and Communication Technology: Process Sociomateriality Measure Development
Investigators: Leslie DeChurch, Ph.D., and Peter Seely, M.S.
Protocol and Consent Title: Main 03/05/14v1
You are being asked to be a volunteer in a research study.

Purpose:

The purpose of this study is to understand how people use communication technology and new media to work in teams. We expect to enroll 500 people in this study.

Exclusion/Inclusion Criteria:

Participants in this study must be at least 18 years old. Individuals less than 18 years old may not participate.

Procedures:

You will be asked to complete a survey that is designed to gauge your experience using communication technology and new media in a team context. This survey will be completed online and anonymously. Participation in this research is completely voluntary, and you may withdraw at any time by closing the survey.
The survey should take approximately 15-20 minutes.

Risks or Discomforts:

The risks involved are no greater than those involved in daily activities such as working on a project team in an organizational setting.

Benefits:

You are not likely to benefit in any way from joining this study.

Compensation to You:

If you participated via mTurk, you will be compensation 10 cents (USD) for your time.
If you are a Georgia Tech student and participated via Sona Systems, you will receive 1.0 credit for completing the survey.
If you completed the survey via Facebook, you will not receive compensation.

Confidentiality:

The following procedures will be followed to keep your personal information confidential in this study: The survey will be completing is anonymous. The data collected about you will be kept private to the extent allowed by law. To protect your privacy, your records will be kept under a code number rather than by name. Your records will be kept in locked files and only study staff will be allowed to look at them. Your name and any other fact that might point to you will not appear when results of this study are presented or published. Your privacy will be protected to the extent allowed by law. To make sure that this research is being carried out in the proper way, the Georgia Institute of Technology IRB may review study records. The Office of Human Research Protections may also look over study records during required reviews.
You should be aware that the experiment is not being run from a 'secure' https server of the kind typically used to handle credit card transactions, so there is a small possibility that responses could be viewed by unauthorized third parties such as computer hackers. In general, the web page software will log as header lines the IP address of the machine you use to access this page, e.g.,102.403.506.807, but otherwise no other information will be stored unless you explicitly enter it.

Costs to You:

There are no costs to you, other than your time, for being in this study.

In Case of Injury/Harm:

If you are injured as a result of being in this study, please contact Leslie DeChurch, Ph.D., at telephone (404) 894-8903. Neither the Principal Investigator nor Georgia Institute of Technology has made provision for payment of costs associated with any injury resulting from participation in this study.

Participant Rights:

Your participation in this study is voluntary. You do not have to be in this study if you don't want to be.
You have the right to change your mind and leave the study at any time without giving any reason and without penalty.
Any new information that may make you change your mind about being in this study will be given to you.
You may print out a copy of this consent form to keep.
You do not waive any of your legal rights by participating in this survey.

Questions about the Study:
If you have any questions about the study, you may contact Dr. Leslie DeChurch, Primary Investigator at telephone (404) 894-8903, or 1-011-404-894-8903 (international) or dechurch@gatech.edu
Questions about Your Rights as a Research Participant:
If you have any questions about your rights as a research participant, you may contact Ms. Kelly Winn, Georgia Institute of Technology Office of Research Integrity Assurance, at (404) 385- 2175 or Kelly.Winn@gtrc.gatech.edu
By completing the online survey, you indicate your consent to be in the study.

- Accept/Reject

Demographics

1) What is your age?

    [Select from dropdown; 18-70]

2) What is your gender?
- Male
- Female
- Other

3) What is your highest education level?
- High School Diploma
- Some College
- Associate's Degree
- Bachelor's Degree
- Master's Degree
- PhD
- JD
- MD
- Other

4) What is your level of fluency in English?
- Fluent
- Conversational
- Basic
- None

Team Information

Think of an [effective/ineffective] team that you are currently on or an [effective/ineffective] team that you participated on in the past. The remainder of these items asks about your experiences on that team.

5) Please select whether you:
- Are currently on this team
- Participated on this team in the past

6) What kind of team is it?
- Leisure (Sports, video games, etc.)
- Academic (class project etc.)
- Work (decision-making, planning, project, etc.)
- Action (Firefighting, Emergency Management, etc.)

7) How many people are on your team?

    [select from dropdown 3-50]

8) How long was your team together?
- A few Hours

- A Few Days
- A Few Weeks
- A Few Months
- A Year or More

9) Please indicate what percentage of your teamwork was conducted via the following platforms (answers will total 100).

- Videoconferencing (WebEx, Skype Video)
- Audioconferencing (Phone, Skype without Video)
- Emails (Gmail, Hotmail)
- Project Management Platforms (Basecamp)
- Instant Messanging (Chat, SMS)
- Face-to-Face
- Other (enter response)

19) Please briefly describe your experience on this team. What types of tasks did you do? How successful was your team?

<u>Team Process (from Mathieu & Marks, 2006, 30 item version)</u>

Please answer the following questions using the scale provided

Transition Processes

To what extent does/did your team actively work to:

1= Not at all; 2= Very Little; 3= To Some Extent; 4= To a Great Extent; 5= To a Very Great Extent

<u>Mission Analysis</u>

*1. Identify our main tasks?

*2. Identify the key challenges that we expect to face?

*3. Determine the resources that we need to be successful?

<u>Goal Specification</u>

*1. Set goals for the team?

*2. Ensure that everyone on our team clearly understands our goals?

*3. Link our goals with the strategic direction of the organization?

<u>Strategy Formulation & Planning</u>

*1. Develop an overall strategy to guide our team activities?

*2. Prepare contingency ("if-then") plans to deal with uncertain situations?

*3. Know when to stick with a given working plan, and when to adopt a different one?

Action Processes

To what extent does/did our team actively work to …..

1= Not at all

2= Very Little

3= To Some Extent

4= To a Great Extent

5= To a Very Great Extent

<u>Monitoring Progress Toward Goals</u>

*1 Regularly monitor how well we are meeting our team goals?

*2. Use clearly defined metrics to assess our progress?

*3. Seek timely feedback from stakeholders (e.g., customers, top management, other

organizational units) about how well we are meeting our goals?
Resource and Systems Monitoring
*1. Monitor and manage our resources (e.g., financial, equipment, etc.)?
*2. Monitor important aspects of our work environment (e.g., inventories, equipment and
process operations, information flows)?
*3. Monitor events and conditions outside the team that influence our operations?
Team Monitoring and Backup
*1. Develop standards for acceptable team member performance?
*2. Balance the workload among our team members?
*3. Assist each other when help is needed?
Coordination
*1. Communicate well with each other?
*2. Smoothly integrate our work efforts?
*3. Coordinate our activities with one another?
Interpersonal Processes
To what extent does our team actively work to …..
1= Not at all
2= Very Little
3= To Some Extent
4= To a Great Extent
5= To a Very Great Extent
Conflict Management
*1. Deal with personal conflicts in fair and equitable ways?
*2. Show respect for one another?
*3. Maintain group harmony?
Motivating & Confidence Building
*1. Take pride in our accomplishments?
*2. Develop confidence in our team's ability to perform well?
*3. Encourage each other to perform our very best?
Affect Management
*1. Share a sense of togetherness and cohesion?
*2. Manage stress?
*3. Keep a good emotional balance in the team?

Process Sociomateriality (50-item measure developed for this study)
Please answer these questions using the following scale:
1= Not at all
2= Very Little
3= To Some Extent
4= To a Great Extent
5= To a Very Great Extent
To what extent does/did your team actively work to:
Idea Generation
1. Use new media to generate ideas?
2. Use new media for brainstorming?
Idea Evaluation

4. Use new media to come to consensus on project ideas?
5. Use new media when we need to agree on a solution?
6. Use new media to come to evaluate the pros and cons of different alternatives?

Activity Synchronization

7. Use new media to synchronize our work?
8. Use new media to coordinate with one another?
9. Use new media to ensure our parts fit together?

Role and Task Assignment

11. Use new media to assign tasks?
12. Use new media to plan who will do what?
13. Use new media to decide how to do our work?
14. Use new media to allocate work?
25. Use new media to divide and conquer?

Team Monitoring and Backup

15. Use new media to monitor our progress?
17. Use new media to ensure we are keeping our deadlines?
18. Use new media to keep tabs on each other?

Motivation and Confidence Building

19. Use new media to build a team bond?
20. Use new media to built rapport?
22. Use new media to create social connections with each other?

Process Expansion

To what extent does/did your team actively work to:

Simultaneous Collaboration

23. Use new media to allow multiple members to contribute to a task-related document at the same time?
24. Use new media so that we can work in parallel?

Creating Scaffolds/Artifacts

26. Use new media to create visual representations of our taskwork?
27. Use new media to convey our ideas using visuals and writing?
28. Use new media to document our ideas?

Automated Coordination Facilitation

29. Use new media to generate automatic notifications about task progress and deadlines?
30. Use new media to automate our scheduling and planning tasks?

Interaction Variability

32. Switch between multiple new media to accomplish taskwork?
33. Seamlessly switch between multiple new media platforms?
34. Shift to another media platform if the current one isn't working for us?
35. Frequently adapt our use of new media to meet our needs?

Bridging Time

37. Use new media to allow us to work together even if we work on different schedules?
38. Use new media to so that we can work during any time of the day?

Bridging Space

39. Use new media to collaborate across distances?

40. Use new media so that we can work from different places?
41. Use new media so that we can work together even when we are apart?

<u>**Process Impairment**</u>
To what extent does/did your team:
Familiarity
42. Struggle to work together because members have different levels of familiarity with new media?
44. Waste time trying to figure out how to use new media?
45. Struggle to work together more so than if everyone knew how to use new media?
Preference
46. Work to overcome teamwork problems caused by members having different new media preferences?
47. Work less well together than if we all preferred to use the same new media?
48. Struggle because we all like to use different new media?
Technology/Process Mismatch
49. Experience teamwork problems caused by using new media new media we use is not appropriate for the task we are trying to accomplish?
50. Encounter teamwork problems caused by trying to use new media for certain tasks?
51. Struggle to work together more so than if new media provided us with the functions we need?
54. Take longer to get things done because we use technology?
Technology Breakdown
52. Struggle to work together because technology does not function properly?
53. Waste time trying to get new media to work?
55. Encounter setbacks caused by glitches in new media?
56. Struggle to work together more so than if new media was reliable?
Attention Check Items:
1. "To monitor quality, please mark 'Not at all.' (after item 1, Coordination, Team Process)
2. 'To monitor quality, please mark 'To Some Extent.' (after item 19, Process Expansion)

Discriminant Validity Measures
Work Group Characteristics Measure
(Campion, Medsker, & Higgs, 1993)
(1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree)
Self-Management
1. The members of my team are responsible for determining the methods, procedures, and schedules with which the work gets done.
2. My team rather than my manager decides who does what tasks within the team.
3. Most work-related decisions are made by the members of my team rather than by my manager.

Participation

4. As a member of a team I have a real say in how the team carries out its work.
5. Most members of my team get a chance to participate in decision-making.
6. My team is designed to let everyone participate in decision-making.

Task Variety

7. Most members of my team get a chance to learn the different tasks the team performs.
8. Most everyone on my team gets a chance to do the more interesting tasks.
9. Task assignments often change from day to day to meet the work load needs of the team.

Task Significance (Importance)

10. The work performed by my team is important to the customers in my area.
11. My team makes an important contribution to serving the company's customers.
12. My team helps me feel that my work important to the company.

Task Identity (Mission)

13. The team concept allows all the work on a given product to be completed by the same set of people.
14. My team is responsible for all aspects of a product for its area.
15. My team is responsible for its own unique area or segment of the business.

Task Interdependence (Interdependence)

16. I cannot accomplish my tasks without information or materials from other members of my team.
17. Other members of my team depend on me for information of materials needed to perform their tasks.
18. Within my team, jobs performed by team members are related to one another.

Goal Interdependence (Goals)

19. My work goals come directly from the goals of my team.
20. My work activities on any given day are determined by my team's goals for that day.
21. I do very few activities on my job that are not related to the goals of my team.

Interdependent Feedback and Rewards (Feedback and Rewards)

22. Feedback about how well I am doing my job comes primarily from information about how well the entire team is doing.
23. My performance evaluation is strongly influenced by how well my team performs.
24. Many rewards from my job (e.g. pay, promotion, etc.) are determined in large part by my contributions as a team member.

Heterogeneity (Membership)

25. The members of my team vary widely in their areas of expertise.
26. The members of my team have a variety of different backgrounds and experiences.
27. The members of my team have skills and abilities that complement each other.

Flexibility (Member Flexibility)

28. Most members of my team know each other's jobs.
29. It is easy for the members of my team to fill in for one another.
30. My team is very flexible in terms of changes in membership.

Relative Size

31. The number of people in my team is too small for the work to be accomplished. *(Reverse Scored)

Preference for Group Work (Team Work Preferences)

32. If given the choice, I would prefer to work as part of a team rather than work alone.
33. I find that working as a member of a team increases my ability to perform effectively.
34. I generally prefer to work as part of a team.

Training

35. The company provides adequate technical training for my team.
36. The company provides adequate quality and customer service training for my team.
37. The company provides adequate team skills training for my team (e.g. communication, organization, interpersonal, etc.)

Managerial Support

38. Higher management in the company supports the concept of teams.
39. My manager supports the concept of teams.

Communication/Cooperation Between Work Groups

40. I frequently talk to other people in the company besides people on my team.
41. There is little competition between my team and other teams in the company.
42. Teams in the company cooperate to get the work done.

Potency (Spirit)

43. Members of my team have great confidence that the team can perform effectively.
44. My team can take on nearly any task and complete it.
45. My team has a lot of team spirit.

Social Support

46. Being in my team gives the opportunity to work in a team and provide support to other team members.
47. My team increases my opportunities for positive social interaction.
48. Members of my team help each other out at work when needed.

Workload Sharing

49. Everyone on my team does their fair share of the work.
50. No one in my team depends on other team members to do the work for them.
51. Nearly all the members on my team contribute equally to the work.

Communication/Cooperation within the Work Group

52. Members of my team are willing to share information with other team members about our work.
53. Teams enhance the communication among people working on the same product.
54. Members of my team cooperate to get the work done.

APPENDIX C

MEASUREMENT BATTERY FOR STUDY 3

***Construct:* Satisfaction with Team**

Adapted from Peeters, M., Rutte, C., van Tuijl, H., & Reyman, I. (2006). The Big Five personality traits and individual satisfaction with the team. *Small Group Research, 37, 187-211.*

(1=Strongly disagree, 2=Disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree)

1. Taken as a whole, I am satisfied with my team.
2. Taken as a whole, interacting with my team is pleasant.
3. Taken as a whole, I enjoy working with my team.

***Construct:* Team Cohesion**

Citation: Taken from 2012 Fall Codebook; No citation available.

Psychometric: Instructions: Please describe your perceptions of your team and your task force.*

(1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree)

1. Our ***team*** is cohesive
2. Our ***team*** likes working together

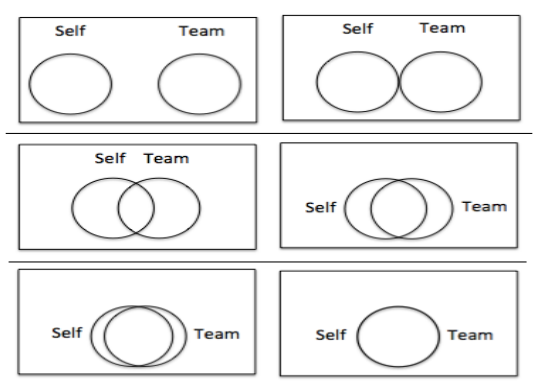
***Construct:* Team Identity (Pictorial)**

Citation: Hinds, P. J., & Mortensen, M. (2005). Understanding conflict in geographically distributed teams: The moderating effects of shared identity, shared context, and spontaneous communication. *Organization science, 16,* 290-307.

(1-very different, 2-somewhat different, 3-a little different, 4-a little close, 5-somewhat close, 6-very close)

Team Shared Identity

Q: Select the picture that most closely matches your relationship with the ***team***.



***Construct*: Team Trust**

McAllister, D. Affect- and cognition-based trust as foundations for interpersonal cooperation in organizations. *Academy of Management Journal*, *38,* 24-59.

(1=Strongly disagree, 2=Disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree)

1. Our team has a sharing relationship. We can freely share our ideas, feelings, and hopes.
2. I can talk freely on this team about difficulties I am having on the project and know that members of this team will want to listen.
3. Our team would feel a sense of loss if one of us could no longer work on the project.

4. If I shared my problems with this team, I know team members would response constructively and caringly.

***Construct:* Team Efficacy**

Citation: Collins, C.G., & Parker, S.K. (2009). Team capability beliefs over time: Distinguishing between team potency, team outcome efficacy, and team process efficacy. *Journal of Occupational and Organizational Psychology*, *00*, 1-22.

Psychometric: Team Process Efficacy (Short form):

Instructions: How confident are you that your ***team*** could, if required, do each of these tasks right now?

(0=Not at all confident, 10=Very confident)

1. Resolve conflicts that have become personalized
2. Identify realistic goals that unify individual team member goals
3. Adapt to changing situations/demands

***Construct*: Motivation to work on behalf of the team**

Created for this study

Please use the rating scale to indicate how much you agree or disagree with the following statements. (1=strongly disagree, 2=disagree, 3=slightly disagree, 4=neither agree nor disagree, 5=slightly agree, 6=agree, 7=strongly agree)

1. While working with this ***team***, I will persist until our goals are accomplished.
2. I give my best effort to this ***team***.
3. I have a desire to help this ***team*** achieve our goals.

***Construct:* Team Viability**

Citation: Bayazit, M., & Mannix, E. A. (2003). Should I stay or should I go? Predicting team members' intent to remain in the team. *Small Group Research*, *34*(3), 290-321.

Please use the rating scale to indicate how much you agree or disagree with the following statements. (1=strongly disagree, 2=disagree, 3=slightly disagree, 4=neither agree nor disagree, 5=slightly agree)

Please describe your perceptions of your ***team***:

1. I really enjoyed being part of this ***team.***
2. I felt like I got a lot out of being a member of this ***team.***
3. I wouldn't hesitate to participate on another task with the same ***team*** members.
4. If I could have left this **team** and worked with another ***team***, I would have.*

***Construct:* Virtuality**

Citation: Rapp, A., Ahearne, M., Mathieu, J., & Rapp, T. (2010). Managing sales teams in a virtual environment. *International Journal of Research in Marketing*, *27*(3), 213-224.

(Set up the following question such that each member can only allocate 100% maximum across the different modalities)

Please indicate what percentage of your teamwork is conducted via the following platforms:

Videoconferencing (WebEx, Skype Video)

Audioconferencing (Phone, Skype without Video)

Emails (Gmail, Hotmail)

Project Management Platforms (Basecamp)

Instant Messaging (Chat, SMS)

Face-to-Face

Other (enter response)

***Construct:* Team Process**

***Measured with same scale (Mathieu & Marks, 2005) used for Study 2**

***Construct:* Process Sociomateriality**

***Measured with same scale used for Study 2 (Appendix B)**

APPENDIX D

BEHAVIORALLY-ANCHORED RATING SCALES (PERSUASIVE POSTER)

Novelty: Persuasive poster demonstrates original thought or ideas.

Rating	Evaluation	Examples
5 (excellent)	**Exceeds Expectations**	The targeted ecological problem is unique. The proposed solution is entirely original. The poster introduces unique insights about human attitudes and behaviors relevant to the ecological issue.
4 (above average)		
3 (average)	**Meets Expectations**	Aspects of the proposed solution are unique. The attitude and behavior analysis introduces some new insights.
2 (below average)		
1 (poor)	**Below Expectations**	The targeted ecological problem is very commonplace – other campaigns have targeted it before. The proposed solution has been done many times before.

Solution Implementability: The proposed solution could be realistically executed.

Rating	Evaluation	Examples
5 (excellent)	**Exceeds Expectations**	All aspects of the proposed solution could reasonably be implemented in a variety of settings. The cost of implementation (e.g. time, money) would likely be low.
4 (above average)		
3 (average)	**Meets Expectations**	The proposed solution is feasible in most settings. The cost of the proposed solution would likely be reasonable.
2 (below average)		
1 (poor)	**Below Expectations**	The proposed solution is entirely unrealistic and could not be feasibly enacted (e.g. too expensive, too large scale).

Solution Effectiveness: The proposed solution would successfully address the ecological issue.

Rating	Evaluation	Examples
5 (excellent)	**Exceeds Expectations**	The proposed solution would directly change relevant attitudes/behaviors. The ecological issue would be entirely fixed if the proposed solution were enacted. All people would adopt the proposed solution.
4 (above average)		
3 (average)	**Meets Expectations**	The proposed solution would fix aspects of the ecological issue. Most people are likely to adopt the proposed solution. The proposed solution would provide a short-term fix, but the problem may persist in the long term.
2 (below average)		
1 (poor)	**Below Expectations**	The targeted human behaviors/attitudes are not easily changed. People are not likely to adopt the proposed solution. The ecological problem is not solvable. The proposed solution is not relevant to solving the ecological issue. The proposed solution would not fix the ecological issue.

APPENDIX E

CONTROL VARIABLES

Two potential control variables were initially collected from participants: technology experience and technology self-efficacy. These control variables were assessed during the first measurement administration of the study (T0), which occurred before team formation and project taskwork began. Technological experience captures the extent to which an individual has utilized a given technology previously. Technological experience was measured using a 7-item scale adapted from Golden and Raghuram (2009). Participants were instructed to indicate the extent to which they are familiar with certain new media (e.g. WebEx, Basecamp, etc.). Items were evaluated according to a 5-point scale (1=Never, 5=A Great Deal).

Technology self-efficacy reflects the propensity to embrace and use technology in everyday life. Technology self-efficacy was assessed using a 6-item measure adapted from Parasuraman (2000). Responses were made according to a 5-point Likert scale (1=strongly disagree, 5=strongly agree). A sample item is “New media gives people more control over their daily lives.” Bivariate correlations (below) revealed that technology self-efficacy and technological experience (at T0) were not statistically related to key study variables; therefore, these variables not included in hypothesis testing.

	Technological Experience	Technology Self-Efficacy
Facilitation/Expansion T1	.02 (ns)	-.13 (ns)
Facilitation/Expansion T2	.08 (ns)	.16 (ns)
Impairment T1	.00 (ns)	-.02 (ns)
Impairment T2	.01 (ns)	.21 (ns)
Solution Effectiveness	.10 (ns)	-.10 (ns)
Solution Implementability	.10 (ns)	-.02 (ns)
Team Viability	.16 (ns)	.03 (ns)

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