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AN EMPIRICAL INVESTIGATION ON THE ROLE OF IT MATERIALITY IN MULTIDISCIPLINARY INNOVATION

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Abstract

Knowledge needs to traverse through social and cognitive boundaries as it is transformed from information to innovation. Little is known, however, regarding what, if any, role various IT material constraints and affordances play in supporting multidisciplinary innovations involving the complexities of heterogeneous knowledge. The notion of affordance has been used in Human Computer Interaction (HCI) to describe the action opportunities afforded by IT functionalities. By IT materiality, we refer to a set of "features that provide opportunities for and constraints on actions" (Leonardi and Barley 2008).

We propose and empirically test a model to address this gap by drawing from the concepts of affordance, social structure theory, and the design of IT functionalities. We hypothesize that the impact of cognitive heterogeneity on innovation performance will be mediated by knowledge coordination and perspective taking. Further, we hypothesize that this relationship will be moderated by the material affordances of IT.

Keywords: IT functionalities, multidisciplinary innovation, affordance, heterogeneous knowledge

Introduction

Innovation has become a way of doing business in contemporary organizations. In particular, the increasing role of information technology (IT) radically changes (a) the nature of the products through rapid digital convergence (Lyytinen and Yoo 2002) and (b) the nature of the communication that is involved in the innovation (von Hippel 2005). Innovations developed by project teams can take on the forms of design, technology, process and knowledge (Berente et al. 2008b). We focus on multidisciplinary innovation that requires mobilization and integration of heterogeneous knowledge, often with little or no centralized organizing (Yoo et al. 2008). This involves the process that spans from generating new ideas to translating those ideas as commercial products and services in non-linear and often recursive ways. This process typically involves heterogeneous teams whose members represent multiple disciplines working together (e.g., Boland et al. 2007; Clark and Fujimoto 1991; Van De Ven 2005).

Heterogeneous teams with various expertise and experiences have a greater variety of perspectives and ideas for discussion, development, and integration compared to more homogeneous teams. The collisions of competing ideas are essential in creating new innovations (Boland and Tenkasi 1995; Brown and Duguid 1991). Heterogeneity, however, adds complexity to the socio-cognitive process, making knowledge sharing among team members problematic (Faraj and Sproull 2000; Kanawattanachai and Yoo 2007). The transfer of knowledge among different actors who do not share a common social context is inherently problematic (Carlile 2002). Therefore, heterogeneous sources of knowledge act as both an opportunity and also a challenge for multidisciplinary innovations.

In the literature, IT has been suggested as a critical tool that can mediate the communication and knowledge sharing among distributed and often heterogeneous team members for enhancing innovation. IT literature in the past, however, has tended to treat IT as a "black box" disregarding exactly "what" IT attributes are used and "how" they are used (Orlikowski and Iacono 2001). With some notable exceptions of a few recent studies (Boland et al. 2007; Carlile 2002; Leonardi 2007; Majchrzak et al. 2005), past studies tend to pay little or no attention to IT materiality, paying much greater attention to social practices around the technology (Levina and Vaast 2008; Orlikowski 1993). Furthermore, given that in multidisciplinary innovation, due to the heterogeneity of knowledge resources, teams are likely to face an increasingly heterogeneous set of IT tools, which will add even greater complications in their efforts to work together (Berente et al. 2007). Thus, it is even more important to develop a precise understanding of IT materiality in the context of multidisciplinary innovation. Recently, IS scholars are beginning to pay greater attention to the materiality of information, how it interacts with human agency, and how it helps form sociomaterial practices in organizations (Leonardi and Barley 2008; Orlikowski 2008; Zammuto et al. 2007). By IT materiality, we refer to "features that provide opportunities for and constraints on actions" (Leonardi and Barley 2008 p.162).

In this paper, we continue on this intellectual path by exploring the notion of affordances or action opportunities to examine the potential roles of IT materiality in supporting multidisciplinary innovations that involve the complexities of heterogeneous knowledge. The notion of affordance has been used extensively in Human Computer Interaction (HCI) and design literature to describe the action opportunities afforded by IT functionalities. Gibson (1977) originally introduced the theory of affordance as naturally existing attributes in the world that enable actors to perform actions in the environment. Affordances provide the means for all actions that are possible from the reference of a user (Gibson 1977, 1986; Norman 1999).

We feel that IT affordance is important because it provides the ability to help us understand the role of materiality of IT without reducing to a "determinist" stance (Leonardi and Barley 2008). For innovations, knowledge needs to traverse through social and cognitive boundaries as it is transformed, expanded and stabilized (Bijker 1995; Yoo et al. 2008). Little is known, however, what if any role various IT material constraints and affordances play in this generative process. In this paper, we developed a model to address this gap drawing from the concepts of affordance, social structure theory, and the IT design for distributed cognition. Specifically, our research question is *how do IT material affordances moderate the impact of heterogeneous knowledge on the coordination of multiple perspectives in the innovation process?* To answer this question, we herein introduce and justify a theoretical model that we propose to empirically test in the future.

Theoretical Development

The Role of IT in the Innovation Process

Innovation is defined as "…the development and implementation of new ideas by people who over time engage in transactions with others within an institutional order" (Van De Ven 1986). Innovations can take on the forms of design, technology, process and knowledge (Berente et al. 2008b). We focus on multidisciplinary innovation, which involves not only drawing upon and developing one's own knowledge community, but also exchanging and integrating knowledge with other communities. Boland and Tenkasi (1995) refer to the former as perspective making and the latter as perspective taking. Heterogeneous teams face increased complexity that must be overcome in the coordination and transformation of knowledge into more innovative ideas across the pragmatic boundaries which separate different types of expertise. Therefore, the effective leveraging of IT by heterogeneous teams to coordinate knowledge and resources across boundaries in innovation projects is more important than the mere existence of IT (Pavlou and El Sawy 2006). IT material affordances need to go beyond the enablement of task related communication and coordination (Leonardi 2007), but include enablement of boundary-spanning activities. In particular, using IT as a boundary object (Carlile 2002) and its different material affordances can provide a powerful way of integrating heterogeneous knowledge for an innovation (Alavi and Tiwana 2002).

In summary, multidisciplinary innovation involves the creation and implementation of new ideas from various existing sources of knowledge. The synthesis of new ideas involves the boundary spanning exchange of information and views from various perspectives. Through their use, the material affordances of IT should provide boundary object affordances for spanning pragmatic knowledge boundaries in the transformation of information into innovation (Carlile 2002).

Team Heterogeneity and the Balancing Mechanisms of Knowledge Coordination and Perspective Taking

First, we develop our hypotheses with regard to the main effects of our model. In this paper, among the many challenges present in multidisciplinary innovations, we focus on the challenges that arise due to cognitive heterogeneity. More specifically, we argue that cognitive heterogeneity influences the team's innovation outcome through two mediating processes – knowledge coordination and perspective taking. We further analyzed what and how IT material affordances can influence these two mediating processes.

The heterogeneity of a team can have either a positive or negative impact on innovation. Blau (1977) defined heterogeneity in the context of social structure theory as the "distribution of the population among many groups, defined by the probability that two randomly chosen persons do not belong to the same group," (Blau 1977 p.276). Through the lens of self-categorization theory, people associate themselves and behave according to the group norms in which they belong. The nature and the role of heterogeneity on team performance have been examined in a number of different contexts (Kilduff et al. 2000; Pelled 1996; Prahalad and Bettis 1986; Reagans and Zuckerman 2001). A key finding from this body of research is the recognition of the importance of cognitive heterogeneity in determining team performance. That is, past research shows that differences in terms of mental model, attitudes, beliefs, and values among members of a heterogeneous group whose members belong to different social groups are key factors that affect team performance. Furthermore, past research shows that cognitive heterogeneity is a mixed blessing when it comes to innovation (Kilduff et al. 2000).

In this paper, we argue that the cognitive heterogeneity of a team has two separate conduits that affect innovation outcome. First, team heterogeneity can have a positive impact on innovation by helping teams consider more perspectives. Past research on group decision-making convincingly demonstrates that homogeneous teams that share strong norms can easily fall into the trap of groupthink (Janis 1972). Hoskission et al (2002) show that heterogeneous teams with external organization membership embrace heterogeneous innovation strategies more easily than teams that consist of homogenous members. Drawing on a sensemaking perspective (Weick 1995), Kilduff et al. (2000) show that cognitively heterogeneous teams tend to retain multiple interpretive schemes that enable them to consider more options. Simply put, cognitively heterogeneous teams are likely to consider more perspectives (Boland and Tenkasi 1995). This leads us to the following hypothesis:

Hypothesis 1: Cognitively heterogeneous teams are likely to consider more perspectives than cognitively homogeneous teams during the innovation process.

Second, past research shows ample evidence that cognitive heterogeneity makes the knowledge coordination process during innovation more difficult and inefficient. Steiner's (1972) classic work on group productivity simply shows that heterogeneous groups will suffer from productivity loss. Stasser and his colleagues (Stasser 1992; Stasser and Titus 1985) also show that heterogeneous groups who have unevenly distributed knowledge often fail to fully utilize collective knowledge as the team members tend to focus on the knowledge that they commonly share. Heterogeneous teams can be mired with political risks that cause everyone to lose sight of the innovation process (Van De Ven 1986). These studies show that cognitively heterogeneous teams are likely to face problems in coordinating knowledge. This leads us to hypothesize:

Hypothesis 2: Cognitive heterogeneous teams are likely to have less effective knowledge coordination than cognitively homogeneous teams during the innovation process.

We further argue that a team's attempt to take more diverse perspectives into consideration during the innovation process will face greater cost of knowledge coordination. More perspectives that are being considered will make it more difficult for teams to establish a common ground (Clark 1996), create more cognitive conflict among team members who do not share the same perspective (Carlile 2002), and require team members to locate other members' expertise (Kanawattanachai and Yoo 2007). All of these are likely to make it more difficult for team members to effectively coordinate knowledge during the innovation process. This leads us to the following hypothesis:

Hypothesis 3: Teams that consider more perspectives will experience less effective knowledge coordination.

Besides cognitive heterogeneity, we recognize both knowledge coordination and perspective taking are important for effective innovation. Hackman (1987) recognized the importance of a balanced knowledge heterogeneity as being a key characteristic of well structured teams. Teams should be heterogeneous enough so that the required skills are available for completing the tasks. Yet, too much heterogeneity can lead to value imbalances and increased tension resulting in negative performance. Past research shows ample evidence that effective knowledge coordination improves team performance (Faraj and Sproull 2000; Kanawattanachai and Yoo 2007; Weick and Roberts 1993). Similarly, we argue that teams that work on innovation projects will perform better if they are able to coordinate their knowledge effectively and integrate it into innovative products and services (Grant 1996). As team members need to integrate different knowledge in order to create novel solutions, they need to interrelate their knowledge (Majchrzak et al. 2004; Malhotra et al. 2001). This leads us to hypothesize:

Hypothesis 4: Knowledge coordination will have a positive effect on innovation performance.

A fundamental reason why heterogeneous teams exist is for the opportunity to gain new, fresh knowledge as they seek novel ideas. Successful multi-disciplinary teams are able to leverage team heterogeneity by embracing the diversity of ideas, while often not being hampered by having to completely align with these ideas. The interactions between heterogeneous disciplines may be confusing and not always go smoothly, yet these types of interactions can initiate the creation of new product ideas, particularly if the team is able to coordinate knowledge effectively. Teams that are able to draw from multiple perspectives have been observed to create "wakes of innovation" in project networks which, in turn, create a system of new innovations for project teams (Boland et al. 2007). This leads us to the following hypothesis:

Hypothesis 5: Perspective taking will have a positive effect on innovation performance.

Having established the theoretical links among cognitive heterogeneity, knowledge coordination, perspective taking and innovation performance, we will discuss the impact of different types of material affordances of IT that can potentially influence the innovation process.

Material Affordances of IT and Multidisciplinary Innovation

Affordances describe how the environment contributes to interactions between agents and situations (Greeno 1994). IT can enable greater boundary-spanning and knowledge sharing action possibilities between heterogeneous knowledge sources, by creating a trading zone among heterogeneous actors and serving as a boundary object (Boland et al. 2007; Carlile 2002). Hence, IT materiality can contribute to these interactions. Boland et al. (1994) developed six design principles showing the material affordances enabled by IT for capturing and utilizing distributed cognition in teams. Majchrzak et al. (2005) empirically tested these principles for a centrally controlled, distributed team. The researchers found that the use of IT tools with these design attributes was perceived to enhance the overall performance of the team for non-routine, complex tasks. Based on several ethnographic studies in architecture, engineering and construction projects, researchers redefined the six design principles for the multidisciplinary innovation of heterogeneous teams in a distributed organization setting (Berente et al. 2008a).

Opening up the "black box" of IT into the appropriation of IT material affordances through the lens of IT design principles enables us to gain new insights in the innovation practices. Innovations are cognitive translations of ideas into different forms of representations, and ultimately into products or services. This innovation process is increasingly mediated by the material affordances enabled by technology artifacts (Yoo et al. 2008). Innovations also involve social translations in that they occur at the boundaries of communities as actors take on new perspectives (Boland et al. 2007; Carlile 2002). Hence, the use of IT artifacts can enable heterogeneous sources of knowledge to connect with outside communities in the innovation process. Since the IT artifact is social and material in that "…the impact of its material features is transformed through the social action of collective appropriation" (Leonardi 2007 p.816), this perspective helps us understand precisely how teams go through both cognitive and social translations during multidisciplinary innovations through the use of technical capabilities. In other words, while the designed material functionalities of IT artifacts provide users affordances and constraints, researchers can determine "how" and "why" the functionalities are appropriated as they are in practices (Leonardi 2007). Furthermore, the appropriation of the IT design principles can be used to analyze why organizations and practices are the way they are (Leonardi and Barley 2008). Since work practices and technologies are intermingled, sociomateriality is the lens through which these combined concepts of the organization can be theorized (Orlikowski and Scott 2008).

Table 1. Description on Six Design Principles

Design Principle	Description
Semantic Coherence	Enables the reconciliation of multiple pieces of information into one unified, meaningful form. The IT functionalities of inserting, merging, attaching, and copying/pasting demonstrate this design principle.
Spatial Traceability	Enables the cross-sectional tracing of emergent changes in content which are interdependent. Spatial traceability provides dynamic contextualization of emergent requirements changes when a change in one dimension affects other dimensions. The IT functionality of notifications demonstrates this principle.
Temporal Traceability	Enables the tracing or auditing of changes in information back in time. The IT functionality of the time-stamp enables one to search previous changes made in archives and browsing history.
Synchronization	Enables the translation of different perspectives or representations created by different groups so that handoffs go smoothly. The IT functionalities of keywords and tags demonstrate this principle.
Representational Flexibility	Enables the translation of multiple representations from different media into other forms of media based on what provides the best affordance for the particular situation. The ability for team members to select and use the optimum tool based on their particular situations demonstrates this principle.
Regenerativity	Enables the reconstruction of representations or models using different forms for deeper understanding. The IT enabled affordance of being able to create digital representations using different IT applications demonstrates the IT affordance of regenerativity.

In this study, we draw on the six design principles of Berente et al. (as shown in Table 1) to further elaborate the role of IT material affordances in supporting multidisciplinary innovation. More specifically, we explore how IT affordances, as represented in these six design principles, moderate the impact of cognitive heterogeneity on the knowledge coordination and the perspective taking processes. Dewett and Jones (2001) identify two key benefits from the moderating role of IT: information efficiencies and synergies. These benefits, in turn, can lead to greater organizational innovation performance. While information efficiencies are realized through such factors as savings in time and cost, information synergies enable boundary-spanning collaboration outside of the team (Dewett and Jones 2001). We draw on these concepts of greater efficiencies and boundary-spanning synergies beyond the team in grouping the six IT design principles into those that unify and those that expand knowledge.

The first three design principles provide the ability to efficiently obtain and provide contextual information in the communication process with respect to semantics, time, and space. These three attributes, thus, provide integrity of knowledge and preserve unity and coherence of knowledge as it traverses and is transformed across knowledge boundaries as presented by heterogeneous members of the team. These three IT material affordances assist actors to transcend the local context in which they are embedded without losing the specificity that is idiosyncratic to that local context. In addition, the risk of team level conflict can be moderated by IT enabled communication and coordination (Hinds and Bailey 2003) as communication of content with contextual information can ensure a more comprehensive understanding of the situation (Majchrzak et al. 2005). Similarly, IT enabled coordination can make project governance more efficient through decreased costs (Argyres 1999). Also, shared context can moderate the effects of task conflict on a team's ability to coordinate knowledge (Hinds and Mortensen 2005). Therefore, these three affordances make knowledge coordination less costly in the presence of cognitive heterogeneity. Taken together, this leads us to hypothesize:

Hypothesis 6: The IT material affordances based on the design principles of semantic coherence, spatial traceability, and temporal traceability will negatively moderate the relationship between cognitive heterogeneity and the team's efforts to coordinate heterogeneous knowledge.

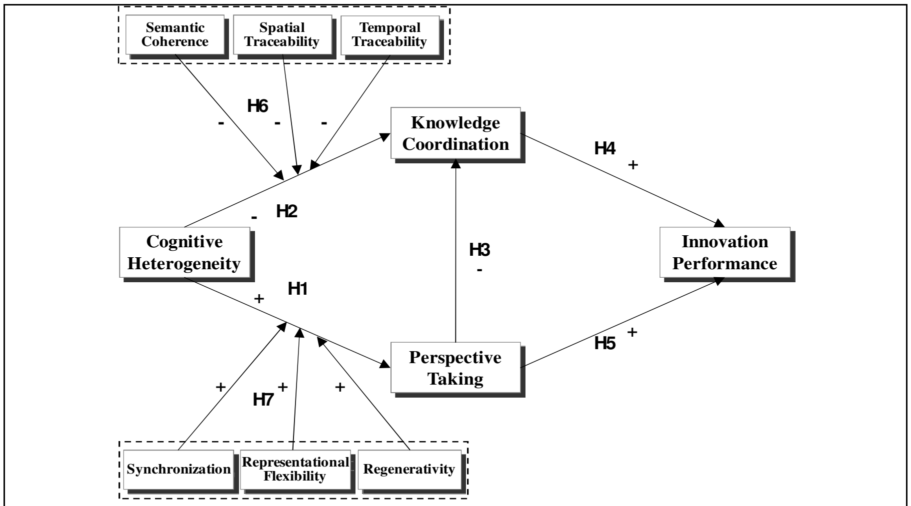

Figure 1. Model of IT Material Affordances in Multidisciplinary Innovation

The IT material affordances based on the remaining three design attributes of synchronization, representational flexibility, and regenerativity enhance the team's ability to collaborate and consider more perspectives, by making it easier for team members to generate different forms of representations. Information synergies enable boundary spanning beyond the team (Dewett and Jones 2001). By providing the affordance of taking in outside perspectives, IT functionalities contribute to the team's ability to process as well as generate increased "wakes of innovation" (Boland et al. 2007) from a greater number of heterogeneous sources of knowledge. Knowledge can be both a constraint and a source of innovation; through the use of boundary objects, however, embedded knowledge can be jointly transformed for resolution (Carlile 2002). Transformations take place at the boundary where old knowledge is changed and new knowledge is created (Carlile 2002). IT material affordances of the knowledge expanding design principles enable the sharing of knowledge with other perspectives outside of the team. These affordances provide variety by mobilizing diverse representational modes that may be more conducive for particular local practices. These affordances enable team members to fully explore their unique local context, without losing the ability to interrelate their knowledge with other members. This leads us to the following hypothesis:

Hypothesis 7: The IT material affordances based on the design principles of synchronization, representational flexibility, and regenerativity will positively moderate the relationship between cognitive heterogeneity and the team's ability to take multiple perspectives.

With the development and integration of these seven hypotheses, we propose a model of IT material affordances in multidisciplinary innovation (Figure 1). We next describe our methodology for measuring the study's constructs.

Methodology

Overall Design Approach and Data Collection Plan

Our overall research design combines survey research triangulated with data collected from semi-structured interviews and archival documents. The unit of analysis for this study is completed projects within the past two years. We defined measures for the variables of the model from the literature and developed a research instrument for collecting data. We will test the validity and reliability of the survey instruments using a correlation matrix, and composite factor scores will be conducted through a pilot study conducted with a small representative (Chin 1998; Pavlou and El Sawy 2006). After the pilot test, we will collect data from approximately 80 projects in one or more organizations. We will minimize the common method bias by asking both project managers and team members to respond to our survey. The full-scale implementation of the survey will be followed with semi-structured interviews and the analysis of archival data for cross-checking. Harman's one-factor test and a correlation matrix will be used to test for common method bias (Pavlou and El Sawy 2006).

Constructs and Measures

Heterogeneity is the distribution of various groups within a population (Blau 1977). As the number of different groups get more evenly distributed, the heterogeneity of the population increases. *Cognitive heterogeneity* is defined as the distribution, within a given population, of differences in knowledge including beliefs, preferences, and views (Miller et al. 1998; Mitchell 2008). Cognitive heterogeneity presents boundaries of knowledge and expertise complexity that need to be overcome by members of multi-disciplined project teams for innovation performance. We draw from previous studies for measuring cognitive heterogeneity that focus on specialization and expertise (Kilduff et al. 2000; Tiwana and McLean 2003; Zucker 1977). *Perspective taking* is the taking and use of ideas from outside one's own community (Boland and Tenkasi 1995). In the context of our research, perspective taking involves using knowledge from outside one's own normal team. To measure perspective taking, we draw from Davis's Interpersonal Reactivity Index (IRI) (Davis 1980, 1983). *Knowledge coordination* refers to the management of dependencies of team member expertise in a project (Faraj and Sproull 2000). Knowledge coordination involves knowing where knowledge is located, where it is needed, and how to deliver it (Faraj and Sproull 2000). We draw from the knowledge coordination instrument used by Kanawattanachai and Yoo (2007) for measuring this construct. *Innovation performance* is the dependent variable and measures the two dimensions of efficacy and efficiency. Efficacy measures how successful the innovation is once it is implemented, while efficiency measures the innovation process from design to implementation (Alegre et al. 2006). We draw from questions used by Alegre et al. (2006) for measuring this construct. *Team size* and *tenure diversity* are both controlled (Ancona and Caldwell 1992; Van Der Vegt et al. 2000). *IT Design Principles* are the functionalities provided by the use of IT for distributed team innovation. The measures for these functionalities are drawn and modified from an earlier instrument used by Majchrzak et al. (2005) for a centrally controlled team. We draw from definitions developed for teams with heterogeneous knowledge and decentralized control enabled by the digital convergence of technology as shown in Table 1 (Berente et al. 2008a; Yoo et al. 2008).

Data Analysis

We will test our hypotheses using structural equation modeling (SEM) since this technique will allow us to analyze multiple constructs simultaneously (Gefen et al. 2000). We will use the component-based SEM partial least squares (PLS) technique since we have both formative and reflective constructs in our model (Gefen et al. 2000). We plan to test the main effects and interaction models as per Chin et al. (2003) following a hierarchical process; the IT design principle moderator variables will be tested separately as well as in interaction.

Discussion and Implications

As organizations try to utilize various forms of IT to support their innovation process and outcomes, it is likely that many of them will face the challenges of distributed, multidisciplinary innovations with increasingly decentralized control (Yoo et al. 2008). Among the many challenges in multidisciplinary innovations, we focused on those that rise due to cognitive heterogeneity. From our model in Figure 1, cognitive heterogeneity influences team innovation through two mediating processes: knowledge coordination and perspective taking. Furthermore, our model specifically fills the gap of "what" IT material affordances are being used, and "how" they are being utilized in supporting multidisciplinary innovation where teams constantly face increasing degrees of cognitive heterogeneity. We propose that the cognitive complexities introduced by heterogeneous knowledge are moderated through the IT material affordances drawing on the six design principles. Our analysis of IT material affordances reveals that the six IT design principles for multidisciplinary innovation can be segmented into two different groups. The first set of principles – semantic coherence, temporal traceability, and spatial traceability – is essential in preserving the *unity* of knowledge, transcending local idiosyncrasy. These three components are, hence, knowledge unifiers. To the contrary, the second set of principles – synchronization, representational flexibility, and regenerativity – is essential in increasing the *variety* of knowledge, highlighting unique local practices. These three components are, therefore, knowledge expanders. Yoo et al. (2006) noted the dialectic between the unity and variety of knowledge as a key element in the dynamics of innovations. Our analysis of IT material affordances suggests that IT tools that are designed to support multidisciplinary innovations must consider the dialectics between unity and variety.

Future theoretical work can extend our work by considering the dynamic nature of the innovation process. That is, one must consider the role of learning. Boland and Tenkasi (1995) have perspective making as another essential dimension of the distributed cognitive process that pairs with perspective taking. Perspective making involves the construction and strengthening of perspectives within a community of knowing over time. Integrating perspective making into our current model will help us understand the dynamic nature of multidisciplinary innovations and the role of IT material affordances. Such an analysis might suggest new types of IT affordances that have not been discussed in the literature. We believe such an elaboration of the model is an important next step.

In addition to future theoretical work, several practical implications can be gained through our model. First, managers of innovation teams should recognize the importance of balancing the opportunities and complexities of heterogeneous knowledge. Managers need to pay attention to two key processes – knowledge coordination and perspective taking – that mediate the impact of cognitive complexity on innovation outcomes. Another practical implication from the model is that managers of innovation teams should be aware how IT material affordances can affect different aspects of the complexities of heterogeneous knowledge. Our framework shows how the use of various IT material affordances can either help amplify the positive effects of heterogeneous teams or dampen the negative effects. Furthermore, the roles of IT are not static but dynamic in the facilitation and coordination of innovative ideas. For these possibilities to be realized, the organization should consider supporting a variety of IT affordances. Heterogeneous teams can then utilize an optimum set of IT tools for knowledge creation and coordination for maximizing innovation performance.

Expected Presentation at ICIS

We expect to present the completed results of our research based on the findings from our empirical data at ICIS. The findings from the hypotheses testing will be provided and reflected in our model. We expect to provide conclusions on how IT material affordances impact the coordination of heterogeneous knowledge from multiple perspectives for enhancing innovation performance. Table 2 shows a sample of our instrument.

Table 2. Sample of Measurement Items

Construct	Measurement Items
Cognitive Heterogeneity	1) Members of our team varied widely in their areas of expertise. 2) Members of our team had skills and abilities that complemented one another's.
Perspective Taking	1) The project team used ideas from outside the team. 2) My contributions to this project benefited from ideas from outside the team.
Knowledge Coordination	1) Our team members carefully interrelated actions to each other in this project. 2) Our team developed a clear understanding of how each member's knowledge should be coordinated.
Design Principles	1) IT tools enabled our team to easily identify needed information from multiple sources (semantic). 2) IT tools enabled our team to easily search historical records (temporal). 3) IT tools enabled our team to easily determine changes in content through notifications (spatial). 4) IT tools enabled our team to easily review and make comments in a shared repository (synchronization). 5) Our team was easily able to use IT tools that were optimal for particular job functions (representational). 6) IT tools enabled our team to easily use multiple representations using different tools (regenerativity).
Innovation Performance	1) This project was a *design* innovation that resulted in a major, new design advance. 2) This project was a *process* innovation that resulted in a major, new technology advance.

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