



Organization Science

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<http://pubsonline.informs.org>

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To cite this article:

Cristina B. Gibson, Patrick D. Dunlop, Ann Majchrzak, Terence Chia (2021) Sustaining Effectiveness in Global Teams: The Coevolution of Knowledge Management Activities and Technology Affordances. Organization Science

Published online in Articles in Advance 11 Aug 2021

. <https://doi.org/10.1287/orsc.2021.1478>

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Sustaining Effectiveness in Global Teams: The Coevolution of Knowledge Management Activities and Technology Affordances

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Received: December 18, 2018

Revised: January 27, 2020; August 19, 2020; December 8, 2020; March 4, 2021

Accepted: March 18, 2021

Published Online in Articles in Advance: August 11, 2021

<https://doi.org/10.1287/orsc.2021.1478>

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Abstract. Despite the dynamic nature of knowledge-related activities and the availability of a variety of communication technologies, many global teams habitually use technology in the same way across activities. However, as teams move through cycles of accumulating, integrating, and implementing knowledge, the purposes for communication technologies change. Current theorizing and empirical work on team knowledge management has yet to develop a dynamic theory that incorporates these changes. By conducting a multiwave, mixed method analysis of 48 global teams, we develop a theory of how global teams sustain effectiveness through technology affordance processes. We found that effective teams are those that recognize cues indicating change is necessary and coevolve a symbiosis between new activities, new purposes for interaction, and new uses of communication technologies. This coevolution of purpose with technology use forms new affordances, which enable the team to move on to new knowledge management activities and sustain effectiveness. Our theory more realistically models the dynamics of staying connected while sharing, combining, and implementing knowledge across the globe.

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Funding: We acknowledge financial support from the Australian Research Council Linkage Program [Grant LP110201117].

Keywords: knowledge management • global teams • communication technologies • team effectiveness • technology affordances

Remote work using technology to interact with others has emerged as an expectation of many employees in the wake of COVID-19, as large-scale polls indicate that 65% want to remain remote and do not want to return to the office on a full-time basis (Brenan 2020, Lister 2020, Ozimek 2021). Yet, organizations are struggling with how best to support employees so reliant on technology, especially given the pace of change in work and the world at large (Gibson 2020). This is even more pronounced in *global teams*, defined as those whose workers are from different locations around the globe (Gibson et al. 2021), which are often established specifically to engage in knowledge management (KM), such as the sharing, combining, and implementing of knowledge across different sites (Hajro et al. 2017). These activities are neither monolithic nor static; instead, they shift as external pressures and progress dictate the need for the different behaviors (Leonardi 2013, Wilson et al. 2013, Tenzer

and Pudelko 2016). Sustaining effectiveness in global teams over time requires the capacity to navigate the changes in activities, and yet, we lack theory regarding how to sustain global team effectiveness as new activities emerge.

We theorize that agility with communication technology is critical. Global teams often have available a variety of communication technologies (devices, applications, and systems that support the transmittal of messages, information, and virtual presence, including email, teleconferencing, instant messaging, and document repositories) (Majchrzak et al. 2005). Numerous theories predict which technologies best fit which tasks to guide the choice of technology, including theories of media richness (Daft and Lengel 1986), task-technology fit (Zigurs and Buckland 1998), media synchronicity (e.g., Maruping and Agarwal 2004), and media naturalness (DeRosa et al. 2004). However, managing the use of technology in a way that

supports a global team's KM activities is a far more complex, dynamic process than these theories represent. This process transcends a one-time understanding of the team's information needs or communication processes and then acquiring the appropriate technology. Such an approach ignores the dynamism in a team's activities and the likelihood that habitual use of the same technology in the same way will be inefficient and suboptimal for all of its KM activities (Zigurs and Buckland 1998, Watson-Manheim and Bélanger 2007, Barley et al. 2011, Gibbs et al. 2013).

To incorporate dynamism into our understanding of how global teams manage changing technology needs, we use an affordance lens. Affordances describe *how* a technology is used to achieve a specific purpose, which can be distinguished from a feature or function (Leonardi 2013, Treem and Leonardi 2013, Majchrzak and Markus 2014). For example, a *function* of email is sending a message; a *feature* of email is the capability to mark a message as urgent. In contrast, email may afford a variety of user purposes such as being used in a manner that helps the user to make sense of a new piece of information about a task, deciding who are powerful people in an organization, or saving face when mistakes are made. Affordance is a relational construct between the human user of the technology and constraints and possibilities offered by the technology (Gibson 1977, Zammuto et al. 2007, Treem and Leonardi 2013, Majchrzak and Markus 2014). Unlike task-technology fit, an affordance lens does not promote a static notion of fit but rather, a notion of relational adjustments between purposes, technology constraints, and affordances. The affordance lens is especially useful because it recognizes that the same tool may serve many different purposes and that the user and tool are often coevolving to achieve a specific purpose. Unlike task-technology fit, the affordance lens does not endow, for example, email with its own agency of features and functions for expected uses. Because purposes are likely to be quite fluid when performing an activity and discoveries about technology affordances and constraints not predetermined, an affordance lens assumes that technology and purposes will be constantly adjusting to each other, leading to what we call a technology affordance process. However, we know little about this process of mutual adjustment. Thus, our study was guided by the research question: *as global teams shift KM activities, how does the technology affordance process unfold to sustain effectiveness?*

Because global teams are fast becoming a normative mode of work (Hinds et al. 2011, Gibson et al. 2014, Gibbs et al. 2021), understanding how shifts in KM activities across the globe are supported by technology affordance processes becomes integral to further theorizing about teams and crucial for the overall success

of firms. If they are to continue to accomplish the objectives their organizations establish for them, global teams must recognize the new KM purposes that emerge, acknowledge when technology affordances have become constraints, and subsequently change the way they use their communication technology to sustain effectiveness. Failure to do so risks a team becoming mired in a specific KM activity and unable to progress on to subsequent KM activities required for success because they have not dynamically adjusted how they use their communication technology.

To develop our theory of how global teams use a technology affordances process to sustain effectiveness as KM activities evolve, we conducted a mixed method exploratory sequential empirical examination (Creswell and Creswell 2019) of 48 global teams, combining qualitative and quantitative data and analysis. In the qualitative exploratory phase, we uncovered which KM activities shifted over time and found patterns as to when, how, and why changes in technology use coevolved with changes in purposes to help sustain effectiveness. This general process is illustrated in Figure 1.

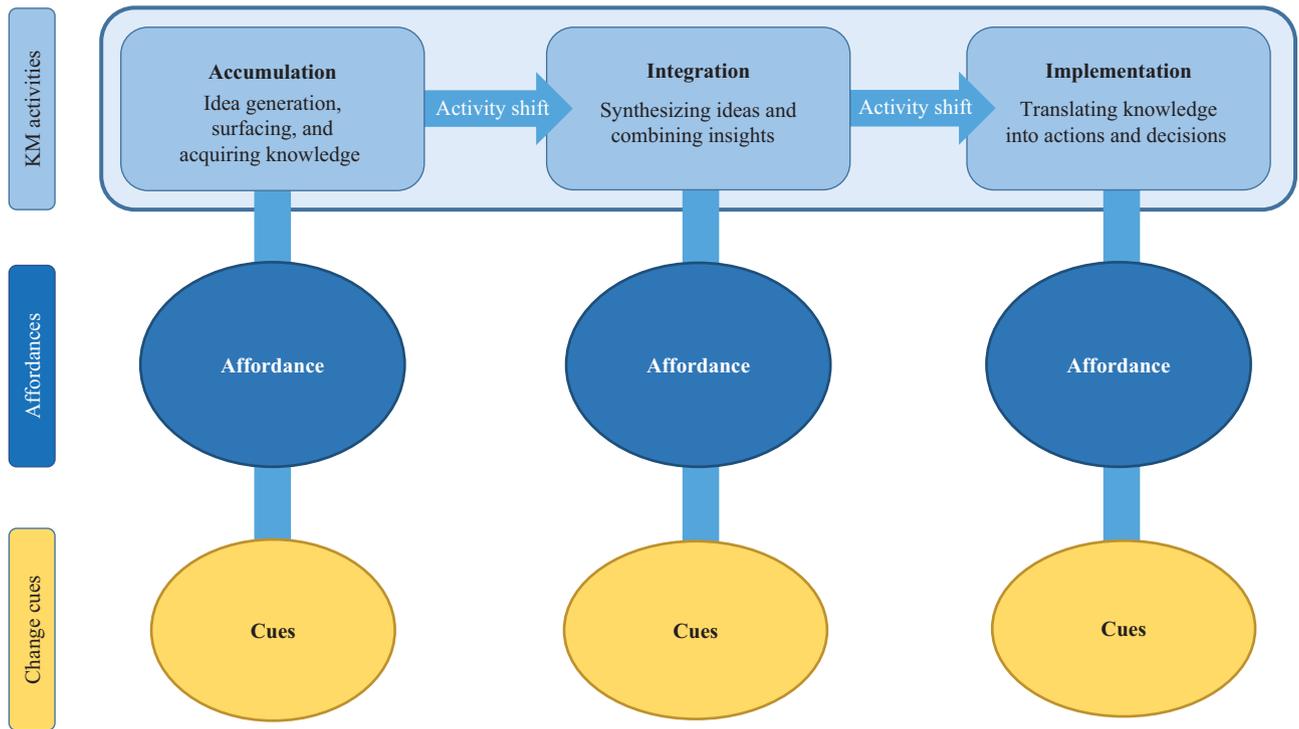
As we reveal, we identified that the most effective teams used specific cues to synchronously shift KM activities and technology uses, in a manner consistent with the relational construct of affordances. The cues indicated that the existing KM activities and technology use were no longer serving the needs of the team, prompting the KM activities and technology use to coevolve in the successful teams, but not in the less successful teams. We then designed a multistage quantitative study including both between- and within-team analyses, which provided systematic evidence that, in more successful teams, shifts in KM activities needed to be done concomitantly with shifts in the purposes with which the technology was used, providing evidence for a theory of the technology affordance process.

Theoretical Foundations

Knowledge Management Activities

A useful framework for understanding the dynamic KM needs in global teams is to consider the stream of activities that KM entails. Managing knowledge is defined as the team's ability to accumulate, categorize, understand the relationships among cognitive categories, discursively discuss, and collectively apply knowledge from team members throughout a process of completing a task (Alavi and Leidner 2001). This is an evolutionary process; as knowledge accumulates, its interpretation among team members will change. For example, after defining a problem, the team will need to transition to compiling potential solutions. For many teams involved with KM, the *raison d'être* is the KM itself (e.g., a team tasked with accumulating information regarding current practices

Figure 1. Initial Framework for KM Activities and Technology Affordances



across multiple global sites). For other teams, KM may constitute a critically important set of activities (Hajro et al. 2017) but may not be the *sole* activity because they also engage in physical manifestations of knowledge work outcomes, such as a production process.

How knowledge is managed in teams over time is addressed by many perspectives, including those regarding collective cognition (Gibson 2001, De Dreu 2007), team learning (Edmondson 2002, Vashdi et al. 2013), and team innovation (West 2002, Tzabbar and Vestal 2015). Many of these perspectives indicate that a team engages in three different KM activities, *accumulation*, *integration*, and *implementation*, and that effective teams must engage in some form of all three, reiterating through these activities (Gibson 2001, Gibson and Earley 2007). This is because even when teams accumulate the knowledge needed for their task, if they do not combine and integrate it or if they fail to implement it into meaningful actions and ongoing practice, they will be unable to reap the performance benefits of the knowledge being acquired and shared (Fang et al. 2014, Seidel and O’Mahony 2014). We adopted this perspective because it is the most broadly applicable across types of teams and most conducive to identifying the role that technology might play for each activity. We describe each of the three KM activities.

Accumulation of Knowledge. The primary purpose of the accumulation KM activity for a team is to

acquire and share knowledge and information among its members (Gibson 2001). To be effective, teams must develop an ability to collectively filter information to focus on what is specifically needed for the team’s task (Anand et al. 1998). In global teams, the information members provide to the team typically derives from their membership in a local operational team, so an important need during accumulation involves structuring members’ time to ensure they are engaged in the global team’s tasks (Metiu and Rothbard 2013). As knowledge in global teams becomes more concrete, localized knowledge remains not only critical to a team but also, provides a necessary feedback loop between local and global (Sole and Huysman 2000); therefore, other challenges are knowing how much information is necessary so that accumulation can stop and how to encode the knowledge so it is easily retrievable. When the speed with which knowledge is contributed slows or team members recognize the volume of knowledge accumulated, a team may sense a need to shift to other KM activities (Gibson 2001). However, in global teams, the process of acquiring knowledge may be prolonged if the team has difficulty combining and integrating complex site-specific local knowledge or fails to understand what the knowledge implies.

Integration. Knowledge accumulation alone does not ensure that the knowledge is agreed upon and collectively interpreted (Huang and Cummings 2011).

Reaching this agreement requires integration, a different KM activity. In contrast to accumulation, the team must turn to integrating the accumulated knowledge into an agreed upon understanding of their work (Walsh et al. 1988). This need not involve unanimity because complete integration leads to less variety in information (Cronin and Weingart 2007). Instead, a team engaged in integration needs to iteratively generate proposals for synthesizing the variety, thus allowing the team to move forward in a way that accounts for, respects, and incorporates the differences (Harvey 2014). Coordinating this process involves managing participation, ensuring members are heard, and making opportunities for the creation of meaning. The challenge with integration lies in coordinating meanings and interpretations (Cronin and Weingart 2007). When integrative proposals remain fairly consistent across iterations, fewer and fewer discussions about meaning arise, and relative equality of participation is achieved, teams may be ready to move onto implementation (Gibson 2001).

Implementation. A third KM activity is implementing knowledge. The team must use knowledge to decide on courses of action that the knowledge may recommend and then, enact them in ways and for reasons that all members understand. Additionally, implementation requires that all members know their roles and how they coordinate with others (Walsh and Ungson 1991). In global teams in which members represent their local operational teams, plans for implementation in each local region must be drafted and agreed upon (Cohendet and Steinmueller 2000). The challenge in implementation is to balance localized and global knowledge because specific regions will benefit most if they can take advantage of the global knowledge that nevertheless may be too contextually removed to be helpful. Implementation is complete when this global knowledge becomes incorporated into local operations.

Technology Affordances

If global teams are to sustain effectiveness, they must execute these three KM activities using communication technology. Numerous theories contend that technologies have been designed by developers and vendors to provide objective features that are, deterministically, better suited for certain activities than others (Daft and Lengel 1986, Zigurs and Buckland 1998, DeRosa et al. 2004, Maruping and Agarwal 2004). For example, Clark and Brennan (1991) argue that the intention of the use of communication technology is to deliver accurate communications such that some features facilitate reviewing prior communications to learn about context and other features facilitate making easy repairs to reduce

misunderstandings. Despite their prevalence, these theories are soundly criticized because people do not use technology deterministically (Fulk 1993, Markus 1994, Maznevski and Chudoba 2000). Moreover, a range of contextual factors, such as circumstances related to the specific communication event, has been found to influence the decision to use a communication medium (Clark and Brennan 1991, DeSanctis and Poole 1994, Te'Eni 2001, Yoo and Alavi 2001, Barley et al. 2011).

To avoid the deterministic, technocentric approaches of the past, some have suggested that an affordance lens be applied to understand how the same technology can be harmful and helpful (Zammuto et al. 2007, Faraj et al. 2011, Yoo et al. 2012). Affordance is a relational concept, indicating a relationship between the materiality of the technology and the human need to accomplish a purpose (Gibson 1977). That is, the value of a technology depends on an alignment between how a team perceives the purposeful needs of the activity in which they are engaged and how they use the technology (e.g., Zammuto et al. 2007, Majchrzak and Markus 2014). Unlike task-technology fit theory, wherein technologies have capabilities that are then matched to tasks, an affordance lens argues that, absent a purpose, technology has no inherent capabilities. Focusing simply on the features of a technology is not likely fruitful to gaining understanding of a technology's use because features of a technology may have multiple uses or affordances for different purposes.

The metatheory of technology affordances and constraints suggests that, as any single action is taken, there is a purpose and a range of technologies that may afford or constrain achieving that purpose (Majchrzak and Markus 2014). Further, scholars of communication technology emphasize that no universal set of affordances fits all contexts (Treem and Leonard 2013). The applicability, nature, and extent of the affordances must be determined in situ, and therefore, we suggest that the affordances of the technology may evolve. An affordance lens does not lead, then, to a list of affordances independent of purpose. Further, the three different KM activities may each evolve to have unique purposes when communicating via the technology. How these KM activities are afforded or constrained by technology was a key focus of our qualitative phase of research.

Cues for Change

To sustain effectiveness, global teams will need to iterate through KM activities conducted through their use of communication technologies (Gibson 2001, Gibson et al. 2019). Although dynamism is inherent in affordances, the dynamics of the relational adjustment among purpose and technology affordances has yet to

be theorized. However, continuing one KM activity and/or one particular use of the communication technology habitually will likely result in cues indicating the need for a change (Burke et al. 2006, Barley et al. 2011, Gibbs et al. 2013). The cues signal the need for adjustment to both their KM activity and the team's use of their technology. For example, a cue may be a recognition of differences across sites in the way in which the team performs a particular operational procedure (Gibson et al. 2019). Another example of a cue is hesitation on the part of members at certain sites in participating (Gibbs et al. 2021). These cues should signal to the team that it is time for existing affordances to change—in terms of both purpose for use and how the technology is used. Providing that adjustments are made to maintain a productive relationship between technology and purpose, the team will continue to proceed toward successful task completion. Thus, a theory of the process of affordances should include not simply the purposes and technologies that support each other but the cues that signal time to change purposes and affordances.

Specifically, to sustain effectiveness, the team needs to recognize and adjust as cues in the work process indicate a need to adjust how KM activities are accomplished through the communication technology and which KM activities should now be emphasized. A reliance on team norms and routines to guide this adjustment process is likely of limited value because they may dictate very little change over time in the habitual use of technologies despite the emergence of different KM needs being accomplished through different uses of communication technologies (Leonardi 2013, Mazmanian 2013, Gibson et al. 2014, Gibson and Grushina 2021). This emergence and coevolution in purpose and technology use have not been documented empirically. There is a need to understand how cues catalyze the coevolution of situational changes in KM activities with changes in technology use. We present the empirical approach we used to reveal these processes and test their relationship with effectiveness.

Overview of Approach

Our approach involved a mixed method exploratory sequential design (Creswell and Creswell 2019). This is a design in which the researchers begin by inductively exploring with qualitative data, build features to be tested (i.e., concepts or relationships), and then, test these features or relationships in a subsequent quantitative phase operating in a deductive mode. Such a design is appropriate to the present research because we lack existing theory that integrates KM with the technology affordance lens to explain how global teams sustain effectiveness. Accordingly, we

proceed first with the exploratory inductive phase that makes use of a grounded theory approach (Strauss and Corbin 1994). We needed to understand what KM activities and affordances occurred and how they unfolded in situ and determine if the KM activities were accompanied by certain affordances and if teams dynamically changed affordances as they changed their KM activities. This was followed by a quantitative phase to test relationships among technology affordance processes and the effectiveness of the global teams that we had arrived at during the qualitative phase. Such a mixed method approach is often recommended when the goal is greater understanding of underlying mechanisms in at least partially new territory or in a new context (Edmondson and McManus 2007, Gibson 2017) or for proximal theory building and testing, which entails openness to dynamic relationships and an appreciation of multiple viewpoints during interpretation of findings (Gibson et al. 2012). These features characterized our theory development and testing because we wanted to understand how global teams sustain effectiveness over the course of shifts in KM activities using technology and address the reality that many global teams habitually use the same or a single technology despite these shifts, which ultimately decreases their effectiveness.

We chose to conduct our study in a multinational corporation to ensure teams were comparable in objectives, membership, and in their likelihood of engaging in all three KM activities. That is, the teams were global and required to accumulate knowledge unknown to other members at different locations. Team members were also members of operational local teams from which local knowledge was derived so that the sources of the accumulated knowledge were comparable; the teams were tasked to develop an integrated package of knowledge (best practices), thereby requiring integration of knowledge, and the local teams were expected to implement the global team's knowledge, thereby requiring KM implementation activities.

The sample consisted of 48 global teams in a mining, minerals processing, and manufacturing organization that were established across sites to share and implement best operating practices. All the teams were formed at the same time (and hence, were of the same "age") for the same purpose, and all had access to the same technologies and were trained to use these technologies. We began our study when the teams were first formed. When founded, each team contained members from plants in six countries (Australia, Brazil, Jamaica, Spain, Suriname, and the United States), including two employees per plant, for a total of 12 "core" members per team. The sameness of the teams in objectives, degree, configuration of national diversity, geographic dispersion, and access to

technologies helped us rule out variances in these features as alternative explanations of our findings, an important step in conducting team research across cultures (Leung et al. 2011, Kirkman et al. 2012, Gibson et al. 2014). Such consistent team composition and tasks in a field setting are rare in the research literature. Indeed, we know of no other field study with such controls.

Each team was tasked with sharing, integrating, and managing members' local knowledge of a specific aspect of plant operations to generate best practices that would ultimately improve standardization and productivity across the organization. A best practice was deemed to be an internal practice performed in some part of the organization in a way considered superior to both internal alternatives and to known external alternatives (Szulanski 1996). Best practices often pertained to operational procedures that, after agreed upon by the team and approved by the organization, were codified in a document containing instructions that standardized how all personnel interacted with the process across locations.

Hence, work within the teams entailed members discussing with others how they performed their process across locations, sharing ideas about defining a "best practice," recording these as generalizable best practices in the firm's knowledge repository, and then promoting the spread of these superior procedures across the organization. Each team had a formally assigned facilitator. The teams' work was undertaken during monthly teleconferences and supplemented by emails, instant messaging (IM), postings in a knowledge repository, and face-to-face meetings. Although this work was in addition to their other work roles, it nevertheless involved similar KM activities and use of the same technologies.

Phase 1: Exploratory Method

The participating firm granted us access to observe, record, and review all communications—teleconferences, face-to-face meetings, email archives, knowledge repository postings, and texts—exchanged during the study period, which coincided with approximately the first two years of the teams' existence. Not all teams engaged in all these forms of communication. We were also allowed to request one-on-one interviews with team members. We observed and recorded 27 teleconference calls held by nine teams. One of the researchers observed, recorded, and transcribed these calls; the average duration of a call was 50 minutes, and average transcript length was 42 pages, for a total of 1,134 double-spaced pages of text.

In addition to attending conference calls, we interviewed 71 team members, based on their availability during the study period, across 16 teams. All interviews were in English. Interviewees were carefully

selected to represent diversity of location, nationality, age, and role in a team. Considerable effort went into ensuring the facilitator and at least two to three other members of each team were included. Most interviews were conducted face to face and were about one hour in duration. The interviews were designed to be open ended to elicit detailed, firsthand accounts (Charmaz 2014). In keeping with grounded theory methodology, the interview protocol (available upon request) was kept flexible to allow for follow-up questions, clarifications, and unanticipated responses (Charmaz 2014). In the end, this approach yielded rich data and "thick description" (Geertz 2008) concerning technology affordances.

Questions in the interviews concerned numerous issues, including team composition, structure, processes, and outcomes. Members were encouraged to provide examples, illustrations, and narratives about specific meetings, conversations, and exchanges in their teams. Interviews were audio recorded and transcribed verbatim, resulting in 2,280 double-spaced pages of text. We attended all face-to-face meetings held during the study period, taking copious notes during the meetings. These occurred across all regions in which the company operated. Collectively, the authors spent 39 days (365 hours) in the field. Notes of observations were transcribed and used as described in the analysis. Finally, we reviewed meeting agendas, email archives, knowledge repository postings, and text messages. In total, we amassed qualitative data regarding 25 teams and had multiple qualitative data sources for each one.

Analysis

We focused on the team level of analysis. First, we used a grounded theory approach (Strauss and Corbin 1994) suited to focusing on "a process or action that has distinct steps or phases that occur over time" (Creswell and Poth 2016, p. 83). Coding followed the Charmaz (2014) process, moving from open codes tied directly to small bits of text from the transcripts to a stage of focusing on connections between codes. This is also referred to as moving from open to axial coding and selective coding (Saldaña 2013), which involves a set of data analytical procedures that assist the inductive development of theory (Glaser 1992). We followed the Urquhart et al. (2010, p. 369) recommendation that constant comparison with previous data, categories, concepts and constructs is the key to developing theoretical constructs from relationships between initial conceptual categories or early-stage codes. For example, we used concepts for KM activities from the literature, but in the inductive mode, the affordances and cues emerged from data.

Following line by line coding of transcripts and observational notes, we constructed pattern-matching

tables (i.e., see Tables 2, 3, and 5) and iterative analytic memos. This lets us link observational notes and information from the conference calls to interview segments, and we noted instances of KM activity and technology use. We discussed emerging findings and returned to informants in the organization when contradictory interpretations surfaced. We also engaged researchers uninvolved with the study to discuss emerging patterns in the data and to critically assess the data collection and analysis procedures. We asked an experienced qualitative researcher external to the research team to help assess the trustworthiness of our data. This researcher examined our records (coding schema, several interview transcripts, and field notes) to confirm the plausibility of our conclusions. These techniques were important because notions of reliability in quantitative research are not directly comparable with qualitative research, which instead emphasizes data trustworthiness (Van Maanen 1979, Lincoln and Guba 1985) by using peer and expert debriefings to discuss emergent codes and relationships. In accordance with the constant comparative method (Glaser and Strauss 1967), we compared interview and observational data to examine whether they provided supporting or contrasting information. As before, we returned to the data sources to resolve discrepancies.

Findings

Findings Regarding Knowledge Management Activities. We began by coding for instances of team behaviors associated with each KM activity, using both in vivo codes and codes from the literature based on characterizations for each process. For example, codes for accumulation included “acquiring information/knowledge,” “sharing information, knowledge, expertise,” and “accumulating information, knowledge, experiences.” Codes for integration included, for example, “combining knowledge,” “collective understanding,” and “perspective taking.” Codes for implementation included, for example, “codification,” “documentation,” “trialing,” “experimentation,” and “reporting results.” Although we coded individual contributions during calls, interviews, and face-to-face meetings, we aggregated them by team, reflecting our team-level focus, to arrive at a characterization of the processes as indicated by each team as well as at a way to make comparisons across teams. We found that members reported highly similar accounts within teams and that easily identifiable differences occurred across teams, which made characterizing and comparing teams straightforward.

Our coding revealed instances of each of the three KM activities across teams and several shifts that occurred (see Tables 1 and 2). Importantly, we found

Table 1. Examples of Knowledge Management Activities

Knowledge activity	Examples
Accumulation	<p>Member on a call: “Another clever idea that I saw at [plant] was that they actually used the online computer to check that the work actually got done during the day . . . during circulation. They were checking that the pump was on and how long the pump was on. And they had a little spreadsheet, which got put out every day to say whether they had met the goal. Just passing that on to you as an idea.” [Team E]</p> <p>Member on a call: “What we have asked for is every location to do a self-assessment on the [program name] best-practice system. Now that we have that information, we can share and see where everybody is, and, you know, where the efforts and focus going forward can be prioritized.” [Team B]</p>
Integration	<p>Member 1 on a call: “That would work for you, via email?”</p> <p>Member 2 on a call: “Yes. That would work for me. I mean, just in the way I process the information, I think that would be good, and I’d know it’d be there and know where to go find what I needed to make comments and provide feedback.” [Team H]</p> <p>Interviewee: “Every call I have, after the call, there’ll be a lot of emails that fly around amongst people. If I’m included on it, I know, if my other team members that report to me are included on it, well then, we’ll know about it, but there are other things that occur we might not find about it. So, one of my frustrations is we, as a group, we don’t share as well, those conversations and things get lost and everyone’s not aware of it.” [Team A]</p>
Implementation	<p>Member on a call: “So, it’s about, it’s a measure of our ability to satisfy the customer contracts that we should have with all of our refineries. And early days, but I think you’ve done a fantastic job for the effort that you’ve gone to get some software and produce these. I think it’s a great job. So, thank you. So, if you could share this information with me on the best-practice share site that would be appreciated as well.” [Team B]</p> <p>Interviewee: “They’ll actually take a whole chain of emails and post them up as a discussion item because they thought, ‘Well hey, it’s worth capturing that.’” [Team M]</p> <p>Member on a call: “At the end of July, I think all of the locations will have had time to look at where is their resource and reserve status. So, they will have had a chance to work on . . . to reconcile that, and management inside the corporation has been asking for a buy-in, and we’ll update on that. You’ll be asked to put your results in there. It’s a tool that can have a lot of benefits.” [Team B]</p>

that some teams attempted to shift to a new KM activity when they sensed that they had made sufficient progress on the activity at hand. For example, teams began to shift away from knowledge accumulation when no new information, data, or ideas were continuing to emerge. The following excerpt from Team A's teleconference meeting illustrates this.

Okay. I think we have what we need. We have the current condition around advanced control, where some of the problems and issues are, and where we will head in the future with it. This is meant for us to use as a lead in to the face to face. I've shown the pre-work. Is there any further information that anyone needs from each site, particularly the international attendees? —Member 1

Yep. We come up with any bumps we will drop you a line. —Member 2

As a second example, teams attempted to shift from knowledge integration activity when members sensed they had reached shared understandings or mutuality in interpretations. An example from Team B shows this, as they shift from integrating knowledge to implementing it on the best-practice site.

The individual values in the upper part of the graph are the almost daily observation, and the lower part

of the graph shows the moving range, in relation to the individual values from the graph above. The spikes, we just explained. Necessary precautions are shared and are communicated to the production and the mining departments so that they can react and correct in a proper manner. —Member 1

Okay, yes, we understand now, it's a measure of our ability to satisfy the customer contracts that we should have with all of our refineries. And you've done a fantastic job, and I'd like to congratulate you for the effort that you've gone to get some software and produce these. I think it has really helped to make sense of it. So, thank you. If you could share this on the best-practice share site that would be appreciated as well. —Member 2

Finally, our data revealed that teams attempted to shift from knowledge implementation when knowledge had been incorporated into operational routines and they were ready to commence a new initiative. Team P reported the following after a face-to-face operational implementation meeting.

Yeah, the group delivered a method They've increased it by a factor of four to four-point-five, which has given us more accurate numbers across different mining areas because, as you know, we're spread out a long way so there's geological or mineralogical

Table 2. Examples of Knowledge Management Activity Shifts

Activity shift	Examples
Accumulation to integration	Member on a call: "As questions arise, be sure to contact [Member 2] or [Member 3] or myself, and we can work through those questions because this is a very important topic to the corporation that's being recognized more and more as something that is really foundational that each location has a good, strategic plan, and that the best practice we create must then be made up of a number of different components." [Team B] Member on a call: "Now that we have the individual reports, I think we'll have to play around with a few ideas and try and get a standard report, but as I said, if anybody's got anything they want to share, please send me an email, so we can get the standard developed." [Team A] Member on a call: "The way to convert how well that's understood is that with the impending end of Quarter 2, we could get each location to send us a report on the first two quarters and the year to date in terms of mine plan compliance and then synthesize it." [Team E]
Integration to implementation	Interviewee: "After the many discussions by email, I posted some shared documents when we did something that I believe was good in my plant and shared it with the other sites, so we all had an idea what was happening at the other sites so we can later on dig and ask people." [Team E] Interviewee: "There was a lot of exchange about this. What I would then do with that is to follow up and ensure that that recommendation is still current and update that information on to the SharePoint site and ensure that everyone gets that so they're aware of the current best practice." [Team C]
Implementation to accumulation	Interviewee: "The plant site event was great. For instance, to understand, you know, why there was a deviation, or the impacts of those deviations as we go forward. I'm going to request that the managers accumulate reactions for their own location and then send me their section of the updated matrix." [Team P] Interviewee: "After the [face-to-face] meeting, we sent out to each of the locations a sort of skills matrix, an internal skills resource matrix for each location. So, then the locations can upgrade that information and it can be discussed." [Team B]

differences between some of our mining pits. And the mine plan, I was looking at a 36-month mine plan today, and it looks like everything's under control now. We've opened up some new areas and balanced it all out. —Member 1

That's good improvement. There's enough known that, in terms of sequencing the ore, there's really a minimal effect on losing any resources. That's pretty good because it sort of came up as a pretty significant issue, I guess, towards the middle of last year, but it seems like it's pretty well in hand. —Member 2

Nevertheless, not every team indicated engagement in all three activities. For example, of the 25 teams, coding for 8 indicated only accumulation behavior, with no indications of knowledge integration processes. Importantly, this shortcoming was despite apparent saturation in accumulated knowledge, perhaps even information overload. Hence, coinciding with our theory development, they indeed seemed mired in accumulation and unable to integrate knowledge or to make use of it to meet objectives. However, this shift was critical, as described by an interviewee.

Once we had all the contributions, next we tried to get a consistent interpretation of this measure. If not, we're probably not highlighting the problems and tackling the right sort of issues. And once we highlight this, we can start to say, "Well, why do we have to do that?" and down the line, there could be opportunities to improve our planning processes to better cater for the sort of circumstances that we're finding. [Team A]

As this example illustrates, getting "stuck" or "bogged down" in a particular KM activity often occurred because the team had not realized that different affordances were necessary to move forward. One interviewee commented on the need for more teleconferences.

We exchange some ideas by email. But some teams, they have more teleconferences. That is, getting the group together and coordinating agendas and sharing and distributing that work or not. Without that, it is difficult to coordinate. In the case of [Team P], they hold roughly monthly meetings.

In contrast, having used teleconferences and off-line instant messaging extensively, one team highlighted the need to move onto knowledge implementation and yet, had difficulty doing so.

In terms of how to get better at best-practice transfer, one thing is some way of organizing that information well, this needs better coordination. Coming to the face-to-face, we probably should've had the face to face earlier. [Team R]

Findings on Technology Affordances. Beyond insights into KM activities, our exploratory analysis also helped us understand technology affordances. All the teams had access to the same technologies, including presentation-based conference calls with other team members, the instant messaging chat function on the team's website, reading/sending emails with team members, contributing to or accessing shared documents in a document repository (SharePoint), planning or scheduling tools (e.g., Outlook, Project, etc.), and meeting face to face with other team members. Three patterns emerged that described different forms of affordances: *technology-focused collective attention (attention focusing)*, *technology-iterated collective sense-making (iterative sensemaking)*, and *technology publicly codified (codification)*. Further, we observed that not all teams engaged in all three affordances. Some teams used only one technology affordance. Others mentioned that over time, they had used all three affordances. Each affordance is described. Table 3 shows evidence of the pattern in which a particular technology (e.g., teleconferences, email, etc.) was used to accomplish a particular purpose (e.g., attention focusing, sensemaking, and codification). The teams were remarkably consistent in their alignment of using technologies for specific purposes.

Technology-Afforded Attention Focusing. A key technology affordance was to focus the collective attention of the team via both *planning and scheduling tools* and *teleconference calls*. Local activities often took precedence over the global team efforts. Consequently, a purpose emerged for using the communication technology to keep the attention of team members focused on the team's activities. The problem was not about the simple sharing of their localized knowledge but rather, the more difficult cognitive task of ensuring that the knowledge and information being accumulated across the diverse locations were comprehensive, globally applicable, and useful. The teams used planning and scheduling technologies to create milestones and meeting times to focus members' attention on the team. The teams also used their teleconferences in a highly structured fashion, driven by detailed agendas, combined with WebEx displays of PowerPoint presentations or analytic results. This structure of the teleconferences seemed to enable the team members to focus not simply on the content from each site but more importantly, on how the content differed across sites and what content should be identified as best practices. Members presented on operational challenges and potential solutions they had experienced at their specific locations, which then focused the team's attention on specific discussions about how those solutions might apply across locations. For example, during one call, a member made a presentation

Table 3. Evidence of Technology Affordances

Technology	Affords focusing attention	Affords sensemaking	Affords codification
Planning or scheduling tools (e.g., Outlook, Project, etc.).	<p>Yes. Members commented about the use of Project to focus on a specific agenda item after a call. For example,</p> <p>“While I’m talking, maybe if there’s an item that people are concerned about, they can raise it up through Project for follow up.” [Team L]</p> <p>All of the teams posted agendas in Outlook to focus attention on specific topics during the meetings.</p>	No	No
Conference calls with other team members	<p>Yes. Many of the call agendas were dominated by formal presentations that served to focus members’ attention on specific topics, issues, and practices. These were of 45–50 minutes in duration; specifically, 73% of the calls had such presentations.</p> <p>One member described this focusing effect of the calls as follows:</p> <p>“We picked a couple of areas in our daily management best practices that none of the members had really scored well on, and those were the financial elements. And so, the focus for these best-practice calls have been having each of the plans reviewed. The application of those best practices occurs later.” [Team A]</p> <p>Following another presentation, a member commented:</p> <p>“I think that’s about it, everyone. I’ve probably spent 25 minutes talking about this so I’d better stop, because we are at the end of the call. But yeah, feedback later by email is more than welcome, and I hope it makes sense.” [Team P]</p>	<p>No. Less than 5% of the time spent on calls was used for open discussion; rather, calls were spent on narrowly defined, forma, agenda items (primarily presentations that focused attention but did not constitute integration).</p> <p>Members often commented that sensemaking was hindered on calls:</p> <p>“Even when we have the representatives, nothing against those guys, but I don’t think they’re necessarily in a position to speak for the BU [Business Unit]. So, it just illustrates again today that everybody’s days are filled with regular work and you guys are doing this in your spare time.” [Team P]</p> <p>Another member curtailed sensemaking following her formal presentation on a call:</p> <p>“If you guys have any improvement or you want to change it in any way, you know, really put your two cents in, okay, you can email me afterwards, send me via email your suggestions of what this could look like.” [Team A]</p>	No
Instant messaging chat function on the team’s website	No	<p>Yes. Members often commented on using chat for sensemaking:</p> <p>“There’s a little chat section, basically, where you can easily chat. And [member] might come in there occasionally, rather than coming into a meeting and cutting the meeting short and talking, he would instead just put a general comment through the chat line. So, you’d see that come up, and you could respond immediately.” [Team A]</p> <p>Another interaction, indicated the same:</p> <p>“Anywhere in our refineries we have the Messenger thing, so if you look you see people who are online; if there is somebody from your committee, you can talk; right away you can say ‘Hey, what’s going on up there?’ We can always contact anybody within the [team] for whatever reason, to get immediate help.” [Team A]</p>	No

Table 3. (Continued)

	Affords focusing attention	Affords sensemaking	Affords codification
Technology			
Reading/sending emails with team members	No. In fact, interviewees described the challenges of using emails to get everyone's attention to attend the biweekly meeting: "It's harder to do that, get everyone's attention, just one by one in emails, when you can do it in a conference call or you can do it with Outlook." [Team R]	Yes. Following a call focused on balancing critical factors like haul distance and grade requirements, one member explained: "Then you can just contact through emails for specific problems. The call is really like an overview of what's going on and some of the issues that are there. Then you might say, 'Look, I'm going to need some help with this; I'll probably give you an email soon; can you give me a hand with that information?'" [Team B]	No
Use of shared documents or team data resources in SharePoint software	No. One member alluded to the difficulty of using SharePoint to focus attention: "I've only just started using the SharePoint site. I think there are lots of opportunities there for the use of it, but it probably needs to be a little bit more structured and focused." [Team M] Another commented: "If it was really urgent it would be done by a phone call or an email. But [in SharePoint] it's not a specific issue that they need an answer or straightaway. It's more like a communication tool for procedures." [Team P]	No. One member indicated that although posting material in the knowledge repository should facilitate discussion of it, this was not a common practice: "The [team facilitator] asked guys in the plant, 'If you do some work, put your reports on SharePoint so other guys can have a look and discuss it in the team,' but I still don't see people doing that, with the frequency that I believe would be best." [Team D] Another commented: "SharePoint gets used very infrequently for problem-solving. I think I've seen one problem on there all year." [Team B]	Yes. One member explained: "If we have anything that we've done and want to share with everybody, we just post it. And they post it as well and I will just go in and read it." [Team P] Another commented: "We would go in and you would find it, the standard solutions across the refineries. So, your documents are stored, or links to stuff are available from the site, as well as innovative solutions that somebody developed." [Team H] During an interview, a member described the usefulness of SharePoint as follows: "We posted shared documents when we did something that I believe was good in my plant and shared it with the other sites, so we all had an idea what was happening at the other sites so we can later on dig and ask people." [Team C] Yes. One member said the following about a recent face-to-face event held by the team: "At this refinery we are flat strapped and we would take months and months to resolve this. [As a result of this event] it is not about leaving the plant with expectations that they will follow up in three months. It is about leaving us with a system that will immediately deliver results; we know from another plant that these are our best test options, and we now need to implement them." [Team P] Another member described the activity at the face-to-face gathering as follows: "So, we did some observation, and had a review of the standardized work for tank circulation which obviously is a critical activity for us. So, we went out there and we actually got out the stop watches, we had a look at the activities list and separate activities." [Team P]
Face to face	No	No	

Table 4. Evidence of Change in Technology Use

Change in technology use	Examples
Changing from technology affording attention focusing to technology affording sensemaking	Member on a call: "Next, I'll be writing sort of a position paper on that and we'll be circulating that to the locations by email because I need to be sure I'm getting a lot of input, and I think maybe even [Member 2] is putting something together for that as well." [Team B] Interviewee: "Items like that come up on the call. Instrument or method issues might come up. So, we'll focus on that. A site might have an issue, 'Can you help us out with that, try and understand that?' So, we send around a lot of emails and documentation and discuss it." [Team H] Interviewee: "Quite often after a conference call, I get emails, you know, 'What about that?' Because they won't ask, they're not comfortable enough to ask that question in front of the group." [Team D]
Changing from technology affording sensemaking to technology affording codification	Interviewee: "Before that our work was usually sort of email driven If there was a problem it went to somebody, to somebody else; it diffused back to the person that had an idea and then it sort of diffused back out. But now, with the best-practice site [in SharePoint], you can centralize it and didn't have to know who the current engineer was." [Team M] Interviewee: "Following a good exchange, at times I've copied the email chains and posted it on the discussion board in SharePoint, and asked people to do the same, to document the best practice." [Team B] Interviewee: "After that email exchange, if you want to see a trial that's happened, say, in another site, if they trialed a particular [practice], and you want to know what the results were, then you check the spreadsheet they uploaded to SharePoint." [Team P]
Changing from technology affording codification to technology affording attention focusing	Interviewee: "For example, last week we participated in a face to face and now we have to put all the presentation and all the things in the page so everyone can see the job that we did. An outcome of the face-to-face meeting, was that we had to have another discussion in the conference call meeting." [Team H] Interviewee: "Over the last couple of years we've been doing audits of laboratories. And then those laboratory audits get fed back into the teleconferences that we have. So, every two months there's a teleconference." [Team L] Member on a call: "After the onsite trials involving our key three suppliers, then can use Project to create a global tracking, a spreadsheet that everyone can all access; you can see who is doing what, what the target is, stuff like that." [Team P]

on compliance with new measurement protocols. Across the 50-minute calls, an average of 95% of the time was spent on these types of narrowly defined, formal, agenda items that served to focus members' attention on specific topics, issues, and practices. Although prior literature on groups has addressed the importance of collective attention (Metiu and Rothbard 2013), noting the challenges when other priorities vie for members' time, not yet addressed are the ways technology, such as planning and scheduling tools and teleconferences, afford such processes. Further, identifying attention focusing as an important affordance demonstrates a critical interpersonal purpose of technologies such as planning tools and teleconferences. This extends prior work on affordances (e.g., Treem and Leonardi 2013) in which characteristics of

the technology such as persistence and visibility are emphasized rather than the coevolution of purpose with particular technology use.

Technology-Afforded Iterative Sensemaking. A second key technology affordance that emerged was iterative collective sensemaking through *the interactive use of email* and *instant messaging chats*. Because the teams were global, the communications among team members needed to elicit a shared meaning and interpretations in a way that allowed for synthesis of the different perspectives across sites without compromising them, as well as identify ways to extend the perspectives to create practices that were not just synthesized but also still applicable to each localized setting. This made sensemaking exceedingly complex,

Table 5. Evidence of Cues for Change in Technology Affordances

Cue category	Cue	Example	Change in technology affordances
Realization of knowledge characteristics	Lack understanding of knowledge	Interviewee: “When I have some doubts about something on a call, I have to ask for a more experienced person, it’s by email but the community has a list of persons that participate of the community, so we can see who fits to our doubts, and then they contact by email.” [Team C]	Attention focusing to sensemaking
	Lack of global applicability of knowledge	Member 1 on call: “We can work side by side on that later. Have we got all the right players involved from around the globe? If anybody had any ideas with how it could be more standard, that was what I was looking for as well.” [Team B] Member 2 on call: “This is new. Every location is beginning to get deeper and deeper into their own use of the technology for a number of different purposes; for the exploration purposes, for the mining purposes and for mediation and environmental, and that is the sort of specialized topic that maybe a subcommittee could be formed in that.” Member 3 on call: “I think it’s a great idea. I’m happy to take it away with you and try and put together some ideas and send it out to the players on the line, so appreciate that feedback.”	Attention focusing to sensemaking
	Complexity of knowledge	Member on call: “Anyone that’s got any of those building tests for any of the activities I’d be really interested to see what you’ve got going so that we might be able to see if those apply That would be great if you could send it through by email. So just to continue on [formal presentation continues].” [Team A]	Attention focusing to sensemaking
	Specificity of knowledge	Interviewer: “If you have a question, what do you do?” Interviewee: “I, normally, I use the email to a specific person, ‘cause sometimes it’s a very specific issue, and sometimes the plants are not equal—there are some particular areas of each plant—and normally you try to, in my case, I try to use a direct information. When the question is general, I put it on SharePoint.” [Team C]	Attention focusing to sensemaking
	Cognitive demands	Member on a call: “Well, I do have a few processes to think about there, but you and I just need to put our heads together, maybe in an email back and forth, and collate those and then we can get that out to everybody.” [Team B]	Attention focusing to sensemaking
Awareness of emergent psychosocial processes	Trust	Interviewee: “Most of the correspondence that happens is via email. And, it’s never really captured. And there’s two reasons for that: one is people think the team might not be interested; or the second one is people don’t trust each other and don’t want to display what they’re talking about to everyone for fear of being stupid, fear of being wrong, I guess.” [Team P]	Sensemaking to codification
	Peer influence/pressure	Interviewee: “I will continue to encourage people to post on SharePoint and to try and impress upon them why I’d like them to do it, but many don’t tend to use the discussion boards, they use email, unless encouraged to do otherwise.” [Team M]	Sensemaking to codification
Awareness of emergent psychosocial processes (continued)	Language challenge	Interviewee: “Maybe it is the language. It is easier to know what they mean if you use email, and if after that you post in SharePoint and get comments.” [Team E]	Sensemaking to codification

Table 5. (Continued)

Cue category	Cue	Example	Change in technology affordances
Recognition of organizing or structuring constraints	Cultural challenges	Interviewee: “There’s some cultural differences. The Jamaicans, they’ll have a point of view, but they don’t want to express it on a conference call. I even deliberately stop on some of the calls if I’m midway through a presentation and say, ‘I just want a comment from each location on what you think about this.’ And then you’ll still have silence. And I’m thinking, ‘Is he actually there, or is he not . . . ?’” There is this sort of pretty powerful hierarchy that exists in the Jamaican organization, and maybe people don’t like to comment prior to hearing what their boss has got to say, just in case the boss has a different point of view Face to face would be better.” [Team B]	Sensemaking to codification
	Message sensitivity	Interviewee: “If you ask questions and everyone knows who you are, that is tough because that’s generally private. But if you post it anonymously, then everyone sees or hears it. Which I think is okay because people are better if they can post anonymously.” [Team C]	Sensemaking to codification
	Time constraints/urgency	Member 1: “We’re running a bit short on time, you probably need to give a brief version of your e-lecture.” Member 2: “I will cover this during this face to face and then I’ll post it on the website so that people can read it and look at it in greater detail before the next call.” [Team H]	Codification to attention focusing
	Agenda full	Member 1: “There’s a lot to achieve in the face to face. And if we run out of time at the face to face, we will put it on the next call agenda.” [Team P]	Codification to attention focusing
	Poor technology quality/access	Member 1: “This isn’t good, right, having technical difficulty?” Member 2: “Can anyone see that . . . it’s not working?” Member 3: “Is it only me?” Member 1: “Let me do something. And again, I apologize. I hate having technical difficulty. Let me resend a meet now to everybody. And I’m also going to post it now so everybody can see it in SharePoint, then we will have a call next week.” [Team A]	Codification to attention focusing
	Physical constraints	Interviewee: “For instance, because there are a lot of people in the room, generally, unless you’re invited to say something, you tend to keep quiet. What I do is, you can question things after the meeting; maybe in a call or email. So, it can happen after the meeting.” [Team C]	Codification to attention focusing

creating an increased need for an iterative process, as single-site meanings were shared, understood, synthesized, and then, made localizable to other sites. The purpose that evolved then was for the team to iteratively sense make through the use of the communication technologies. Prior literature has defined collective sensemaking as a team effort to arrive at shared meaning, which involves merging the sensemaking that occurs within members’ individual frames of reference (Hsiao et al. 2012, Wolbers and Boersma 2013, Merkus

et al. 2017). However, this literature does not extend this to the need for sensemaking to yield localizable practices and to describe how this is accomplished through communication technology.

Iterative sensemaking was conducted using communication technology for back-and-forth dialogue. The dialogue focused on assumptions underlying each person’s perspective so that a common perspective could be developed. As shown in Table 3, the team used *email* and *instant messaging chats* iteratively

to engage in this purpose. Members used these to discuss different perspectives on a single issue. All team members were copied, and the team asynchronously and gradually worked through the collective sense-making process over multiple iterations. For example, one member might send the entire team an initial interpretation for a specific issue. Other members then responded with variations to it based on their perspectives. These iterations through email and IM continued until the team made collective sense of the issue. Although the use of email and IM specifically for the purpose of iterative sensemaking might be in part because of some features of email and instant messaging such as asynchronicity, editability, and persistence (Clark and Brennan 1991), members of the teams in our sample seemed to benefit primarily from a willingness to use the technologies as a way to continue back-and-forth conversations that were often quite complex to accommodate the unique perspectives of each team member. Interestingly, in our context, collective sensemaking did not occur in teleconference calls, although one might expect it to be a forum in which it could occur. In fact, across all the calls, 77% had no open discussion or question and answer whatsoever. In those few calls that did have open discussion, it was brief, on average taking less than 5% of the time on the call. As we discuss, this is likely because of the global nature of the teams, with members being embedded in different locations and time zones and with different degrees of language proficiency. The asynchronicity, persistence, and editability of email and instant messaging clearly were instrumental in their use, but it was the manner in which they were used to engage in difficult conversations that afforded more collective sensemaking than did conference calls in this context. During a call, members often suggested follow-up via email for the purpose of sensemaking; for example, a member from Team A said:

And look, I think we'll have to play around with a few ideas and try and get a standard report, but as I said, if anybody's got anything they want to discuss, please send me an email. I'll post up the information that I've spoken about in the next day or so, and if you have any other questions after the call is finished tonight, please feel free to send me an email.

Technology-Afforded Public Codification. A third technology affordance that emerged was public codification, which was carried out with the joint use of *public repositories and face-to-face meetings* to pilot the content of the repositories. The emphasis here was that this codification occurred collectively and was often event based. This result extends prior research that focused simply on visibility of social media (i.e., Treem and Leonardi 2013). For example, interviewees

explained that SharePoint allowed for posting for broad accessibility and version control of information that had been collectively derived. More importantly, however, the codification in SharePoint was the collective result of a preceding face-to-face meeting conducted as a *kaizen* event (i.e., multiday change workshops focused on a particular process improvement) (Glover et al. 2014), in which members from around the world traveled to a refinery to jointly codify knowledge so that it could be implemented to meet a specific operational challenge. Procedures were piloted during such events, and results were discussed so that the procedures could be documented for members' locations upon their return to their own refinery. Therefore, the SharePoint repositories did not make the mistake of most repositories, which are rarely used because of the difficulty of localizing the repository knowledge (Gray and Tehrani 2003); instead, these repositories when coupled with face-to-face meetings represented a collective commitment to use.

Findings Regarding Cues for Change in Technology Affordance. Next, we examined whether each of these three technology affordances remained stable in a team or were switched over time. Table 4 provides examples of reported changes in affordances. We then examined *when* and *why* teams changed technology affordances. Through our analysis, we came to understand that certain cues signaled that the current purpose and concomitant technology in use were inadequate to keep the team moving forward in its task. This prompted switches between technology affordances in some of the teams. By changing the technology affordance, this enabled a shift to a different KM activity and sustained effectiveness.

It is important to note that these were collective processes. Our observations were conducted with the entire team, and we were careful in our interview protocol to prompt the members to respond based on the team, as a whole. Interviewees sometimes pointed to an instance in which a member first suggested a change in technology affordance that required involvement by the entire team. Our data suggested that such changes were subsequently discussed and agreed upon, and then, the change was a collective team process involving all members. For example, if during an email exchange, a member suggested changing to a team conference call to focus attention, the team had to agree to attend and participate; likewise, if during a conference call a member suggested a follow-up via email to afford better opportunity for sensemaking, agreement from the team with this action was sought before the call ended. Some teams attempted to shift KM activities but were unaware of the cues regarding the need for new affordances; they

tended to continue habitual use of the same technology affordance, and their effectiveness suffered.

Our analysis revealed 14 cues that prompted awareness of the inadequacies of the affordances of a current technology. After identification of these cues by using open coding, we engaged in axial coding as an intermediate step, which is a process in which data are put back together in new ways after open coding, by making connections between categories (Strauss and Corbin 1994). In this step, we aggregated the 14 raw codes for the cues into three categories of cues: *realizing knowledge-related needs*, *awareness of emergent psychosocial processes*, and *recognition of organizing or structuring constraints*. Table 5 illustrates the 14 cues that emerged and how we organized them into three categories as well as the corresponding new affordances developed in response to the cues. Each of the three categories of cues signaled the when and how of the need for changes in technology affordances to sustain effectiveness.

Realizing Knowledge Characteristics. The first category of cues related to characteristics of the knowledge being managed and the collective limitations associated with those characteristics. This included a lack of shared understanding of knowledge, realizing the complexity of knowledge, the local specificity of the knowledge, or cognitive demands in assembling the knowledge across members. We found that this category of cues prompted a change from the team using their communication technology for the purpose of focusing attention to instead use their technology for the purpose of collective iterative sensemaking. For example, interviewees mentioned that if there was an inconsistency across members in their understanding of something introduced on a call, they might prefer to make sense of it later in an email exchange with the team; the lack of shared understanding signaled a need for new technology affordances to digest the material. The lack of shared understanding required the team to use technology not simply asynchronously (as would be a planning tool, which was no longer helpful) but also, allowed for iterative interpretations to arrive at the shared meaning (such as their use of email). Likewise, interviewees commented that complexity of knowledge prompted a change in their use of the communication technology to enable sensemaking because it was difficult to interpret complex ideas during a call, without having time to reflect and arrive at the collective construction. Members were also prompted to change to a different technology affordance when knowledge brought to their attention seemed highly specific, localized, or idiosyncratic. For example, during one interview, a member of Team E explained the change from technologies that supported attention focusing (i.e., conference calls) to technologies that supported sensemaking (i.e., email).

We start with the call. But then you get contacts through emails for specific problems, so the call really just seems to be an overview of what's going on for some of the most important issues. But then you can say, "Look, I'm going to need some help with this; I'll probably give you an email soon; can you give me a hand with that information?" And then they get your name and know what project you're working on, and then you get the email feedback from several members.

Finally, although conference calls were used to focus attention on important topics, cognitive demands during calls were also high, including keeping track of who said what and which location was represented and then translating that to one's own context. When knowledge demanded advanced cognitive resources, this prompted the teams to recognize that the structured conference calls for focused attention were inadequate because the team members were having trouble making sense of the knowledge. In that case, the teams coevolved to change their immediate purpose to collective sensemaking, using the interactive nature of email and chat.

Awareness of Emergent Psychosocial Processes.

A second category of cues related to emergent psychological or social needs, such as trust, message sensitivity, peer pressure, language, or cultural challenges. These cues often prompted changes in affordances from collective sensemaking to public codification. For example, a member of Team B said that language differences often prompted a change in affordances.

It is quite often hard to get into the conversation sometimes. Having 12-odd people on the line is very difficult to handle as a group, and often people are very quiet and don't talk; because firstly it's not their natural language, and secondly the clarity isn't as good as it should be. To get that clarity, you might need to meet with the person.

Highlighting that psychosocial cues made the shortcomings of the technology salient, which then prompted a change in affordances, one interviewee from Team R said:

It wasn't a daily thing for people to log on there [to the SharePoint site] and see what's going on, but that made for coordination challenges. And now I've seen it sort of evolve into a place to coordinate globally ... provide different people globally in a group with a desired direction for putting the best practices in place, the way they want technology or practices to go.

Recognition of Organizing or Structural Constraints.

Finally, our analysis indicated that sometimes time constraints, the structure of the agenda, the quality or accessibility of technology, or physical constraints in the local workplace prompted a team to

change technology affordances. Most often, these cues signaled the need to change from affording codification to affording attention focusing. For example, one interviewee from Team H mentioned that although SharePoint allowed public codification, when they completed establishment of a best practice, then they collectively realized they needed a new focus for the next project. At that point, they commenced with a teleconference. However, the way the calls were being organized at some sites resulted in a change to technologies (i.e., email) that better supported understanding, which they used to prepare for the next call to focus attention.

How much do you use each of the technologies?
—Interviewer

We might start with the SharePoint site. But then we used Acrobat for the presentations. But we're on the telephone at the same time. But the call quality can vary, and at times can be really destructive. And, it's not necessarily the service provider, it's more way the calls are set up at the receiving location. So then after the call, we use email to better understand. Next, after the face to face, we also have calls in which we are able to become focused. [Team C] —Interviewee

In summary, we noted three patterns in the categories of cues and the changes they prompted. First, characteristics of the knowledge were most often the cue to change from a technology affordance for focusing attention to a technology affordance for iterative sensemaking. For example, when the knowledge being accumulated was perceived as highly complex or applicable only in a specific context, this prompted members to change their use of their communication technology to afford greater sensemaking such as with instant messaging. Second, emergent psychosocial processes often prompted the change from a technology affordance for iterative sensemaking to a technology affordance for public codification. For example, even if initially uncomfortable, trust building and peer pressure prompted members to see the value of public codification through the use of repositories and face-to-face meetings. Finally, organizing and structuring-related cues were influential in prompting change from a technology affordance for public codification to a technology affordance for attention focusing. For example, time constraints during face-to-face meetings prompted conference calls to focus attention on specific issues for follow-up and subsequent KM.

Notably, we did not find in our sample evidence of conflict concerning these changes in affordances. This contrasts with prior research that highlighted that collaborators may disagree about when to discontinue or adopt technologies (e.g., Leonardi et al. 2012). Specifically, Majchrzak et al. (2000) and Leonardi (2007) both examined discrepant events (disruptive occurrences

that can shape the way people use communication technology) and found conflict often occurs about whether such an event even happened, followed by debates about technology. We found no evidence that someone had proposed a new technology affordance that led to conflict, nor was there clear evidence of resistance to change. In interviews, several members did reflect that perhaps a different affordance was needed (typically phrased as using a different technology for a different purpose), but we did not see this as conflict per se.

Emergent Model

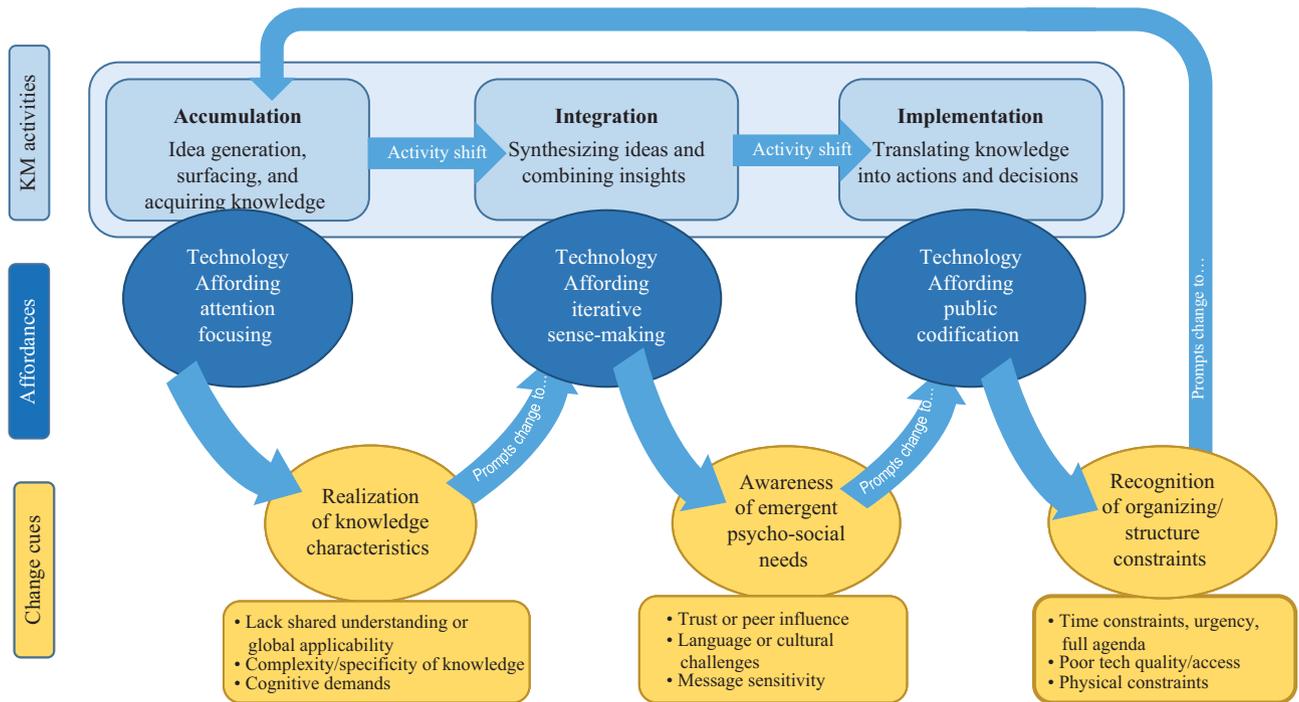
As a final step in our qualitative analysis, we undertook selective coding to understand and integrate categories to produce an organizing scheme (Strauss and Corbin 1994) and enable further systematic thinking about the phenomenon. These categories and their interrelationships formed the basis for our emergent theoretical model in Figure 2.

In answer to our research question as to how the technology affordance process unfolds to sustain effectiveness in global teams, we found that as KM activities evolved, some teams noticed and reacted to cues that a change in affordances was needed, but others did not. Teams that habitually focused on the same affordance over time were not able to shift KM activities and sustain effectiveness. Specific KM activities were matched to certain technology affordances.

In contrast, teams became mired in a specific KM activity and unable to progress on to other KM activities that were required for success when they failed to evolve affordances. For many teams, this meant being stuck in the accumulation of knowledge, without the affordances necessary to integrate that knowledge. That is, the initial accumulation of knowledge was facilitated by a technology affordance for focused attention. However, to shift from accumulation to integration of knowledge, effective teams changed to a technology affording iterative collective sensemaking. In order to shift from integration to implementation of knowledge, effective teams changed to a technology affording public codification. Otherwise, they were unable to progress. Heeding the cues in Figure 2 and changing technology affordances enabled them to shift KM activities.

We came to understand this as a type of “symbiosis” that emerged as KM activities and technology affordances coevolved, which ultimately was necessary to sustain global team effectiveness. Symbiosis is a concept borrowed from evolutionary biology, which refers to the development of any type of close and long-term interaction that enmeshes two different entities (Paracer and Ahmadjian 2000). By identifying these cues and processes, we developed an understanding of how teams sustain global team effectiveness—

Figure 2. Emergent Model of the Coevolution of KM Activities and Technology Affordances in Effective Teams



through coevolution of KM activities and technology affordances. This is new to the organizational literature.

Having developed this novel model of the coevolution of KM and technology affordances, we next sought to better understand the more systematic implications for effectiveness in a larger sample of teams in the same context. Thus, in our second phase, we modeled quantitative relationships among KM activity shifts, affordance changes, and effectiveness and compared those teams that were effective with those that were not. By complementing our qualitative analysis with a quantitative approach, we were also able to empirically test the extent to which processes were similar within the teams and able to differentiate between teams. In doing so, we provided evidence for a shared collective sense of KM activities and technology affordances in the global teams. Thus, building on our qualitative study, we hypothesized that over time as they shift in their KM activities, the most effective teams change their technology affordances to gain new affordances necessary for the processes they will commence.

Phase 2: Quantitative Evidence of Implications for Effectiveness

Our quantitative study unfolded during years 4–5 of the teams’ existence. The study had three stages. In the first phase, we looked for patterns in technology affordances to determine if differences existed within teams or across geographies and sites. In the second stage, we used a between-team approach to examine

the transition between KM activities, when a change in affordances also occurred, to understand the implications for effectiveness. In the third stage, we conducted a within-team analysis of KM activities and affordances based on the survey data at each time point for each team. This important analysis let us understand the trajectory of the broader sample of 48 teams and highlight the shift between KM activities, along with corresponding changes in technology affordances, as well as the implications for effectiveness.

Method

Sample and Procedure. We engaged in four waves of survey data collection (an average of six months apart) in the same context as in our exploratory phase but across 270 employees in all 48 of the firm’s teams. In addition, we obtained ratings of the effectiveness of the teams from an independent source—the Global Knowledge Manager (GKM)—whose role was to oversee the implementation and development of the global teams. In all four waves of data collection, the researchers invited all members of all teams to complete an online survey. The invitation was extended via an email that contained broad information about the study and its purpose, assurances of anonymity and confidentiality, and a hyperlink to the questionnaire. The surveys were delivered in English, which was deemed appropriate because all team meetings were conducted in English. Email reminders were sent out weekly to all invited participants.

We received 261 (T1), 221 (T2), 228 (T3), and 270 (T4) surveys. Individual surveys were excluded from analyses if the participant failed to identify his or her team; some additional teams were excluded depending on the availability of data. Across all four time points, demographic characteristics were similar. The mean ages were early to mid-40s (standard deviation (SD) of about 11 years), 80%–87% of participants were male, and most participants (70%–85%) held at least bachelor-level qualifications. Mean organizational tenure across the four surveys was about 14 years (SD of approximately 11 years). Across the four waves and 48 teams that we retained, we received mean numbers of responses of 6.35 (SD = 1.03, range = 0–23), 5.68 (SD = 0.83, range = 0–10), 5.49 (SD = 0.87, range = 0–24), and 6.62 (SD = 1.00, range = 0–26), for an average response rate of about 60%.

We took two approaches to investigating whether any of these characteristics were associated with survey completion. First, we compared the demographic variables of those who completed multiple surveys with those who completed only one. This did not reveal any statistically significant differences for age ($t(518) = 0.030, p = 0.976$), sex ($\chi^2(1, n = 517) = 0.83, p = 0.403$), educational level ($\chi^2(4, n = 523) = 7.97, p = 0.093$), or job level ($\chi^2(11, n = 522) = 16.76, p = 0.115$). Second, we investigated whether demographic variables were associated with the number of surveys completed (one to four), finding no such associations. Altogether, we surmise that survey completion was not strongly associated with demographics.

Measures. Our measures were each adapted from prior research for the context and consisted of multiitem scales with Likert-style response formats. Although individual team members completed most of the measures (one exception is noted), all measures captured constructs expected to function at the team level. We explain how each specific measure functioned at the team level, but our general strategy involved aggregating team members' responses to the team level by calculating the mean of those responses. Therefore, for all measures, we confirmed the statistical appropriateness of aggregation by computing the average deviation index ($AD_{M(j)}$), a prominent scale-level interrater agreement index (Burke et al. 1999, Burke and Dunlap 2002, Smith-Crowe et al. 2013). It provides the average of the absolute numerical distances between the mean rating for a team and the ratings obtained from each team member (hence, smaller $AD_{M(j)}$ values are indicative of stronger interrater agreement). Smith-Crowe et al. (2013) have provided critical values for $AD_{M(j)}$ as a function of the number of response categories and the "null" distribution chosen to model the absence of within-team agreement. For all Likert-type measures, we compared the $AD_{M(j)}$

indices obtained for our variables with several "critical" values for $AD_{M(j)}$ based on three alternative null distributions, namely uniform (critical $AD_{M(j)} = 0.85$), slightly skewed (critical $AD_{M(j)} = 0.69$), and moderately skewed (critical $AD_{M(j)} = 0.49$).

Knowledge Management Activities. Our measure of KM activities consisted of six items, with two items capturing each activity, adapted from Gibson and Vermeulen (2003). Respondents were asked to consider the previous six months (i.e., the average time between survey administrations) as the reference point for answering the items. Because individuals were asked to report on the status of their team, reflecting a referent-shift consensus composition model (Chan 1998), aggregation to the team level was justified theoretically. *Accumulation* was captured with "[team] members actively share knowledge" and "[the team] calls to members' attention new ideas and/or best practices" (mean Cronbach's $\alpha = 0.78$, median $AD_{M(j)} = 0.44$). *Integration* was captured with "[the team] serves as a sounding board for members with different and interesting ideas" and "members provide other members with helpful feedback on the meaning of ideas" (mean Cronbach's $\alpha = 0.69$, median $AD_{M(j)} = 0.54$). *Implementation* was captured with "[the team] generates novel ideas that result in major improvements in operational performance (e.g., increased production, cost savings)" and "[the team] often implements new ideas to improve the quality of our operations" (mean Cronbach's $\alpha = 0.89$, median $AD_{M(j)} = 0.53$). The correlations among the three KM processes were moderate, averaging about $r = 0.46$.

We first categorized each team, at each observation, as to which KM activity was predominant, based on which of their three KM activity scores was highest. For example, if a team in T1 had an average of 4.5 for accumulation, 3.0 for integration, and 1.5 for implementation, we categorized it as predominantly engaged in accumulation. Having identified the KM activity that the team was predominantly engaged in for each time period, we then calculated whether a shift to a different predominant KM activity had occurred at each of three opportunities (T1 to T2, T2 to T3, and T3 to T4). Teams were coded as having made a shift if a different activity was more prevalent at time T than at time $T - 1$.

Table 6 summarizes the KM activity shifts made by our sample teams, as captured by the quantitative data. We required sufficient data from teams at both time $T - 1$ (to capture a team's "prior" state) and time T (to capture a team's "current" state) to be included. In other words, without knowledge of both a team's prior and current state, it is impossible to determine whether an activity shift occurred in KM activities from $T - 1$ to T . When data from both time points

were unavailable, the activity shift opportunity could not be included in the analyses. Thus, a total of 94 KM activity shift opportunities were available for examination. This corroborates the qualitative analysis, which indicated that numerous teams remained engaged in accumulation of knowledge across all four time points, but other teams did make several KM activity shifts during the study period.

Technology Affordances. Technology use was measured by first asking members to allocate the percentage of their team’s time spent (of 100% of their time together as a team) on each of the technologies available to them (planning and scheduling tools, teleconferences, emails, instant messaging, SharePoint, and face to face). Next, because we were interested in the perceived affordances of these technologies (not the technologies themselves), we aggregated these six technologies into the three affordances they offered based on those identified in the qualitative phase: *attention focusing* (planning/scheduling tools and teleconferences), *sensemaking* (emails and instant messaging), and *codification* (SharePoint and face to face). Using a direct consensus composition approach (Chan 1998), these scores were aggregated to the team level by taking the mean across members. The average deviation indices (median across teams and averaged across time points) were attention-focusing $AD_{M(j)} = 0.07$, sensemaking $AD_{M(j)} = 0.05$, and codification $AD_{M(j)} = 0.07$, indicating significant within-team agreement (Smith-Crowe et al. 2013). Figure 3 depicts the use of the separate technologies, as well as the categories of affordances at each time point.

We created three measures of changes in technology affordances from $T - 1$ to T . These were operationalized by the average percentage reported for each of the three technology affordances (attention focusing, sensemaking, and codification) at time T , subtracting the corresponding percentage at time $T - 1$. Thus, positive scores on these variables indicate an increase in that technology affordance at a time point relative to the previous time point (and negative scores indicate a reduction in that specific technology affordance).

Team Effectiveness. We obtained two types of ratings of team effectiveness. The first was obtained from the GKM on two occasions: once immediately after the T1 survey and once immediately after the T4 survey. Given his supervisory role, the GKM was well positioned to compare the effectiveness of the teams. The GKM was also blind to our research propositions and to results of the surveys from team members. In rating teams’ effectiveness, we asked the GKM to rate each team from 0 to 10 in response to three questions: (1) To what extent have the changes to processes and procedures that have been developed by [Team X] during

Table 6. Knowledge Management Activities at Time T by Activities at Time $T + 1$

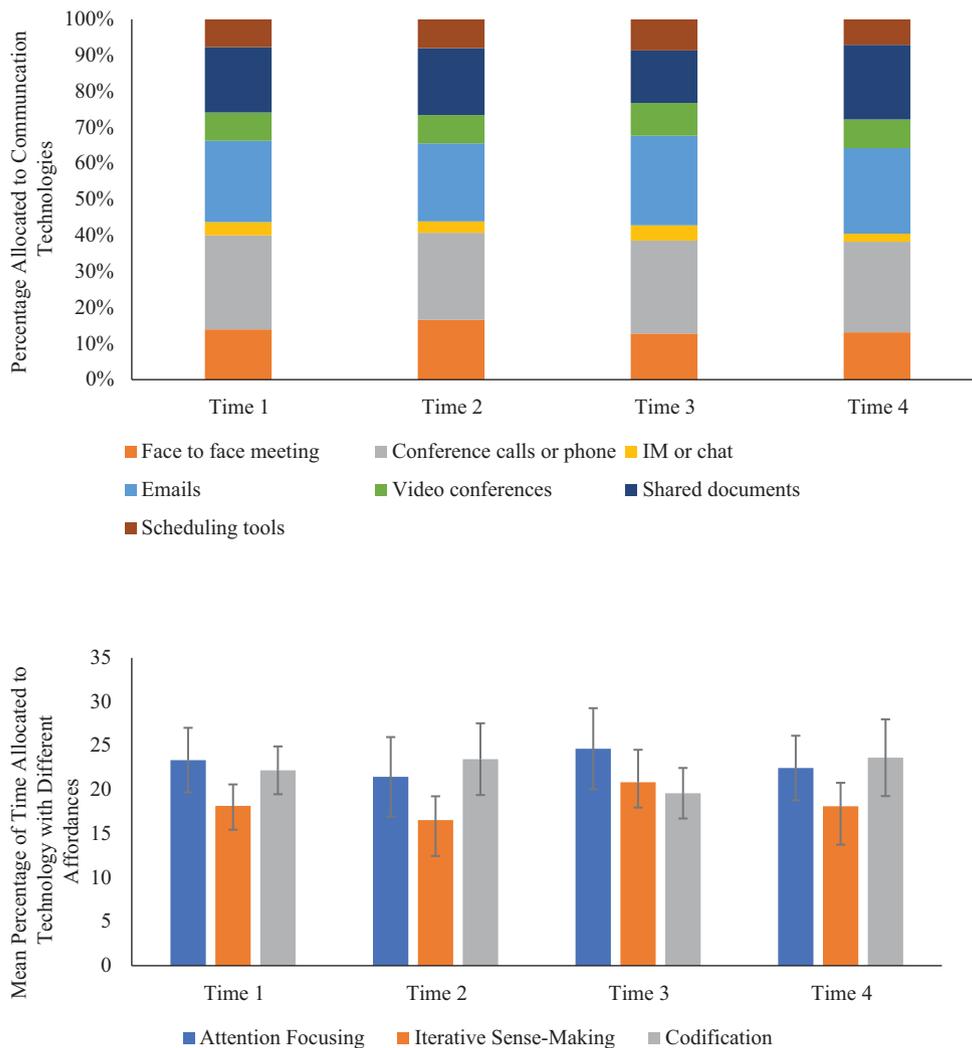
	Accumulating	Integrating	Implementing	Total
Activity at T2				
Activity at T1				
Accumulating	18	2	7	27
Integrating	0	1	0	1
Implementing	1	0	2	3
Total	19	3	9	31
Activity at T3				
Activity at T2				
Accumulating	13	2	7	22
Integrating	1	1	1	3
Implementing	4	0	3	7
Total	18	3	11	32
Activity at T4				
Activity at T3				
Accumulating	15	2	0	17
Integrating	1	0	1	2
Implementing	7	0	5	12
Total	23	2	6	31

Notes. The rows show the number of teams engaging predominantly in each knowledge management activity at time T , and the columns show the number of teams in each knowledge management activity at $T + 1$. Shaded cells show teams that did not make an activity shift between times T and $T + 1$.

[immediately after T1 survey/after T4 survey] added value to the organization (such as through cost savings, improved yields, reduction in raw materials consumption)? (*not at all to a very great extent*). (2) To what extent has [Team X] created and implemented new performance practices or standards during [this period] that have raised average performance across all locations? (*not at all to a very great extent*). (3) To what extent was [Team X] “active” during this period; that is, to what extent did [Team X] members have routine teleconferences, use their website, create practices, and solve problems during [the study period]? (*not active at all to extremely active*). These three items were highly correlated (ranging from 0.80 to 0.86). As such, we combined them into a single GKM effectiveness rating (coefficient $\alpha = 0.93$).

As a second assessment of team effectiveness, we asked team members to respond to eight statements that captured different aspects of their team’s effectiveness, reflecting a referent-shift composition model (Chan 1998). Examples included “[this team] delivers outcomes (products) that are valued by internal and/or external customers,” “[this team] serves the purpose it is intended to serve,” and “[this team] is productive.” Participants responded to each item on a five-point *strongly disagree to strongly agree* scale. Cronbach’s α of this measure ranged from 0.91 to 0.94 (mean = 0.93). The median $AD_{M(j)}$ for this measure ranged from 0.45 to 0.59 (mean = 0.50), suggesting that members generally shared similar perceptions of

Figure 3. Technology Use and Affordances at Each Time Point



Note. Error bars in the chart in the lower panel show 95% confidence intervals.

their teams’ effectiveness. Their ratings also correlated positively with the GKM’s ratings (e.g., at T1, $r = 0.40$, $p = 0.015$). Therefore, we used the GKM’s ratings in the later analysis as an independent source of external data about the teams.

Control Variables. Finally, we controlled for two team member-reported variables at time T —perceived copresence and identification with the team—based on prior research that they might represent alternative explanations for team effectiveness (Gibson et al. 2011). Perceived copresence was captured via six items (e.g., “during your [team teleconferences], to what extent would you say that the technology makes it seem as though other members of the [team] are right there with you?”). Participants responded on a five-point *not at all* to *a great deal* scale. This scale was internally consistent, with Cronbach’s α coefficients ranging from 0.93 to 0.96 (mean = 0.95). The median

$AD_{M(j)}$ for this variable ranged from 0.58 to 0.75. The extent to which participants identified with their team was measured via three items (e.g., “when I talk about [my team], I usually say ‘we’ rather than ‘they’”), to which participants responded on a five-point *strongly disagree* to *strongly agree* scale. This scale exhibited internal consistency (Cronbach’s α ranged from 0.79 to 0.81; mean = 0.80). The median $AD_{M(j)}$ for this variable ranged from 0.49 to 0.52.

Analysis and Results

We organized our results into three sections: (1) patterns in technology affordances, (2) relationship of KM activity shift/technology affordance change with team effectiveness, and (3) within-team trajectories over time.

Patterns in Technology Affordances. We began by examining potential patterns in technology affordances

to determine if the teams differed internally or across geographies and sites. The average within-team deviation index suggested very small within-group differences, regardless of age, gender, or role on the team. To further investigate whether these demographics were associated with the extent of team technology affordances reported, we ran a series of tests; t tests comparing genders revealed no appreciable differences between men and women. Correlations between age and technology affordances showed less than 3% shared variance. Finally, we used t tests across the four time points to test whether facilitators differed from nonfacilitators and found no evidence of any differences (all p -values were > 0.05).

As for geographic or cultural differences, the teams were deliberately structured to maximize cross-site representation. This meant that many teams had only one member from each geography and one per culture, so there were no within-team subgroups. Nevertheless, we analyzed across the entire sample as to whether participants from any one country were more (or less) inclined to systematically report affordances in a way different from those in other countries. We used Analysis of Variance followed by pairwise comparisons to compare team members from the six countries—Australia, Brazil, Jamaica, Spain, Suriname, and the United States—in terms of the percentages of time spent using the technologies that offered the three affordances of attention focusing, iterative sensemaking, and public codification. We found that affordances did not differ by geography. We repeated this analysis according to plant sites and again found no patterns.

Activity Shift/Technology Affordance Change and Effectiveness. In our next stage of analysis, we were interested in determining whether teams that shifted KM activities, and correspondingly changed technology affordances, were more effective. Our qualitative phase indicated that the most critical KM activity shift in our context was the shift from knowledge accumulation to knowledge integration. Many teams did not make this shift and remained in knowledge accumulation; our analysis indicates that such teams were ineffective. For those teams that did make the shift, we were interested in learning if the most effective teams also changed from technologies affording attention focusing to those affording sensemaking, thus achieving through this coevolution a symbiosis between knowledge activities and technology affordances.

We analyzed the observations nested within the teams with the TYPE = COMPLEX function in Mplus 7.3 to ensure that standard errors of parameter estimates were robust to violations of the independence assumption. In step 1 of the regression analyses, we regressed team effectiveness at time T onto team effectiveness at $T - 1$, thus enabling the forthcoming steps of the regression analyses to model the impact of the predictor variables on *changes* in team effectiveness from $T - 1$ to T .¹ In step 2, we added four control variables: time (in months) between $T - 1$ and T (because the surveys were not administered at equidistant points in time), perceived copresence, identification with the team, and a binary variable indicating whether the team was in accumulation at $T - 1$. As the second column of Table 7 shows, perceived copresence and identification with the team were both positive

Table 7. Moderated Regression of Team Effectiveness on Activity Shifts and Changes in Technology Use

	Step 1 <i>b</i> (SE)	Step 2 <i>b</i> (SE)	Step 3 <i>b</i> (SE)	Step 4 <i>b</i> (SE)
Intercept	1.277 (0.251)	0.323 (0.451)	0.073 (0.382)	0.085 (0.396)
Effectiveness at $T - 1$	0.672** (0.068)	0.507** (0.085)	0.541** (0.071)	0.493** (0.073)
Control variables				
Months since $T - 1$		-0.001 (0.012)	0.003 (0.011)	-0.002 (0.012)
Perceived copresence		0.184* (0.077)	0.171* (0.077)	0.147* (0.068)
Identification with the team		0.300** (0.083)	0.342** (0.076)	0.407** (0.080)
In Accumulation at $T - 1$		-0.023 (0.056)	-0.097 (0.055)	-0.094 (0.055)
Main effect variables				
Shifting out of accumulation			0.128 (0.081)	0.145** (0.053)
Δ Tech for SM			-0.003 (0.005)	-0.011** (0.004)
Δ Tech for AF			-0.004 (0.003)	-0.005 (0.003)
Δ Tech for codification			0.003 (0.003)	0.001 (0.003)
Interaction terms				
Shift out of accumulation \times Δ tech for SM				0.040** (0.008)
Shift out of accumulation \times Δ tech for AF				0.007 (0.006)
Shift out of accumulation \times Δ tech for codification				0.009 (0.006)
ΔR^2 (from previous step)		0.120**	0.042	0.093**
R^2	0.415**	0.535**	0.577**	0.670**

Notes. $N = 94$ potential shifts in learning nested within 37 teams. AF, attention focusing; b , unstandardized regression weight; Δ , change; SE, standard error (estimated with the Huber–White sandwich method); SM, sensemaking; T , time.

* $p < 0.01$; ** $p < 0.01$.

significant predictors of changes in team effectiveness. Collectively, the control variables accounted for an additional 12% of the variance in team effectiveness.

In step 3, the variable for whether the team had shifted out of accumulation and the three technology affordance change measures were added to the model with the controls. This model, in the third column of Table 7, explained an additional 4.4% of the variance in team effectiveness; however, this incremental prediction was not statistically significant.

In step 4, we added three product terms with shifting out of accumulation, one for each of the three technology affordance changes. Results of these analyses are shown in the fourth column of Table 7, indicating that changes in the use of technologies for sensemaking interacted significantly with the shift, whereas changes in use of the other technologies did not. The model with the interaction terms accounted for an additional 9.3% of the variance in effectiveness relative to step 3. These findings support our hypothesis.

To investigate the form of the interaction, we constructed a plot of the statistical model, which is shown in Figure 4, by holding the control variables at their means. When a shift out of accumulation was made, a strong positive association occurred between increasing the use of technology for sensemaking and changes in team effectiveness. The relationship was nearly zero when any other KM activity shifted, or there was no shift at all. This result (i.e., no significant main effect in the model without the interaction terms but significant main effect in the more complex model) exemplifies a statistical phenomenon sometimes called “suppression.” That is, sometimes the addition of a new [set of] variable[s] to a regression model can increase the strength of a beta weight that, in a simpler model,

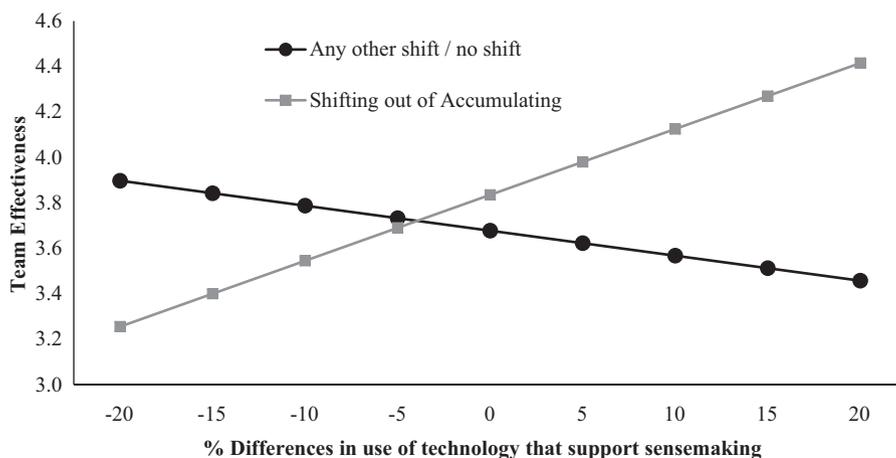
was not significant (Paulhus et al. 2004). The best explanation is that the effect of a shift out of accumulation of knowledge hinges on a change in technology affordance to increase sensemaking. These findings support our proposed relationships.

Within-Team Trajectories over Time. To provide additional interpretive insight, we graphically displayed, based on the survey data, the predominant KM activities and technology affordance scores for each of the 48 teams at each time point, and then, we compared and contrasted the within-teams patterns of change in KM activities and technology affordances for those that were above the mean on effectiveness with those that were below the mean. We noted that during the study period, the ratings for team effectiveness were fairly consistent for each team across time (the poor-performing teams continued to be poor performing, and the highly effective teams sustained effectiveness). We offer examples of one highly effective and one ineffective team (i.e., 2 cases of the 48 in the sample) to illustrate both the benefits of coevolution between KM activities and technology affordance over time and the liabilities of not making such changes (see Figure 5). Both teams attempted to shift KM activities, but only Team P changed its technology affordances to achieve symbiosis and was able to sustain effectiveness over time.

Team P: Change in Technology for New Affordances.

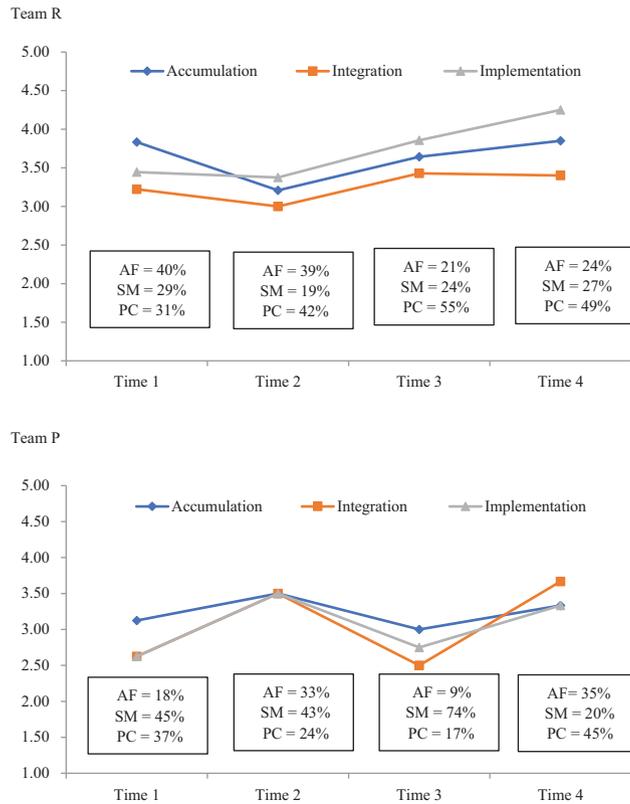
Team P was highly effective. The GKM rated it above 8.7 at each time point, compared with a mean rating of 6.30 across all teams. Our analysis suggests Team P was effective to a large extent because it strategically changed its technology affordances to enable shifts in KM activities. For example, initially at T1, the team’s score on

Figure 4. Team Effectiveness as a Function of Shifting out of Accumulation Activity and Change to Technologies Affording Sensemaking



Note. Lines are plotted with control variables set to their mean.

Figure 5. Scores on Survey Data at Each Time Point for Two Sample Teams



Notes. Team P was an effective team (scoring 8.7 on effectiveness at both times it was rated); Team R was ineffective (scoring 4.67 and 5.2 on effectiveness on the first and second times it was rated, respectively). AF, use of technologies for attention focusing; PC, use of technologies for public codification; SM, use of technologies for sensemaking.

knowledge accumulation was the highest relative to other activities, and they had a greater use of technologies that afforded attention focusing. Coinciding with our theory, in their conference calls, they spent much time focusing attention on specific issues that required accumulation of additional knowledge. For example, an early exchange during a call emphasized the mission.

Our mission statement, our first focus right now . . . one that is very real for all of us, is the one related to network governance and segregation. —Member 1

I took the task of getting a charter together for that one, so that we have alignment. —Member 2

We’ll be spending a lot of time here approving it as our focus. —Member 1

As accumulation activities decreased over time, so too did the use of technologies that afforded attention focusing. Recognizing saturation in knowledge accumulation and prompted by a cue in the form of a lack of trust in technologies that primarily focused attention, the team reported changing to technologies that

afforded sensemaking and shifted to integration activities. A member described it like this:

For discussions, usually I use email. I don’t trust the best-practice team calls to be the tool to raise questions and discuss them. We usually email, and then we know we will get the answers discussed and good back and forth.

As their emphasis on implementation activities gradually increased, the team increased its use of technology that afforded codification (e.g., from 31% relative use at T1 to 55% at T3). Prompted by a cue pertaining to the specific nature of the knowledge (i.e., the specificity of the nature of the project) and recognition that they next needed to coordinate action, an interviewee described this change as follows:

Yes, once we get to something very specific that we all agree on, a project we have come to decisions about, what we would do with best practice, is we would post something in SharePoint, which presents to all the groups what we came up with . . . That forum, that definitely allows you to get quick, rapid implementation of solutions.

Another added:

Yes, so it gets to the person who is ultimately responsible. They look at it and say, “Okay, yes, this is in fact a better way to do it than what we were doing before.” And they do it.

In summary, Team P recognized cues that signaled the need for change in technology affordances, and as they approached shifts in KM activities, they changed technology affordances. Rather than fall into habitual technology use over time, the KM activities and technology affordances coevolved, and they achieved symbiosis between KM activities and technology affordances that allowed them to sustain effectiveness.

Team R: Ineffectiveness Driven by Lack of Coevolution.

In contrast, the GKM rated Team R below the mean on effectiveness at each time point (e.g., at T1: 4.70; at T2: 5.20). Our analysis indicates the team’s inability to achieve their objectives may have been partly because of insensitivity to cues that their technology was poorly suited to their KM activities (see the lower panel of Figure 3). The team reported an emphasis on accumulation activities at T1, yet its use of technologies that afforded attention focusing at T1 was only 18% (relative to 45% use of technologies for sensemaking and 37% for codification). Coordination suffered because of an inability to focus the collective attention necessary for knowledge accumulation. At T1, they would likely have been more effective if they had used technology that afforded attention focusing such as conference calls with presentations that emphasized awareness of the key issues. Acknowledging that technology

for sensemaking (e.g., engaging in dyadic emails) was inefficient for focusing attention, one member said:

I might send out an email and say, “Okay, what do we think is a focus this year?” And I get nothing back. So, then I think, “Okay, well we’ve got to have something. So, what do I think?” And I might ask the local guys here what the focus is. Would be better to have the conversations on our focus on the conference call.

At T4, members of this team reported mostly integration activities that likely would have benefited from technologies that afforded sensemaking (such as using email and instant messaging for iterative exchanges). However, instead of increasing their use of technologies that afforded sensemaking at T4, they significantly *decreased* this use (e.g., from 74% at T3 to 20% at T4). Again, they were unable to collectively develop shared meaning and interpretation. Lamenting the lack of attention focusing and iterative sensemaking, one member said:

We never knew our focus on the calls. We’re probably not tackling the right sort of issues. Then, it would have been better if we had shared it as some sort of an email distribution list or chat function. There could be opportunities to improve our processes to better cater for the sort of circumstances that we’re finding.

Although they never reported an emphasis on implementation activities, their use of technologies that afforded codification was high, relative to other affordances at T4. Said one member:

We used to have like a conference call every month or so, but we haven’t had any in a long time, probably more than a year. But every so often someone puts up a post on SharePoint and whoever reads it, you know, maybe will comment Sometimes I offer a comment, sometimes I don’t.

At T4, given that they reported mostly integration activities, technologies like SharePoint that afforded codification were likely less helpful than technologies that afforded sensemaking would have been. Essentially, this team failed to recognize cues signaling the inadequacies of its affordances; so, its shifts to different activities were unaccompanied by a corresponding change in technology use, and they were rated by the GKM as ineffective.

Discussion

Across this body of evidence, our findings indicate that to sustain global team effectiveness, KM activities and technology affordances must coevolve. Extending from prior research that focused on a static task-technology fit with a single task or technology rather than relative emphases on activities, changing purposes of the activities, and relative uses of technologies, we show that as KM activities were completed and the

team attempted to move onto other KM activities, change in technology affordances was critical for success. Effective global teams recognized cues indicating when existing technology affordances had become constraints and then took action to remedy this. Specifically, effective teams sensed the current KM activity was nearing completion, perceived cues that signal an affordance misfit, and changed technology affordances to improve effectiveness in dealing with emerging KM needs. Teams that failed to do so were less effective. These findings contribute to the development of the technology affordance process described in Figure 2, which captures the dynamism in global work over time. Such a process model has implications for three areas of research.

Theoretical Contributions

Knowledge Management Shifts in Teams. We contribute to the literature on team knowledge management by showing that although teams may attempt to move through KM activities, they may fail to sustain effectiveness because of an inability to recognize that the purpose of interaction through communication technologies shifts with the activities. That is, we found that for the KM activity of knowledge accumulation, the most effective purpose for the communication technology was attention focusing, carried out by using scheduling tools and conference calls; for the KM activity of knowledge integration, the most effective purpose for the communication technology was sensemaking, carried out using email and instant messaging; and for the KM activity of knowledge implementation, the most effective purpose for the communication technology was public codification carried out through face-to-face meetings and a shared repository. Moreover, these shifts did not happen implicitly but required teams to recognize cues indicating that a new purpose to their use of communication technology had emerged. Thus, our findings indicate that explanations of how global teams shift their work over time need to include not simply the activity they are performing but the purpose for applying the communication technology, the specific tools to support that purpose, and the cues that indicate a new purpose had emerged.

In effective teams, movement across KM activities and the cues that occur as these activities evolve prompt changes in technology affordances that enable teams to sustain effectiveness. Technology affordances refer to the mutually supportive relationship between human-endowed purposes to an activity and the technology use. Our theorizing about KM activities and technology extends current models of knowledge work that have yet to specify the role of technology affordances (e.g., Edmondson 2002, Gibson and Vermeulen 2003). This is an important omission in

prior research because we found that progressing across different KM activities was only possible when there was a change in technology affordance. This implies that if knowledge is to be managed effectively, teams must develop an agility with technology affordances. The effective teams in our sample used a variety of technology affordances and understood that these needed to be symbiotic with the nature of the KM activity at hand, as both evolved over time. In global teams, this need is explicit because technology is often essential to their interaction; therefore, the co-evolution of purpose and technology use may become routine over time (Leonardi 2013). As more work is conducted remotely, even domestic teams and individual contributors can use the theory that emerged in our study to progress through different knowledge activities, dynamically leveraging technology affordances.

At a minimum, our findings suggest that especially for teams primarily charged with managing knowledge, following a technology affordance process in which change in affordances occurs over time is a functional way to ensure team effectiveness is sustained. However, this is an empirical question worthy of additional attention in longitudinal studies. Further, because shifts in KM activities are only likely to occur when the team senses cues, this also highlights the importance to teams of understanding the indicators of readiness for technology affordance changes; otherwise, effectiveness could suffer. We encourage future research that examines the process of KM activity shifts in a broader sample of teams working on different types of activities. Further, we anticipate that establishment of key shift indicators (similar to the key performance indicators used in performance management) might be a useful extension of our work. Shift indicators might be especially helpful for global team members who serve on multiple teams, each working on different KM activities using technology in different ways. This was not the case in our sample (each member was on only one global team) but is increasingly true in other contexts (O'Leary et al. 2011).

Technology Affordances. Relatedly, a second theoretical implication concerns the affordance process and the role of changes in technology affordances in global teams. We theorized that changes in technology affordances are critical to enabling the shifts across KM activities, especially when members are unable to meet physically and must rely on technology for their communication. As a relational construct, technology affordances require mutual support between the purpose of an activity and how the human uses the technology to achieve that purpose. We found that, as KM activities shifted, the

purposes of the interactions coevolved with how the technology was used for the interactions, creating a dynamic process of coevolution. The shifts in the activities coupled with other cues we discovered indicated to the teams the need to continually adjust their affordances. This implies that application of affordances is far more dynamic than depicted in earlier models.

Further, we identified affordances important in our context (collective attention focusing, collective sense-making, public collective codification) that have not yet been the focus in prior work. That is, Clark and Brennan (1991) identified *visibility*, *reviewability*, and *revisability*; and two decades later, Treem and Leonardi (2013) discussed similar affordances of social media. However, they also acknowledged that the applicability, nature, and extent of affordances must be determined in situ (Treem and Leonardi 2013). Our study provides a midrange theory (Eisenhardt and Graebner 2007) of affordances applicable to a wide variety of knowledge management contexts and illuminates a temporal coevolution to develop new affordances, a coevolution that was symbiotic with KM activities. Several studies have documented that as the number of communication technologies at workers' disposal increases, the complexity of work practices increases because choices regarding which technology to use and when to use it abound (Tyre and Orlikowski 1994, Watson-Manheim and Bélanger 2007). Our findings provide an alternative, which involves adopting different affordances within the same general umbrella of communication technologies, rather than increasing the number of technologies available.

Our work also extends recent research into the timing of technology use (Knight 2015, Szulanski et al. 2016) by showing that effective timing of technology use depends on three factors: the KM activity to be performed (accumulation, integration, or implementation of knowledge), the purpose of interacting with others via communication technology (attention focusing, sensemaking, and codification), and the technologies available for use (planning, face to face, etc.). Shifts over time require a symbiosis among all three. This work continues the stream of research that calls for revision of media choice theory, arguing that technologies such as email can be used for a range of diverse intentions. An important empirical question for future research pertains to potential path dependence in a team's technology choices. Perhaps the first choice of technology influences later adoption of technologies. It is also possible that given the emergence of corporate social media, communication, and collaboration platforms such as Teams, Yammer, and Slack that combine many different applications and hence, increase the variety of potential affordances, that changing affordances will be even easier. In

investigating these changes further, it will be important for future research to address the multilevel nature of the changes in technology use. It may be that there are some affordances that members individually perceive, which then enable a team to engage in team-level affordances. Indeed, affordances may depend on the level that they are perceived.²

We also have provided a way to measure technology affordances: to first qualitatively understand the purpose for using the technology and then, to measure the degree to which multiple technologies have been used for that purpose. Following on from this, quantitative approaches that simply ask about technology use can then appropriately infer rather than assume the way in which the technology is used. Moreover, our findings indicate that to navigate KM activities in global teams, what matters most is the *use* of technology to support the predominant activities at a given time. This may outweigh which tool is put to that use. So, effectiveness hinges (at least in part) on technology affordances that support the needs of specific processes at a specific time. For example, in knowledge accumulation, it is the ability of the technology to support attention focusing (not which technology is used to engage in that attention focusing) that matters, and then, these needs change when the team shifts out of accumulation, as suggested in our findings reported in Table 7. This was the most critical KM activity shift in our sample; our qualitative phase indicated that many teams did not make this shift, remained in knowledge accumulation, and were ineffective as a result. Yet, teams were able to sustain effectiveness when a shift out of accumulation coincided with an increase in the use of technology that afforded iterative sensemaking. The relationship was nearly zero when any other shift, or no shift at all, was made.

Sustaining Effectiveness in Global Teams. Recent work on team effectiveness has focused on adaptation processes (Burke et al. 2006), developmental trajectories (Mathieu and Rapp 2009, Collins et al. 2016, Quigley et al. 2018), and the features of teams and their context that enable turning teams around when their performance is stagnating or declining (Vashdi et al. 2013, Collins and Gibson 2014). Much of this recent research isolates a specific feature of the team (e.g., a team mental model) or a specific aspect of context (e.g., supportive leadership) and shows its role in the team over time. Our research indicates that when studying team effectiveness over time, it is useful to explore the coevolution of shifts and changes because they are unlikely to occur independently. None of the prior work on trajectories have examined this coevolution of team features, nor global teams more specifically, despite their recognized importance for organizations in the twenty-first century (Kirkman et al. 2012).

Further, work in organizational behavior on sustaining team effectiveness has not yet incorporated technology-related concerns in general and technology affordances in particular. Thus, our theorizing serves to integrate elements among the literatures on information systems (e.g., Ziguers and Buckland 1998) and team change (e.g., Collins et al. 2016) to improve our understanding of how to sustain team effectiveness. Yet, other coevolutions are likely to be discovered. For example, we can imagine avenues for research that examine the coevolution of shifts in technologies with team shifts in leadership or mental models. For example, it may be that members who recognize the cues for change in affordances in global teams emerge as leaders, given the fundamental nature of affordance processes in our study. Such research would enrich the focus on developmental trajectories and team adaptation as the means for sustaining or improving team effectiveness.

Technology affordance is a feature of global teams that is malleable and can be developed. Hence, it represents an evidence-based point of leverage for improving the effectiveness of global teams and enabling them to meet the challenges they face in accumulating, integrating, and implementing knowledge across sites as requirements, organizational priorities, or environmental conditions change. We see as promising the examination of inflection points in trajectories of team effectiveness that may occur as a result of these changes (Collins and Gibson 2014, Collins et al. 2016).

Limitations and Future Research

Our analyses represent a deep examination of specific KM activities in a relatively small number of teams; however, we deemed this an appropriate strategy for the nascent work on shifts in activities and changes in technology affordances in global teams. A welcome extension of our research would be to examine larger samples across different team types as well as organizational and industrial contexts to determine the generalizability of our model. It may be that certain types of teams or contexts highlight the need for different technology affordances and that a more extensive set of technology affordances can refine our model and define greater applicability across many different teamwork settings. Further, our study population is one that comprises a high proportion of educated male workers from technical or engineering backgrounds who have relatively long average tenures. Although these characteristics are typical for the resources sector and related industries (construction, infrastructure development, planning, and management), additional research might examine whether these characteristics play a role in shaping results in other contexts, such as healthcare or education. With that said, our approach to attempting to understand the specific technology affordances in a given context,

and the fit between that affordance and team KM activities is one that could be applied in many settings as diverse as the military or product development. We anticipate the findings are applicable in many teams, even those that are not global but yet, rely on communications technology, as is increasingly common in the postpandemic world.

Further, our focus on depth of understanding in a smaller sample of teams rather than breadth across a much larger sample prohibited us from conducting highly sophisticated growth modeling of effectiveness, but our longitudinal approach coupled with the combination of both qualitative and quantitative evidence increases our confidence in our observations about change and effectiveness. Nevertheless, we see great promise in adding precision to our theory by using growth modeling techniques, especially latent growth and latent transition models (Collins et al. 2016) that enable quantitative identification of different profiles in large datasets. With growth modeling, the focus turns to tracking teams over multiple time points and then, separating within-team, between-team, and error variance. This allows for the identification of a latent trajectory in the population, examination of whether this average trend reflects the journey of all teams, and investigation of specific points in the teams' trajectories (e.g., an intervention). Our approach allowed us to only investigate moments of change within teams; however, by using a trajectory approach, we can envision investigation of a training intervention that would highlight how and when, to facilitate effectiveness, changes should occur in technology affordances. This would be a logical next step in this research domain and a powerful contribution to both theories of team development and of team practices. Examining the malleability of technology affordances in this way would extend the precision of our theory and also provide concrete action for teams.

Next, beyond shifts in KM activities, we encourage investigation of other types of transitions in teams using similar approaches. For example, it may be that transition from directive leadership to shared (or self) leadership in teams is an important transition that requires a change in technology affordances. Prior research has examined changing leadership needs in teams (Lorinkova et al. 2013) but has not included a consideration of technology affordances. Or, perhaps transitions in team composition (i.e., enlarging the team to include a greater span of involvement) benefit from incorporation of new technology affordances. Finally, research into innovation in geographically dispersed teams indicates the importance of building relationships (Tzabbar and Vestal 2015). Our model could be used to examine the extent to which different technology affordances foster such relationships

and how they relate to teams' effectiveness and efficiency. The results would further show the value in understanding how technology affordances and team priorities mesh.

Finally, our focus was on documenting the shifts and changes that occurred. Our qualitative analysis revealed numerous potential cues that change was necessary. We view a systematic analysis of these cues as an important next step and a promising avenue for future inquiry. We anticipate that strong team facilitation and processes for team reflexivity (West 1996, Schippers et al. 2012) are precursors to identifying these factors. Hence, developing symbiosis between KM activities and technology affordances over time is likely a basic aspect of good team functioning.

Conclusion

Global teams often develop habitual reliance on a single technology, despite shifts in their activities, emergence of new purposes for interaction, and having multiple technologies available. This can prohibit knowledge management and reduce team effectiveness over time. We have shown that coevolution of knowledge management activities and technology affordances is both possible and beneficial for sustaining team effectiveness. As more and more employees work remotely and rely on communication technology, achieving a symbiosis between activities and technology affordances over time will be paramount. We hope our theory development and evidence-based model encourage similar shifts in both future research and practice.

Acknowledgments

The authors acknowledge the tremendous dedication to this project demonstrated by the company participants. Their deep involvement in study design, data collection, and interpretation of findings was essential. They also appreciate James Grey for his collaborative spirit, determination, and commitment to the project. The authors are thankful for the insights offered during the collaboration among the broader project team, including John Cordery, Jennifer Gibbs, and Yana Grushina. The authors thank their colleagues in the research incubator at Pepperdine Graziadio School of Business, at the University of Western Australia, at the Academy of Management, and at the Academy of International Business for their generous feedback on earlier versions of this research and for their encouragement along the way. The authors also thank the Senior Editor and three anonymous reviewers for their guidance during the review process.

Endnotes

¹ When we removed this variable (that is, modeled team effectiveness at time T rather than changes in effectiveness), the results involving the proposition tests were essentially unchanged.

² We thank an anonymous reviewer for this suggestion.

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