The Engineering Project Organization Journal, 2014
Vol. 4, No. 4, 193–208, http://dx.doi.org/10.1080/21573727.2014.947269

Taylor & Francis
Taylor & Francis Group

Achieving reliability in transnational work on complex projects: new directions for research

SHOBHA RAMALINGAM[1*], SUNILA LOBO[2], ASHWIN MAHALINGAM[1] and JENNIFER WHYTE[2]

[1]*BTCM Division, Civil Engineering Department, IIT Madras, Chennai, India*
[2]*School of Construction Management and Engineering, University of Reading, Reading, UK*

(Received 23 December 2013; accepted 18 July 2014)

The delivery of complex engineering projects today often involves globally distributed teams. In these teams, engineers must check for inadvertent errors by following the assumptions, logic and computations of others and define processes to reduce these errors. Engineering firms are thus increasingly using digital technologies to enable teams to do transnational work. While project management research on global virtual teams articulates how team performance relates to composition and characteristics, it has paid less attention to reliability and how this is achieved in such transnational work. This paper considers how constructs related to reliability—trust, culture and communication—become inter-related in work on complex projects. Recent research on work practice, which examines dynamics over time, is brought into dialogue with the literature on global virtual teams, re-conceptualizing *trust* as enacted in practice; *culture* as a resource for action and *communication* as a mediated dialogue. Vignettes from pilot work are used to support this re-conceptualization and illustrate how it extends research on teams to enable new insights into reliable performance in transnational work. The paper suggests a new agenda for project management research on achieving reliability in complex projects where delivery is digitally mediated and involves a global team, concluding by highlighting areas for further research.

Keywords: Engineering and construction, global virtual teams, reliability, work practices.

Introduction

Complex projects have become increasingly 'global' in sectors such as construction, automotive, aerospace or oil and gas, with teams coordinating work across the distributed offices of associated firms (Ainamo *et al.*, 2000). These delivery teams are multicultural in nature working in differing time zones and local histories (e.g. Ochieng and Price, 2010). Building global virtual teams may tap scarce global resources and draw on niche skill-sets while reducing costs in the delivery of complex projects. Yet, studies show that global virtual teams are prone to several challenges that may lead to damaged reputations, increased coordination costs in projects, project delays, cost overruns and poor project performance thereby eroding the value proposition of globalization (Orr and Scott, 2008; Scott *et al.*, 2011). While project management research on global virtual teams articulates how team performance relates to composition and characteristics, it has paid less attention to reliability (Grabowski and Roberts, 1999) and how this is achieved through transnational work.

'Reliability' is both anticipating and containing unexpected events and the unintended consequences that may result (Weick and Sutcliffe, 2007). Good engineering requires judgements to be made with careful attention to potential sources of error and safe modes of failure. As Petroski notes:

> In any project, large or small, each engineer's work is expected to be consistent and transparent so that another engineer can check it – by following its assumptions, logic, and computations – for inadvertent errors. This constitutes the epitome of team play, and it is the give and take of concepts and

*Author for correspondence. E-mail: shobha@smail.iitm.ac.in

© 2014 Taylor & Francis

> calculations among engineers working on a project that make it successful. (Petroski, 2012, p. 30)

Historical analyses of unanticipated and catastrophic failures in engineering systems suggest that, in many cases, there are root causes in engineering design (Petroski, 1992, 1994, 2012). Using technology for coordinating can propagate human and organizational errors and organizations can encourage risky practices through too much stretching of goals or rewards for the wrong behaviours (Grabowski and Roberts, 1999). Thus the dynamics of individuals and organizations executing tasks may create a context in which engineers cut corners in their analyses, or do not feel able to ask questions or to question others calculations.

To mitigate risks in engineering design, engineering teams need to be reliable. Achieving such reliability in transnational work is important in the delivery of complex engineering projects. Weick and colleagues observe that 'for a system to remain reliable, it must somehow handle unforeseen situations in ways that forestall unintended consequences' (Weick *et al.*, 1999, p. 85). High-reliability organizations have been characterized by safe operations and a compliance-based yet adaptable culture, through research on the dynamics of individuals and organizations that mitigate risks in flight cockpits; military organizations; nuclear, railroad and other operational environments in which risk mitigation is important (e.g. Grabowski and Roberts, 1999; Weick *et al.*, 1999; Roth *et al.*, 2006). We need to know more about how risks are mitigated to achieve reliable performance in transnational work on complex projects.

The literature on global virtual teams conceptualizes project performance as a multi-variable construct (Gibson and Cohen, 2003; Powell *et al.*, 2004). There is no single framework or theory in the literature to assess the interplay of several factors on project performance, with most studies using variants of McGrath's (1984) Input-Process-Output (IPO) framework to identify critical factors and to show their inter-related impact on team performance. Some of the key findings from these studies indicate both strong positive and negative performance outcomes of such teams. For instance, studies by Hinds and Weisband (2003) and Daft and Lengel (1986) argue that while technology-mediated communication can act as a barrier to understanding, richer medium of communication can help teams to exchange social information to develop stronger cohesion and enable knowledge sharing. Similarly, studies by DiMarco *et al.* (2010) and Ramalingam and Mahalingam (2011) contend that cultural diversity in cross-national teams can give rise to conflicts and deter performance; but that cultural boundary spanners can enable transfer of necessary information that is critical to resolve cross-cultural conflicts and steer project performance. In yet another instance, while a study by Jarvenpaa and Leidner (1999) contend that swift trust is necessary for virtual teams to develop cohesion due to the absence of face-to-face interaction, a study by Peña-Mora *et al.* (2009) argue that role clarity and process clarity (such as developing team norms and explicitly stating role expectations) more positively affect relationship building processes and therefore project outcomes. Scholars therefore argue that there is ambiguity in determining which factors assess and contribute to the performance of complex projects (Zakaria *et al.*, 2004).

Informed by sociology, recent research by organizational theorists and social scientists have begun to expose and unpick assumptions of this literature, challenging the idea that the design of collaborative arrangements is free from cultural bias and that globally diverse members of a team will interpret and use a shared technology in the same ways (Hinds *et al.*, 2011, p. 169). These studies draw attention to working practices within transnational teams. For instance, a study by Leonardi and Bailey (2008) show how new work practices are developed to overcome problems of interpretation and coordination while making implicit knowledge explicit in task-based offshoring projects. Scholars have also studied collaboration technologies that affect team work patterns leading to emergent behaviours and work practices (Fruchter, 2008). Studies by Kellogg *et al.* (2006) and Faraj and Xiao (2006) examine how members of different communities perform coordination practices in dynamic and digitally mediated environments to make their work visible and legible to each other through their ongoing interaction with technology. Other scholars have examined how organizational practices both shape and are shaped by the use of new technologies (Boland *et al.*, 2007; Whyte and Lobo, 2010; Whyte, 2011). Simply put, these studies attempt to understand 'how work is organized' which draws attention to the dynamics of everyday activity and their emphasis on the situated integration of contextual factors such as artefacts, tools and documents; and their social interplay leading to actions and interactions. Therefore the focus is on 'dynamics, relations and enactment' (Feldman and Orlikowski, 2011). Terms used to describe this approach are a practice-turn (Schatzki, 2005); practice lens (Orlikowski, 2000); practice-based approaches (Carlile, 2002) and practice-based perspective (Sole and Edmondson, 2002). Findings from these studies offer significant insight into the innovative work practices that both conventional and fast-paced organizations have adopted.

Taken together, these two bodies of knowledge—one which attempts to understand factors critical to global

Table 1 Broad comparison of the two streams of literature

	Global virtual teams	Transnational work practices
Level of maturity of the literature	Mature	Intermediate (nascent; but draws on mature literature on work practices)
Type of theory	Variance	Process
Typical methods	Large-scale surveys	Interviews and observation
Source of validity	Testing of constructs, proxies and controls	Elaboration of constructs and testing of assumptions through empirical observation
Contribution to the literature	Macro causes and effects, but ignores team dynamics	'How' teams collaborate to achieve project delivery
Example author	McGrath's (1984) IPO framework	Leonardi and Bailey's (2008) five practices

team success and the other that attempts to describe work practices that teams undertake—can provide deep insights into the study of transnational projects and together help identify a more robust set of constructs that have a bearing on global virtual team performance. Yet, these streams of literature present contrasting approaches. On the one hand, while traditional global team studies identify several significant constructs, scholars have limited their observation to one or few variables at a time. On the other, the practice literature concerns itself mainly with the question of 'how' teams collaborate and focuses on work practices and coordination of work wherein multiple constructs are enacted in practice. Researchers have spoken about the need to observe work practices in dynamic and uncertain environments and the rich insights that practice theories generate (Barley and Kunda, 2001; Bechky, 2006; Kellogg *et al.*, 2006; Leonardi and Bailey, 2008; Clear and MacDonnell, 2011; Feldman and Orlikowski, 2011). Table 1 provides a broad comparison of these two streams of literature.

Team member sampling and variable-based team research at a point in time have been the norm (Mathieu *et al.*, 2008) in global virtual team research, until recently. However, this tradition now argues that 'team arrangements suitable for IPO-style investigations may be more of the exception than the rule in modern-day organizations' (Mathieu *et al.*, 2008, p. 463). These authors call for a new research paradigm, using both quantitative and qualitative methodologies, to capture the dynamics of modern virtual teamwork, for example, archival research of threaded discussion lists and video conferences. Relatedly, in the work practices literature that is starting to deal with transnational work, a combination of methods such as surveys and interviews (Leonardi and Bailey, 2008) has already been utilized effectively to examine collaborative work. The method used to interrogate the meaning of the constructs in previous literatures was a process of inquiry rather than mechanical search. These broad perspectives on the two streams of literature raise interesting questions and hence we ask, 'How will a practice approach enable understanding of the dynamics of reliable performance of virtual teams on transnational projects?'

The paper explores the utility of using a practice-based lens to augment current insights on global virtual teams and to identify some starting points for research in this direction. In order to accomplish this, we first conducted a one-day workshop in joint collaboration with industry practitioners in order to understand industry trends, current working practices and global delivery challenges. Based on the preliminary insights from the workshop, we further reviewed relevant and existing literature and synthesized the findings to propose an agenda for future research. The rest of the manuscript is therefore structured as follows. The second section discusses the constructs that emerged as distinct and significant in global delivery from the workshop conducted in collaboration with industry and academia in July 2012 in the UK. The third section discusses the existing theoretical understanding on the emergent constructs through a comparison across the two broad streams of literature, global virtual team studies and practice-based studies and also through interviews conducted with a UK-based engineering firm executing transnational work. The fourth section concludes by summarizing and identifying the limitations in these studies and proposes a new direction for future research.

Industry trend and challenges—an insight

A half-day workshop on 'transnational design practices' was held in the UK in July 2012 to understand the current industry trends and practices in the delivery of global projects and the associated challenges. This workshop was attended by 9 participants with over 15 years of experience in the industry and a minimum of 3 years'

experience in handling global projects and working with virtual transnational teams. They were from seven leading UK-based firms that execute transnational projects through their global delivery centres. The objective of the workshop was to identify key constructs affecting the performance of transnational work in the Architecture, Engineering and Construction (AEC) industry.

Two presentations by academics from the universities in the UK and India, on observed challenges in transnational work in the AEC industry, set the stage for a panel discussion on transnational work practices in the industry. The participants predominantly discussed their experiences and the challenges faced in some of their transnational projects, leading to possible directions for future research. The discussion was moderated by the academics and attended by a team of researchers from the two universities (including the authors). Following Spradley's (1979) ethnographic interview techniques for exploratory work, the questions asked to the panellists were semi-structured and open ended, such as 'can you explain what practices make for efficient delivery?', and drew on cues from comments made by the participants.

The workshop discussion was audio-recorded, transcribed, coded and analysed qualitatively using the software tool Nvivo. Open coding techniques (Strauss and Corbin, 1998) were adopted to categorize the data into industry and organization level practices, project processes and systems, project challenges and outcomes. These constructs were further fragmented to identify sub-categories. Axial coding was performed on these categories and sub-categories to identify themes and patterns relating to critical challenges faced in transnational projects and constructs or strategies that played a key role in the enactment and resolution (successful or unsuccessful) of these challenges. Coding was done primarily by one of the Indian researchers but these codes and analysis were cross-verified with other members of the team who also had access to the data.

We first present trends in the industry gleaned from the workshop. This is followed by a discussion of project challenges and the subsequent identification of constructs that emerged as significant for further research.

At the workshop, participants noted that the nature of transnational design had changed over recent years. As one industry representative noted:

> … It has been relatively positive, but it has changed … the nature of the way we work has changed, information exchange has changed, it used to be batch exchange of information, you send and get back the batch, now it has tended to be live—a model, that model has to exist and we need it all the time …

Another practitioner echoed this sentiment of increasing complexity in the work being undertaken and also pointed out that organizational dynamics were also changing:

> … The big trend now is the change in the way we design things, whether we buy in or buy outsourcing, it's actually changing gradation—contractors, consultants, big firms are all being created … all the three factors and the work itself (complex) is making a difference on how we design …

Challenges and risks in global delivery

Participants identified several challenges in managing transnational teams. Foremost among these were difficulties in communicating with members distributed across geographies. While this was an expected finding, several participants pointed out a nuanced view on the pitfalls of poor communication, indicating how breakdown of trust led to poor performance. In the words of one experienced manager:

> It is more on the communication; you lose trust in the information that exists at that point of time very quickly, because the turnaround time is slow. Each module is massive, and sometimes we need to find another way of handling huge data sets and representing it in a smaller data set, so that we can take a look quickly and get a feel.

Several participants then spoke on the importance of gaining and building trust. For instance, another participant said:

> And here is the one on efficiency that ensures that everyone is working in the same platform, and ensuring that all engineering managers are working together so that communication gets better and more importantly the trust, trust is a human thing, trust is not about buying trust, it is gaining trust, earning trust, we can't gain it in the first project, it happens over time.

A second set of issues that were raised related to difficulties in knowledge sharing and the role of cultural and broader institutional differences in inhibiting knowledge transfer. Differences in language, building standards and work practice norms all led to inefficiencies in information and knowledge exchange. Related to the previous construct, these inefficiencies in turn manifested as breakdowns in communications and led to reduction in trust within the team and consequential poor performance. One practitioner highlighted the

differences between participants from different countries:

> The cooperative and collaborative behaviour between Germany and UK, that can be more difficult than talking much further … it is interesting, US-UK collaboration, different to UK-India collaboration … I think the trouble with UK and US is that the culture is so different, countries divided by a common languages … lots of difference in regulations and the way—rules are set up, the way industries are set up … Construction is so different and trying to draw a common chord is difficult.

Other participants then brought out the challenges arising due to these differences and underlined the role that standards, processes and practices would need to play to cope with these challenges. For instance, one practitioner observed:

> We need to apply a project standard, a project process because within our own office whether in India, Singapore, Australia or States, the process is slightly different, because our process in UK does not apply 100% in US for example. They have different requirements; they have different legislations to do with. So we have to ensure that the processes though they may be different within the organization, simultaneously when you merge with the project, you have to come with a combined process, so that everybody works together … it is called the bag sharing knowledge, it is a bag putting a central repository of information of every single offices around the world, and using and re-using of information, so sharing of data, calculations, sharing of sub-stations, then we in UK, tap at Singapore and say ooh, I like that and the calculations maybe put into our region and similarly, this happens around the world.

In particular, the participants stressed the role that digital technologies could play in bridging communication difficulties and enhancing the efficacy of knowledge transfer. While there was no emphasis on any particular set of technologies, the general consensus was that information technology could be applied in a wide variety of ways to enhance the functioning of global teams. One participant said:

> Digital is a lot more complex, the language of the engineer is … so difficult to catch up … we can use [a] richer communication medium that allows us to develop trust and share culture in a better way. The more complex the project is, it becomes more relevant.

In general, most participants concluded that managing transnational project teams was a complex and risky endeavour requiring quick responsiveness, and consequently a high degree of reliability. As one participant concluded:

> Sometimes there are more risks of not collocating … so what we are driving at is that in collaboration, communication is risk. If we have a virtual team, how is that less risky?

Upon analysis of these and other vignettes from the workshop, we observed the repeated emergence of three key constructs—communication, trust and culture—as being critical for ensuring knowledge exchange and reliability in global project delivery. While other constructs such as organizational structure also appeared in our analysis as being relevant, the strength of our codes indicated that these three constructs played a more significant role in influencing the actions and outcomes on transnational projects. It is worth noting that the emergent constructs were not mutually exclusive but tend to be inter-related in influencing project outcome. This led us to review the relevant literature on these identified constructs, as discussed in the subsequent section.

Theoretical and practical underpinnings of transnational work

We next compared and contrasted the treatment of the three key constructs identified in the previous section in the traditional literature on global virtual teams as well as the 'practice' literature. The work involved shared reading and reviewing of papers found through searches in major databases, with an emphasis on interpretation; comparing and contrasting findings to identify contradictions and the limitations in the existing studies.

Vignettes are also used to illustrate the key points drawing on five interviews conducted in a global engineering firm (based in the UK) in July 2012, post the workshop, whose employees conduct consulting, design, design-build, operations and programme management. These interviews were conducted with individuals working on a particular transnational UK–India project, both in India (Hyderabad) and in London thus providing a valuable perspective on both sides of the digitally mediated work interface.

The interviewees were from the top management including the CEO, Risk and Operations Manager (Europe), two Project Managers handling transnational projects between the UK and India offices and a Business Development Manager who also had experience in outsourcing operations with India. The

interviews ranged for one to two hours which was audio-recorded, transcribed and analysed. The interviews were exploratory in nature to understand the project challenges in global delivery, and hence semi-structured and open-ended questions were asked. The analysis methodology adopted was identical to the grounded-theory approach adopted for the workshop as the first step, but with apriori constructs in mind. Codes pertaining to trust, communication and culture were isolated and were used to augment our understanding of these theoretical constructs, as discussed in the following subsection.

Trust

Studies on 'trust' from the two broad streams of literature are discussed here. While the global team studies discuss earning or developing trust, practice studies discuss an adaptive trust process.

Trust—a process variable

There is a broad literature on trust in global virtual teams, which sees trust as a process variable that is influenced by input factors such as geographic dispersion, time-zone difference, task interdependence, communication media, and cultural and team diversity. This study perceives trust as being either swiftly achieved but fragile or as slowly built (developed over a period of time in conventional projects). In both cases, it is seen as a mediating variable to the development of team cohesion.

In transnational work on complex projects, it may be productive to understand trust as swiftly established, but incomplete and capable of being broken, rather than to see it as built progressively over time. Project teams are temporary forms of organization. Their work needs high levels of trust as a result of high interdependencies, highly customized processes and complex interfaces (Jarvenpaa and Keating, 2012). The notion of 'swift trust' has become used to explain the rapidly developed trust observed between remote participants involved in geographically dispersed project work (e.g. Jarvenpaa and Leidner, 1999; Robert *et al*., 2009). Initial perceptions of trustworthiness are found to be important in cross-functional and geographically distributed work (Zolin *et al*., 2004) and swift trust is found to be important for effective virtual team performance (Jarvenpaa and Leidner, 1999). Yet such swiftly established trust may break down easily and trust often remains an issue in transnational work. In one instance, one of the respondents also refers to building trust and developing swift trust in virtual projects:

> So there is a part where you got to develop the trust with the team in India, so they actually say I don't understand this. That is why I think it is important to people to visit on a regular basis. If you are just talking to someone on a videoconference, you can develop trust over a long period of time, it could take you years. So to accelerate that you have got to visit and develop that trust so that somebody knows how you react to the situations and they know the individual and can say we haven't finished the drawing on time, or we haven't done this. So I think there is a lot of requirement of trust because we are dealing with people. We are not dealing with machines.

These understandings show how *trust* may be productively considered *as* 'fragile' in the work of transnational project teams. Yet another quote from the same interview illustrates an instance of fragile trust while dealing with project stakeholders as observed below:

> In the water related engineering activities which we did from India, the quality of work that came through wasn't much good, it wasn't adequately protected, so it simply fell through, which is not a good thing. The client's reaction was, 'that's it, how are they going to do this work. I am going to do this work … we will do it here'. It was an emotional response, 'I want to do it down here. You don't outsource anymore.' Now … that, we actually managed to stick with it. So I said, 'look, it is a hard decision. Where we do the work is quality management. You see, we will sort it out, track the problem, but please don't tell us where to do the work', and eventually we managed to get the work flow properly, suitably to the last standard and at last now, happy to see the sales benefit to the customer side.

Seeing trust as fragile in transnational work on complex projects is different from the traditional view of *trust as progressively built* through the life of the project. As an example of the latter, Schilcher *et al*. (2011) articulate a three-step process over the project life cycle, a *building* trust phase that includes factors such as setting mutual goals, commitment; *developing* trust phase that includes factors such as transparency in decisions, reciprocal contribution and a *strengthening* trust phase that consists of factors such as addressing conflicts and failures, risk tolerance, etc. While such a life-cycle model may be useful as a normative guide to managers in setting team expectations, it has limitations when considering the challenges in fast-paced organizations such as in outsourcing operations.

Trust is seen as a *mediating variable for cohesion building* in transnational teams. For instance, Ashleigh and

Nandhakumar (2007) empirically investigate the concept of trust across organizational work practices by examining three groups: within the team, between teams and when interacting with technology. Their findings indicate that communication is a key factor in the development of trust and important for facilitating cohesive collaboration across inter-organizational contexts. They insist that teams must have a shared understanding in terms of common business processes and a common goal, need for consistent feedback and appropriate use of technology for effective knowledge sharing in order to develop trust and enhance inter-team or inter-organizational collaboration. This need for consistent feedback and developing trust with the client as well was stressed upon by one of the interview respondents:

> Trust to us and our client is when we commit ourselves, that we live up to our commitment. On many occasions, early warning is better rather than coming at the 11th hour and say, sorry I didn't deliver due to … Communication is key to all. Communicate, communicate, communicate. As soon as you know, what is happening, regular status allows that trust to be achieved.

Trust—adaptive and enacted in practice

The research insights about the fragile and incomplete nature of swift trust draw on practice theories and approaches (Javernpaa and Leidner, 1999; Robert *et al.*, 2009) as well as the literature on global virtual teams. In their three-year ethnographic research on communication practices in cross-cultural virtual teams, Javernpaa and Keating (2012) examined how onshore (the USA) and offshore (mainly India, Romania) global engineering project teams build trust, finding that it was a challenge even though the projects studied were multi-year ones. These researchers call for research to understand interpret and translate trust as well as trust repair (Dirks *et al.*, 2009) across cultures in globally dispersed work. Transnational work involves high interdependencies, highly customized processes and complex interfaces which result in high trust needs (Javernpaa and Keating, 2012). For Grabowski and Roberts (1999), trust becomes manifested in a *willingness to learn and adapt*, where such communication processes and role clarity are key to its development. The following excerpt from an interview also illustrates and supports this stance:

> There are a few areas: one is clear communication and second is building trust in the process. It is having what it is that you want delivered set out clearly; maintaining regular contact with your team, So that they don't feel left out … regular contact, making sure that they understand what you have asked them to do, for them to send back what they think was asked as well, making sure they have got the required standards so they have got an idea what the quality is that that you are expecting back … We found that the guys over there, when they are keen to learn, you can tell them how to improve, and show where things aren't quite right. If you do that with them then their learning goes up, mutual trust also builds up.

These theoretical views from the practice literature coupled with practical insights thus show trust to be fragile and therefore adaptive and enacted in practice, while also being interdependent on other constructs such as culture and communication. If trust is considered both as a process variable and being enacted in practice, it raises interesting questions on: 'what factors or practices would enable the team building process and influence project success?'

Culture

Cultural understandings may surface in the negotiation of trust and communication patterns of transnational teams. While prior treatment of culture articulates it as nationally invariant in most of the global team studies, practice-based studies reconceptualize culture as a resource for action.

Culture—as stable and static

Many variance studies use Hofstede's (1983) four dimensions (power distance, uncertainty avoidance, individualism–collectivism and masculinity–femininity) to assess cross-cultural difference and consider culture as a static dimension, related to process and outcome variables such as team conflict, cohesion building, knowledge sharing and effective performance rather than a factor to be examined (Keil *et al.*, 2000; Stahl *et al.*, 2010; Dulaimi and Hariz, 2011). Hence studies have focused on understanding the influence of culture at different levels of organization: individual, team, organization and national. Findings are both from empirical studies on multinational organizations (e.g. Maznevski and Chudoba, 2000; Hinds *et al.*, 2011) and through student teams (e.g. Workman, 2005) sometimes using large data-sets. In such work, culture is viewed as part of team diversity which includes individual, demographic, gender, educational and national factors. While this approach has been productive in the analysis of performance, we argue that it has limitations with respect to understanding

the reliability of digitally mediated and globally distributed teams. As one of the respondents reported:

> Culture is very important for virtual teams, because if I have sat in the UK for last 20 years, I am familiar with the working culture here and it is a natural tendency to impose that culture on another party. But you should have appreciation of where the project is based, so if I have got a team from Argentina for instance, they would do things in one way, their way is not necessarily the wrong way, it has what has been proved successful in their region. To work globally, you have to have appreciation of global culture. So, kick off meetings through video conference are very vital or essential for globally distributed culturally diverse teams.

This work is extending understanding of national differences in project management. However, this static view of culture has been criticized for its focus on differences in national cultures which need to be bridged while ignoring situationality, ambiguity, power relationships between project partners and other issues (McSweeney, 2002). The latter includes latent inequalities between cultures which have been historically developed and the coping strategies of firms and individuals on cross-cultural projects (Marrewijk and Veenswijk, 2006). For instance, in their study of an infrastructure mega-project, Marrewijk and Veenswijk (2006) found that project culture needs to be managed differently during the different phases of the project life cycle.

The fragmented nature of knowledge and the institutional differences in global engineering projects have proved to be challenging for globally distributed teams. For instance, in synthetic experiments with global project and global virtual teams, DiMarco *et al.* (2010) and Ramalingam and Mahalingam (2011) demonstrate the cultural and institutional conflicts teams encounter due to differences in work practices and the role of cultural boundary spanners to resolve them. These insights raise interesting questions on 'what organizational culture supports or enables virtual team process performance?' It is these questions that are leading researchers to draw on and synthesize understanding from more sociological literatures to extend current understanding, which are more psychological in origin.

Culture—as resource for action

A contextual and dynamic view of culture as evoked in the practice-based literature pays attention to such meaning-making and framing in inter-cultural collaboration rather than treating national culture as invariant. Walsham (2002) examines the conflict in inter-cultural collaboration between onsite Jamaican and Indian programmers and consultants working in Jamaica. Here, there were different views on power relations and behavioural norms for working, including conflict management, coordination and perspectives on deadlines (Walsham, 2002). In Walsham's study, the Indian team were perceived as being given power over the locals, with differences in 'deep-seated cultural attitudes to hierarchy and authority' (Walsham, 2002, p. 365). In contrast, in a study across the Japan–India context (Sahay and Krishna, 1999), the Japanese team were uncomfortable with the extensive documentation of the Indian team, because they relied more on face-to-face contact and discussions. They describe their Indian counterparts as culturally incompatible, as they were 'too westernized' and contemplated changing to an on-site offshoring model to minimize the need for written communication. Thus Indian participants are viewed differently by their Jamaican and Japanese counterparts and may also act differently in these exchanges. From this perspective, cultures, both national and local, are relevant in relation to meaning-making, hence: 'One of the reasons that solutions to similar problems evolve differently in different national cultures is because the assignment of meaning varies and therefore how the problem is framed and the practices that are appropriate vary' (Hinds *et al.*, 2011, p. 159).

While this quote suggests national differences, such a view also allows for the same culture to be differently enacted in transnational teams. In the transnational project between Dutch and Indian team members studied by van Marrewijk (2010), both the Dutch and Indian team members were seen to have an asymmetric access to cultural power. While this may be because of the wide cultural differences within the Indian sub-continent, it may also be as a result of cultural negotiation as meaning is assigned, problems framed and practices developed within the transnational team. In the UK–Indian context as one of the interview respondents observed, cultural differences will need to be addressed dynamically:

> The cultural element in India, where the people don't want to not perform. So there is this very much wanting to please culture. Now, this is a cultural snobbery that needs to be addressed and that's why I am going back to the point of having right people at the right end of the pipeline … in order to ensure that it will happen.

To address reliability in transnational work on complex projects, it is hence proposed that it may be productive to understand cultural differences as resources for action, rather than as static or fixed. Such a perspective builds on anthropological studies of major projects that

see culture as strategic resources for action (van Marrewijk, 2010); and recent work that explores the organizational culture of transnational project teams (Adenfelt and Lagerström, 2006). Workers are seen to have the capacity to maintain multiple meaning systems that can be called upon as needed, based on the situation (Benet-Martínez *et al.*, 2002). While studies of global virtual teams uncover institutionalized cultural understandings, they have also begun to uncover the development of new cultures that emerge as a result of transnational work. For example, in research on a UK–Indian collaboration, Nicholson and Sahay (2001) found a dis-embedding and re-embedding of methodologies from one context to another. The Indian workers' prior training in International Organization for Standardization methodologies were seen as a dis-embedding of Western methodologies into the Indian context. This methodology was then re-embedded into the UK through the collaboration of this Indian team with a British company. It is this kind of locally emergent culture that has been explored in studies of reliable work.

Achieving reliability, according to Grabowski and Roberts (1999), requires both a decentralized culture in which engineers take responsibility for their own actions and a shared culture that values reliability. Engineering culture has been examined by Kunda (2006) and Vincenti (1990), who draw attention to the social interactions that are central to accomplishing engineering work; and by Henderson (1999), who, as discussed earlier, argues that engineering culture is a visual culture. Such professional engineering culture overlaps with national cultures in transnational design work, where culture is a resource for action that is both institutionalized and emergent. A shared identity between teams has been described as an ongoing accomplishment (Orlikowski, 2002). This is continually enacted in practice, hence Hinds *et al.* (2011) question the sustainability of a stable 'hybrid team culture' or a group-specific identity. Embedding, harnessing and taking advantage of the knowledge of these competing cultures (engineering and national) in the division and management of transnational collaborative work rather than letting these cultures act as obstacles, will therefore help achieve task and project goals.

Communication

In transnational work on complex projects, it may be more productive to frame communication not as the sending and receiving of a message, but rather as dialogical, a flow of communication that shapes and is shaped by team members' interactions with each other and with the material artefacts that are the focus of the work. This shifts attention away from the work on global virtual teams that treat communication in terms of information and media richness to other areas such as boundary-spanning. This section hence conceptualizes *communication* as a *mediated dialogue* and shows how this differs from its treatment by scholars of global virtual teams as a *transfer*.

Communication—as technology-mediated transfer

The existing literature on communication in global virtual team studies takes an information processing perspective, pointing, for example, to high coordination costs as correlated with distance, time-zone difference, cultural and national differences. In the project management literature, communication is seen as an important component of project success in virtual teams, where the characteristics of these teams necessitate more effective communication than is required in traditional team work. Significant studies of projects have been conducted that consider communication as a variable alongside project uncertainty, task complexity and level of interdependence (Gibson and Gibbs, 2006; Orr and Scott, 2008). Communication is observed as the biggest risk factor by one of the interview respondents as given below:

> If you are working with misinformed information, you would not be making the right decision at the moment to progress the project, so what you are actually doing is going along, making a wrong decision, you fall back, you got to work forward again, got to rectify. That would cost money, what you are doing is a waste to that firm. If it affects third party, you could be at risk for litigation. In other words, having information in a controlled manner that you can trust the information actually would minimize the risk on the project, that's the biggest thing.

Hence, within the literature on global virtual teams, there is a long tradition of treating communication as a transfer of information. It is well understood that the quantity and nature of transfer is dependent on the technology where communication is online. There is a significant discussion of technology and its impact on communication within this tradition. While some studies differentiate between the kinds of tools suited for specific tasks (e.g. Fox *et al.*, 2010), much of the literature examines variables relating to the media: its 'richness' and synchronicity. The related constructs such as 'virtuality' are variously defined. Kirkman and Mathieu (2005), for example, define team virtuality in terms of the degree of reliance on virtual tools, the informational value of the mediums used and the synchronicity of interactions. Gibson and Gibbs (2006) define it in terms of geographic dispersion, electronic

dependence, structural dynamism and national diversity. While technologies are used to mediate interactions among distant team members (Maznevski and Chudoba, 2000; Hinds and Bailey, 2003) technologies such as email and web conferencing are not as effective in facilitating the exchange of contextual information. Perhaps for this reason, such studies of coordination activities and knowledge sharing present contradictory evidence on whether there is a need for richer medium of communication for effective interaction (Espinosa *et al.*, 2007; Peña-mora *et al.*, 2009). As one of the respondents observed:

> I think what we have found is given complexity of the task and where they are located and how they are operating, it is important to use the right tool for the right job. So, also some of the tools were good to a certain extent but there was a need for looking at other things as they got more complex, On the whole, we need technologies, at the end of the day that are – easy to use, its intuitive, and helps you to do what you want to do. If you have a complex project, you don't want to waste time to get it to work, it takes time away from important things you want to do.

There have been both survey and experimental studies that address communication in global virtual teams. For example, Peña-Mora *et al.* (2009) study the impact of interactions through audio, video and face-to-face media on team interaction and perceived performance. Results indicated that communication technologies, organization protocols and a spatial set-up affected interaction effectiveness. The authors also contend that technologies used by globally dispersed construction teams need to consider the ability to use the medium to interact, capability of the medium to support the interaction space, reliability of the medium, accessibility from multiple locations and support provided. Similarly, in an experimental study, Iorio *et al.* (2011) highlight competing factors that impact the usage patterns and adoption of collaborative tools designed to support global virtual engineering work such as the simplicity of the tool, tool's ability to promote group cohesion, the emergent need for the tools, and local factors specific to the experiences of the domestic teams. The contradictory findings of such variance research on communication in global virtual teams motivate our reconsideration of communication as mediated dialogue as a starting point for work on achieving reliability.

Communication—as mediated dialogue

Research in the practice tradition draws on studies that explore the coordination challenges relative to knowledge sharing capabilities in virtual teams to reconceptualize communication as mediated dialogue. Adenfelt (2010) finds that in a transnational project, performance was hampered by communication and coordination difficulties and that shared knowledge as well as knowledge sharing capability of the organization set boundaries for project performance. In another study, they investigated the coordination needs of geographically distributed software teams. They contend that such teams require three distinct types of coordination—technical, temporal and process oriented and that these needs vary with the member's role. They found that geographic distance plays a negative effect on coordination, but is mitigated by shared knowledge of the team and presence awareness (Adenfelt and Langerstorm, 2006). Kanawattanachi and Yoo (2002) argue that a shared store of knowledge or 'transactive memory' can be formed even in virtual team environments where interactions take place solely through electronic media, although they take a relatively long time to develop. Once developed, they argue that this becomes essential to performing tasks effectively in virtual teams.

Other management scholars, such as Hinds and Bailey (2003), Jarvenpaa and Leidner (1999) and Leonardi and Bailey (2008), go further by merging insights from psychology and sociology to develop such new understandings of communication in the work of transnational teams. This research does not seek to characterize the types of individuals and team compositions that have higher performance, but rather focuses on the interactions that unfold within team work practices. It goes beyond cognitive metaphors such as 'transactive memory' in the above literature and seeks to build grounded understanding of the cultural, organizational and social processes at play through field-based research of particular global collaborations (Hinds *et al.*, 2011, p. 139). This introduction of more sociological understandings into the work on global virtual teams draws attention to the dialogical nature of communication across the institutionalized practices that exist in particular national contexts and across disciplines.

It also draws attention to the mediated nature of communication, which involves the rarefication and circulation of engineering representations as well as direct interaction and discourse between engineers in different communities of practice. Here scholars have started to consider the emergence of boundary-spanning competence, as teams use different artefacts in their communication (Levina and Vaast, 2005); the perceived interdependence and shared identity that these technologies enable (Cramton and Hinds, 2005) and how the material nature of the technologies involved mediating communication across boundaries, as well as the issues that arise across these boundaries as practice unfolds (Leonardi and Bailey, 2008).

Table 2 Comparison of constructs across two streams of literature

Constructs	Transnational work practice	Global virtual team studies
Trust	As *fragile*, swiftly established, but incomplete and capable of being broken. Trust is earned by demonstrating engineering competence, awareness of limitations and shared motives. It is important in raising and resolving engineering issues. Design checks and proof are highly valued as misplaced trust may lead to failure	As a *building process*, related to cohesion and dependent on inputs such as geographic dispersion, time-zone difference, task interdependence, communication media, cultural and team diversity and important in knowledge sharing
Culture	As a *resource for action* that is both institutionalized and emergent. Achieving reliability requires both a decentralized culture in which engineers take responsibility for their own actions and a shared culture that values it	As a *stable input*, culture is seen as static or fixed, related to team conflict, cohesion building, knowledge sharing and effective performance. Many studies draw, for example, on Hofstede's analyses of cross-cultural differences
Communication	As *mediated dialogue*, involves the rarefication and circulation of engineering representations as well as direct interaction and discourse between engineers in different communities of practice. It is important to manage risks that may arise at interfaces	As *technology mediated* and as a *transfer*; communication is seen as an input, described in terms of media richness and synchronicity, and related to task and socio-emotional process coordination, knowledge sharing and performance

As project delivery becomes increasingly digitally mediated, this perspective on communication as a flow of mediated dialogue becomes important for understanding reliable work practices.

Summary

A comparison of the three constructs is given in Table 2. Most of the extant global team studies are performance based and attempt to explain the cause–effect relationship between the variables using the IPO framework. These analyses portray teams as flatter hierarchies and network structures that respond to environmental turbulences. Such accounts ignore the dynamic nature of work within all organizations. Though distinct and significant, the global team's literature focuses on macro causes and effects, virtually ignoring the micro-team interactions.

In contrast, the practice literature concerns itself mainly with the question of 'how' teams collaborate and offers rich insights by allowing us to observe the interaction between multiple constructs (Barley and Kunda, 2001; Bechky, 2006; Kellogg *et al.*, 2006; Leonardi and Bailey, 2008; Clear and MacDonnell, 2011; Feldman and Orlikowski, 2011). Most of these studies involve within-firm analysis (such as Boland *et al.*, 2007; Ewenstein and Whyte, 2009). It must be noted that while there are studies on technology, knowledge flow and boundary concepts that focus on the transnational context very few are rooted in the AEC industry. The literature encompasses transnational teams in other contexts such as manufacturing and software development (e.g. Espinosa *et al.*, 2003; Levina and Vaast, 2005).

The rich insights gained from these practice-based studies points to a dearth of similar studies in the transnational context in the AEC industry, a vital flaw as proclaimed by Barley and Kunda (2001). Thus we contend that one needs to rectify this flaw and therefore researchers need to take a practice approach to explore the processes pertinent to transnational project delivery. We further argue that in the absence of a unifying theory to observe multiple constructs (such as coping with cultural and institutional differences, sharing knowledge across several boundaries) in virtual team interactions; practice-based theories offer great advantage, which remains unexplored.

Towards new research on transnational work in complex projects

Reviewing the literatures and drawing insights from the primary data suggest a new research agenda for transnational project management research on achieving *reliability* by mitigating risks in complex projects. Reliability is important in the delivery of complex (virtual) engineering projects and needs to be understood with regard to working practices. It has been considered in research on work practices in operations within organizations such as flight-decks and battle management operation (e.g. Weick and Roberts,

1993). Indeed, when such organizations are virtual and involve distributed working, Grabowski and Roberts (1999) see organizational *trust*, *culture* and *communication*, alongside the ability to provide varied organizational structures in response to environmental demands, as important in increasing reliability. To meld multiple cultures into a whole in which assumptions and values are built around the shared need for reliability involves dealing with vulnerabilities such as different languages and customs, units with comparable status but different levels of experience and training, rivalry, reluctance to ask questions and ethnocentrism (Grabowski and Roberts, 1999, p. 712). Although engineering failures may occur where reliability is not adequately addressed (Petroski, 1992, 1994) and though there is recent interest in virtual engineering teams (Hosseini and Chileshe, 2013), there has been little consideration of achieving reliability through transnational work practices in the delivery of complex projects.

This paper hence reconceptualizes how trust, culture and communication inter-relate in achieving reliability. While the Grabowski and Roberts (1999) framework and approach towards reliability is not the only framework, it seems to be an appropriate one to frame a practice-based approach to study virtual teams (as also supported by the vignettes). It will therefore bring recent literature on global virtual teams into dialogue with research on reliable working practices, which draws on more sociological sources.

The above sections show how achieving reliability in transnational teams requires deeper understanding of trust, culture and communication that re-conceptualizes these constructs. Using this review and synthesis, this final section reconsiders how they inter-relate and sets out a new research agenda to achieve reliability through globally distributed work. This is important as work in project teams is now distributed internationally and digitally reintegrated; and such teams have to manage the complex inter-dependencies that occur on engineering projects. Recent research shows that the export of engineering services is more extensive than recognized in international statistics (Jewell *et al.*, 2010) and is changing the nature of global engineering firms (Jewell and Flanagan, 2012). Digital technologies enable the integration of project work and new sources of competitiveness in such major firms (Baark, 1999) and are providing an infrastructure for delivery in major projects (Whyte and Lobo, 2010). In this context, new understanding of reliable transnational work practices becomes vital to the delivery of complex projects. Building on work on global projects (Mahalingam and Levitt, 2007; Alin *et al.*, 2011; Javernick-Will, 2011), and recent studies of the effectiveness of project managers in virtual work (Verburg *et al.*, 2013), this research agenda seeks to address how reliability is achieved in globally distributed work.

Trust, culture and communication are inter-related. In identifying and addressing these as key factors in achieving reliable delivery, this paper builds on and concurs with previous research in the field of reliability. It contributes by re-conceptualizing trust as fragile, culture as resource and communication as mediated dialogue in relation to the work practices of global virtual teams. Drawing on the sociological traditions of practice research, these factors are seen to be enacted in the working practices of project delivery. Hence any communication draws on cultural resources, and is a part of an unfolding dialogue, in which trust—in the engineering data, and the people that produce it—plays a central role. In the delivery of complex engineering projects mistakes do happen. Trust here is not, and should not be, unconditional, but is constantly tested and reconsidered in relation to other sources of evidence. This testing of engineering data, and the culture in which mistakes can be identified, discussed and addressed, is vital to reliable delivery.

Empirical research on achieving reliability requires different methods and approaches, as summarized in Table 1. Most work on global virtual teams is variance research; it identifies variables about individual team members and correlates the characteristics and composition of teams with their performance. The proposed shift in focus is supported by Mathieu *et al.* (2008), who call for a new research paradigm using both quantitative and qualitative methodologies, which captures the dynamics of modern virtual teamwork, for example, archival research of threaded discussion lists and video conferences. Their work shows how the literature on global virtual teams is itself changing, as recent studies begin to explore questions beyond the reach of the influential IPO framework. Building on Mathieu *et al.*'s (2008) observation that organizations are far more complex and changeable than acknowledged in this model, future work may develop process rather than variance theory, exploring the unfolding practices that enable reliable performance. Hence in the study of transnational work on complex projects the argument is for 'bringing the work back in; (Barley and Kunda, 2001) to understand the nature of the work performed and its accompanying practices, using a combination of methods. With a few exceptions, such as the study by Leonardi and Bailey (2008), there is very little study of 'how' dynamics unfold in engineering teams. Such understanding is essential to understanding reliability in transnational work on complex projects.

There are new approaches to research on reliability in transnational teams suggested by this review. For example, most existing work has been conducted from

an etic[1] perspective in at least one of the national contexts involved. Perhaps because of the limitations of researchers' own abilities to work across national boundaries, there is a lack of research that examines both cultures involved in transnational work; or work that reflects on the limitations of any study in this field. This is extremely important in the context of culture as a 'resource for action' as discussed earlier. There is also a need for an emic, rather than etic approach or a combined one in empirical research: such studies could involve transnational collaborations between researchers. Researchers could thus be simultaneously embedded within both national offices involved in a transnational work practice and collaborate to unpack how team effectiveness and project performance are understood within and across these remote locations.

There are also new areas for research on trust, culture and communication and their relationship to reliable working practices that are suggested by the review. These can clarify understandings where there currently are contradictory findings. For example, in contrast to the work on 'swift trust', experimental studies find trust starting lower in computer-mediated teams but increasing over time to levels comparable to face-to-face teams (Wilson *et al.*, 2006). They can also fill gaps, where there is, for example, very little research exploring the relationship between trust and artefacts used in transnational work (Mitchell and Zigurs, 2009). Further research is needed to explain why different patterns of trust are observed in different studies, and also to articulate different kinds of trust, in order to develop new understanding about the relationship between trust and reliability in the delivery of complex projects. Such research also needs to examine how the rarefication and circulation of engineering representations, as well as the direct dialogue between members of global virtual teams, has consequences for the development of reliable transnational work practices.

Next steps are to conduct emic research, where data on transnational work are collected from within different regional offices involved in the delivery of complex projects and to consider reliability in relation to other performance-related issues, both within complex projects and the global design firms that work on these projects. The perspectives on trust, culture and communication that we have outlined in this paper can act as the initial set of constructs for investigation and supplement traditional perspectives on global virtual teams to provide an enhanced understanding of reliability through a *practice* approach within transnational work. Such understandings can be of benefit to practitioners in delivering projects and to academics seeking to understand dynamics on such projects.

Note

1. *Etic* and *emic* are two broad ways to operationalize the concept of culture, where etic is from the outside, and emic is from the inside. Thus from the first perspective, one culture can be compared with others on the same dimensions. From within, the unique characteristics of a particular culture which distinguishes it from others can be understood as more varied and nuanced. There are different methodologies to capture emic (e.g. ethnography) and etic (e.g. one questionnaire survey method) aspects of culture (Bala *et al.*, 2012). Some scholars have attempted to combine both with local expressions of universal constructs and indigenously derived constructs providing a measure that is relevant to the specific cultural context (Leong *et al.*, 2010).

References

Adenfelt, M. (2010) Exploring the performance of transnational projects: shared knowledge, coordination and communication. *International Journal of Project Management*, **28**(6), 529–38.

Adenfelt, M. and Lagerström, K. (2006) Enabling knowledge creation and sharing in transnational projects. *International Journal of Project Management*, **24**(3), 191–8.

Ainamo, A., Artto, K., Levitt, R., Orr, R.J., Scott, W.R. and Tainio, R. (2000) Global projects, strategic perspectives. *Scandinavian Journal of Management*, **26**(4), 343–51.

Alin, P., Taylor, J.E. and Smeds, R. (2011) Knowledge transformation in project networks: a speech act level cross-boundary analysis. *Project Management Journal*, **42**(4), 58–75.

Ashleigh, M.J. and Nandhakumar, J. (2007) Trust and technologies: implications for organizational work practices. *Decision Support Systems*, **43**(2), 607–17.

Baark, E. (1999) Engineering consultancy: an assessment of IT-enabled international delivery of services. *Technology Analysis and Strategic Management*, **11**(1), 55–74.

Bala, M., Chalil, G.R.B. and Gupta, A. (2012) Emic and etic: different lenses for research in culture: unique features of culture in Indian context. *Management and Labour Studies*, **37**(1), 45–60.

Barley, S.R. and Kunda, G. (2001) Bringing work back in. *Organization Science*, **12**(1), 76–95.

Bechky, B.A. (2006) Talking about machines, thick descriptions, and knowledge work. *Organization Studies*, **27**(12), 1757–68.

Benet-Martínez, V., Leu, J., Lee, F. and Morris, M.W. (2002) Negotiating biculturalism: cultural frame switching in biculturals with oppositional versus compatible cultural identities. *Journal of Cross-Cultural Psychology*, **33**(5), 492–516.

Boland, R.J., Lyytinen, K. and Yoo, Y. (2007) Wakes of innovation in project networks: the case of digital 3-D representations in architecture, engineering and construction. *Organization Science*, **18**(4), 631–47.

Carlile, P.R. (2002) A pragmatic view of knowledge and boundaries: boundary objects in new product development. *Organization Science*, **13**(4), 442–55.

Clear, T. and MacDonell, S.G. (2011) Understanding technology use in global virtual teams: research methodologies and methods. *Information and Software Technology*, **53**(9), 994–1011.

Cramton, C.D. and Hinds, P.J. (2005) Subgroup dynamics in internationally distributed teams: ethnocentrism or cross-national learning? *Research in Organizational Behaviour*, **26**, 231–63.

Daft, R.L. and Lengel, R.H. (1986) Organizational information requirements, media richness and structural design. *Management Science*, **32**(5), 554–71.

DiMarco, M.K., Taylor, J.E. and Alin, P. (2010) The emergence and role of cultural boundary spanners in global engineering project networks. *ASCE Journal of Management in Engineering*, **26**(3), 123–32.

Dirks, K.T., Lewicki, R.J. and Zaheer, A. (2009) Repairing relationships within and between organizations: building a conceptual foundation. *Academy of Management Review*, **34**(1), 68–84.

Dulaimi, M. and Hariz, A. (2011) The impact of cultural diversity on the effectiveness of construction project teams. *Engineering Project Organization Journal*, **1**(4), 213–21.

Espinosa, J.A., Cummings, J.N., Wilson, J.M. and Pearce, B. M. (2003) Team boundary issues across multiple global firms. *Journal of Management Information Systems*, **19**(4), 157–90.

Espinosa, J.A., Slaughter, S., Kraut, R. and Herbsleb, J. (2007) Team knowledge and coordination in geographically distributed software development. *Journal of Management Information Systems*, **24**(1), 135–69.

Ewenstein, B. and Whyte, J. (2009) Knowledge practices in design: the role of visual representations as 'epistemic' objects. *Organization Studies*, **30**(1), 7–30.

Faraj, S. and Xiao, Y. (2006) Coordination in fast-response organizations. *Management Science*, **52**(8), 1155–69.

Feldman, M.S. and Orlikowski, W.J. (2011) Theorizing practice and practicing theory. *Organization Science*, **22**(5), 1240–53.

Fox, S., Leicht, R.M. and Messner, J.I. (2010) Assessing the relevance of media synchronicity theory to the use of communication media in the AEC industry. *ASCE Journal of Architectural Engineering*, **16**(2), 54–62.

Fruchter, R. (2008) Degrees of engagement in interactive workspaces, transdisciplinary perspectives on interactive technology, in Gill, S. (ed.) *Cognition, Communication and Interaction, Human-Computer Interaction Series*, Springer, London, pp. 56–69.

Gibson, C.B. and Cohen, S.G. (2003) *Virtual Teams That Work: Creating Conditions for Virtual Team Effectiveness*, Jossey Bass, San Francisco.

Gibson, C.B. and Gibbs, J.L. (2006) Unpacking the concept of virtuality: the effects of geographic dispersion, electronic dependence, dynamic structure, and national diversity on team innovation. *Administrative Science Quarterly*, **51**(3), 451–95.

Grabowski, M. and Roberts, K. (1999) Risk mitigation in virtual organizations. *Organization Science*, **10**(6), 704–21.

Henderson, K. (1999) *On line and on Paper: Visual Representations, Visual Culture and Computer Graphics in Design Engineering*, MIT Press, Cambridge, MA.

Hinds, P. and Bailey, D. (2003) Out of sight, out of sync: understanding conflict in distributed teams. *Organization Science*, **14**(6), 615–32.

Hinds, P. and Weisband, S. (2003) Shared knowledge and shared understanding in virtual teams, in Gibson, C.B. and Cohen, S.G. (eds.) *Virtual Teams That Work*, Jossey-Bass, New York, NY, pp. 21–36.

Hinds, P., Liu, L. and Lyon, J. (2011) Putting the global in global work: an intercultural lens on the practice of cross-national collaboration. *Academy of Management Annals*, **5** (1), 135–88.

Hofstede, G. (1983) National cultures in four dimensions. *International Studies of Management and Organization* 13 (1/2), 46–74.

Hosseini, M.R. and Chileshe, N. (2013) Global virtual engineering teams (GVETs): a fertile ground for research in Australian construction projects context. *International Journal of Project Management*, **31**(8), 1101–17.

Iorio, J., Peschiera, G., Taylor, J.E. and Korpela, L. (2011) Factors impacting usage patterns of collaborative tools designed to support global virtual design project networks. *Journal of Information Technology in Construction*, **16**(1), 209–30.

Jarvenpaa, S.L. and Keating, E. (2012) Global offshoring of engineering project teams: trust asymmetries across cultural borders. *Engineering Project Organization Journal*, **2**(1/2), 71–83.

Jarvenpaa, S.L. and Leidner, D.E. (1999) Communication and trust in global virtual teams. *Organization Science*, **10** (6), 791–815.

Javernick-Will, A. (2011) Knowledge-sharing connections across geographical boundaries in global intra-firm networks. *Engineering Project Organization Journal*, **1**(4), 239–53.

Jewell, C. and Flanagan, R. (2012) Measuring construction professional services exports: a case for change. *Building Research and Information*, **40**(3), 337–47.

Jewell, C., Flanagan, R. and Anac, C. (2010) Understanding UK construction professional services exports: definitions and characteristics. *Construction Management and Economics*, **28**(3), 231–9.

Kanawattanachai, P. and Yoo, Y. (2002) Dynamic nature of trust in virtual teams. *Journal of Strategic Information Systems*, **11**(3/4), 187–213.

Keil, M., Tan, B., Wei, K., Saarinen, T., Tuunainen, V. and Wassenaar, A. (2000) A cross-cultural study on escalation of commitment behavior in software projects. *MIS Quarterly*, **24**(2), 295–325.

Kellogg, K.C., Orlikowski, W.J. and Yates, J. (2006) Life in the trading zone: structuring coordination across boundaries in post-bureaucratic organizations. *Organization Science*, **17**(1), 22–44.

Kirkman, B.L. and Mathieu, J.E. (2005) The dimensions and antecedents of team virtuality. *Journal of Construction & Engineering Management*, **31**(5), 700–18.

Kunda, G. (2006) *Engineering culture: control and commitment in a high-tech corporation*, Temple University Press, Philadelphia.

Leonardi, P.M. and Bailey, D.E. (2008) Transformational technologies and the creation of new work practices:

making implicit knowledge explicit in task-based offshoring. *MIS Quarterly*, **32**(2), 411–36.

Leong, F.L., Leung, K. and Cheung, F.M. (2010) Integrating cross-cultural psychology research methods into ethnic minority psychology. *Cultural Diversity and Ethnic Minority Psychology*, **16**(4), 590–7.

Levina, N. and Vaast, E. (2005) The emergence of boundary spanning competence in practice: implications for the implementation and use of information systems. *MIS Quarterly*, **29**(1), 335–63.

Mahalingam, A. and Levitt, R.E. (2007) Institutional theory as a framework for analyzing conflict on global projects. *ASCE Journal of Construction Engineering and Management*, **133**(7), 517–28.

van Marrewijk, A. (2010) Situational construction of Dutch-Indian cultural differences in global IT projects. *Scandinavian Journal of Management*, **26**(4), 368–80.

Mathieu, J., Maynard, M.T., Rapp, T. and Gilson, L. (2008) Team effectiveness 1997–2007: a review of recent advancements and a glimpse into the future. *Journal of Management*, **34**(3), 410–76.

Maznevski, M.L. and Chudoba, K.M. (2000) Bridging space over time: global virtual team dynamics and effectiveness. *Organization Science*, **11**(5), 473–92.

McGrath, J.E. (1984) *Groups: Interaction and Performance*, Prentice Hall, Englewood Cliffs, NJ.

McSweeney, B. (2002) Hofstede's model of national cultural differences and their consequences: a triumph of faith – a failure of analysis. *Human Relations*, **55**(1), 89–118.

Mitchell, A. and Zigurs, I. (2009) Trust in virtual teams: solved or still a mystery? *Database for Advances in Information Systems*, **40**(3), 61–83.

Nicholson, B. and Sahay, S. (2001) Some political and cultural issues in the globalisation of software development: case experience from Britain and India. *Information and Organization*, **11**(1), 25–43.

Ochieng, E.G. and Price, A.D.F. (2010) Managing cross-cultural communication in multicultural construction project teams: the case of Kenya and UK. *International Journal of Project Management*, **28**(5), 449–60.

Orlikowski, W.J. (2000) Using technology and constituting structures: a practice lens for studying technology in organizations. *Organization Science*, **11**(4), 404–28.

Orlikowski, W.J. (2002) Knowing in practice: enacting a collective capability in distributed organizing. *Organization Science*, **13**(3), 249–73.

Orr, R.J. and Scott, W.R. (2008) Institutional exceptions on global projects: a process model. *Journal of International Business Studies*, **39**(4), 562–88.

Peña-mora, F., Sanjeev, V. and Zeeshan, A. (2009) Technology strategies for globally dispersed construction teams. *Journal of Information Technology in Construction*, 14, 70–80.

Petroski, H. (1992) *To Engineer Is Human: The Role of Failure in Successful Design*, Vintage, Random House, New York.

Petroski, H. (1994) *Design Paradigms: Case Histories of Error and Judgement in Engineering*, Cambridge University Press, Cambridge.

Petroski, H. (2012) *To Forgive Design, Understanding Failure*, Harvard University Press, Cambridge, MA.

Powell, A., Piccoli, G. and Ives, B. (2004) Virtual teams: a review of current literature and directions for future research. *The Database for Advances in Information Systems*, **35**(1), 6–36.

Ramalingam, S. and Mahalingam, A. (2011) Enabling conditions for the emergence and effective performance of technical and cultural boundary spanners in global virtual teams. *Engineering Project Organization Journal*, **1**(2), 121–41.

Robert, L.P., Dennis, A.R. and Hung, Y.-T.C. (2009) Individual swift trust and knowledge-based trust in face-to-face and virtual team members. *Journal of Management Information Systems*, **26**(2), 241–79.

Roth, E.M., Multer, J. and Raslear, T. (2006) Shared situation awareness as a contributor to high reliability performance in railroad operations. *Organization Studies*, **27**(7), 967–87.

Sahay, S. and Krishna, S. (1999) *Software Outsourcing from Japan and Korea to India: Some Initial Impressions*, Indian Institute of Management, Bangalore.

Schatzki, T.R. (2005) Peripheral vision: the sites of organizations. *Organization Studies*, **26**(3), 465–84.

Schilcher, C., Poth, A.K., Sauer, S., Stiefel, K.P. and Will-Zocholl, M. (2011) Trust in international teams: cultural, spatial and organizational issues. *International Journal of Business Research*, **11**(4), 29–38.

Scott, W.R., Levitt, R.E. and Orr, R.J. (2011) *Global Projects: Institutional and Political Challenges*, Cambridge University Press, Cambridge.

Sole, D. and Edmondson, A. (2002) Bridging knowledge gaps: learning in geographically dispersed cross-functional development teams, in Choo, C.W. and Bontis, N. (eds.) *The Strategic Management of Intellectual Capital and Organizational Knowledge*, Oxford University Press, New York, pp. 587–604.

Spradley, J.P. (1979) *The Ethnographic Interview*, Harcourt Brace Jovanovich College Publishers, Fort Worth, Texas.

Stahl, G.K., Maznevski, M.L., Voigt, A. and Jonsen, K. (2010) Unraveling the effects of cultural diversity in teams: a meta-analysis of research on multicultural work groups. *Journal of International Business Studies*, **41**(4), 690–709.

Strauss, A. and Corbin, J. (1998) *Basics of Qualitative Research*, 2nd edn, Sage, Thousand Oaks, CA.

Van Marrewijk, A.H. and Veenswijk, M. (2006) *The Culture of Project Management. Understanding Daily Life in Complex Megaprojects*, Prentice Hall, London.

Verburg, R.M., Bosch-Sijtsema, P. and Vartiainen, M. (2013) Getting it done: critical success factors for project managers in virtual work settings. *International Journal of Project Management*, **31**(1), 68–79.

Vincenti, W. (1990) *What Engineers Know and How They Know It*, The John Hopkins University Press, Baltimore.

Walsham, G. (2002) Cross-cultural software production and use: a structurational analysis. *MIS Quarterly*, **26**(4), 359–80.

Weick, K.E. and Roberts, K.H. (1993) Collective mind in organizations: heedful interrelating on flight decks. *Administrative Science Quarterly*, **38**(3), 357–81.

Weick, K.E. and Sutcliffe, K.M. (2007) *Managing the Unexpected: Resilient Performance in an Age of Uncertainty*, Jossey Bass, San Francisco, CA.

Weick, K.E., Sutcliffe, K.M. and Obstfeld, D. (1999) Organizing for high reliability: processes of collective mindfulness, in Sutton, R.S. and Staw, B.M. (eds.) *Research in Organizational Behavior*, Jai Press, Stanford.

Whyte, J.K. (2011) Managing digital coordination of design: emerging hybrid practices in an institutionalized project setting. *Engineering Project Organization Journal*, **1**(3), 159–68.

Whyte, J. and Lobo, S. (2010) Coordination and control in project-based work: digital objects and infrastructures for delivery. *Construction Management and Economics*, **28** (6), 557–67.

Wilson, J.M., Strauss, S.G. and McEvily, B. (2006) All in due time: the development of trust in computer-mediated and face-to-face teams. *Organizational Behaviour and Human Decision Processes*, **99**(1), 16–33.

Workman, M. (2005) Virtual team culture and the amplification of team boundary permeability on performance. *Human Resource Development Quarterly*, **16**(4), 435–58.

Zakaria, N., Amelinckx, A. and Wilemon, D. (2004) Working together apart? Building a knowledge sharing culture for global virtual teams. *Creativity and Innovation Management*, **13**(1), 15–29.

Zolin, R., Hinds, P.J., Frutcher, R. and Levitt, R.E. (2004) Interpersonal trust in cross-functional geographically distributed work: a longitudinal study. *Information and Organization*, **14**, 1–26.