Understanding Virtual Team Performance: A Synthesis of Research on the Effects of Team Design, Emergent Processes, and Emergent States

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ABSTRACT

Virtual teams are essential to the functioning of numerous organizations. They are the subjects of much research, resulting in a growing body of literature on the topic. Nevertheless, our understanding of what types of factors (e.g., people, task, and technology), drive performance in virtual teams and the processes through which they do, remain relatively limited. We review and synthesize the extant empirical research on virtual teams in order to provide insights into the direct and indirect antecedents of virtual team performance. Drawing on existing models of differentiated performance and emergent processes and states that have been applied to traditional teams, we review ninety-seven empirical studies of virtual teams published between 1990 and 2008. We use the results of a vote-counting analysis to develop an integrative model of the direct and indirect drivers of virtual team performance. Based on this model, we highlight key gaps in both our knowledge of, and approach to studying, virtual team dynamics and performance. Using this model, we outline areas for future research, provide managerial recommendations, and highlight implications for the study of both virtual and traditional teams.

KEYWORDS: Virtual teams, virtual team performance, emergent team processes, emergent team states, team design, information technology.

INTRODUCTION

Technological advances, a globally distributed workforce, and a rapidly changing business context have created both the ability and need for organizations to operate across distance. Virtual teams,[1] defined as *interdependent individuals physically separated from one another and relying on information technologies to communicate, collaborate, and coordinate work to achieve a common goal* (Cramton 2001; Maznevski et al. 2000), are seen as a means to face these challenges. They allow firms to leverage their intellectual capital, enhance work unit performance, face changing customer demands, and acquire and sustain a competitive advantage in turbulent and competitive environments (Jarvenpaa et al. 1999; Malhotra et al. 2001; Sole et al. 2002; Townsend et al. 1998). Consequently, it is common to see organizations rely on virtual teams for core processes including knowledge management, R&D and product development, software development, customer service, and strategic analysis (Espinosa et al. 2007; Majchrzak et al. 2000; Malhotra et al. 2004; Maznevski et al. 2000).

Virtual teams have also been the subject of considerable research attention, which has yielded interesting insights on the drivers of different dimensions of performance. However, our knowledge on the topic, especially how drivers relate to one another, remains fragmented and not well integrated. For instance, researchers have investigated the effect of factors such as trust (e.g. Kanawattanachai et al. 2002; Paul et al. 2004), conflicts (e.g. Mortensen et al. 2001; O'Connor et al. 1993), shared norms of IT use (Majchrzak et al. 2004; Majchrzak et al. 2000), and task-IT fit (Hollingshead et al. 1993; e.g. Malhotra et al. 2004) on the quality of output of virtual teams. Others have studied the effects of shared understanding (e.g. Majchrzak et al. 2004; Malhotra et

[1] The terms virtual teams, dispersed teams, distributed teams, far-flung teams, and global teams are also used to represent teams that rely on IT to perform their work and span multiple geographical locations. In this paper, we use the term virtual teams to represent this construct.

al. 2001), and geographical dispersion (Gibson et al. 2006) on creativity and innovation. Research has also been conducted to understand the effect of computer-mediated communications (e.g. Andres 2002; Galegher et al. 1994) on production efficiency of virtual teams. The factors influencing member satisfaction such as leadership style (e.g. Kayworth et al. 2000), sharing and communicating information (e.g. Jarvenpaa et al. 2004; Piccoli et al. 2004) have also been investigated as has been the effect of task-IT fit on individual learning (Majchrzak et al. 2005; Malhotra et al. 2001). Scholars have looked at factors built into teams through their initial design as well as those that emerge over time through day-to-day functioning and interaction. They have examined characteristics of virtual teams' membership, their tasks, and their technologies.

Such a fragmentation, which is a frequent occurrence as fields mature (King et al. 2005), makes it difficult to fully understand the functioning of virtual teams and obtain an integrated and holistic view of the factors contributing to or inhibiting virtual team performance. The advancement of a domain of study requires the accumulation and refinement of a body of knowledge (Hunter, 1982; Pillemer and Light, 1980) and the integration of previous studies and findings (King et al., 2005). Significant insights and benefits can thus be gained through a comprehensive review of empirical evidence, examining both the direct and indirect drivers of different performance dimensions in virtual teams. For example, while we do not have empirical evidence directly linking computer mediated communication (CMC) to output quality, the evidence provided by an integrative review would lead us to expect that its indirect impact is negative. CMC hinders the sharing and communication of information among team members (e.g. Chidambaram et al. 1993; Cramton 2001; Hightower et al. 1996), which would otherwise positively impact output quality and satisfaction with team processes (e.g. Piccoli et al. 2004;

Smith et al. 1990; Warkentin et al. 1997). Beyond this, a comprehensive review will help us to identify relationships among relevant antecedents of specific dimensions of performance that have been understudied. For example, while unique expertise and shared understanding are both positively correlated with outcome quality and innovation (Balthazard et al. 2004; Majchrzak et al. 2000; Malhotra et al. 2004; Sole et al. 2002; Yoo et al. 2001), the relationship between these predictors remains unclear.

Thus, the goal of this paper is to review and synthesize the current literature in order to build nomological nets that map the factors driving virtual team performance. The paper is an effort to provide a complete perspective of the relationships among elements of virtual teams, to develop a better understanding of how they directly and indirectly affect performance, and to offer substantive directions for future research.

The paper contributes to both research and practice. For research, we provide nomological nets that allow us to better understand the effects of several elements of virtual teams on different types of performance, identify gaps existing in research, and recommend avenues for future research. Our classification of virtual team performance antecedents can also help scholars better differentiate among such antecedents and better understand their relationships. This paper thus helps scholars to situate and integrate existing virtual team research. The model developed based on our analysis can also serve as the theoretical foundation for future research on virtual teams. For practice, we provide managers with insights as to how they can design virtual teams and manage processes and states so that they can obtain the specific outcomes they wish to obtain (e.g., output quality, production efficiency, innovation and creativity, member satisfaction, individual learning, and desire to work together in the future).

The paper is structured as follows. In the first section, we define the key categories of virtual team characteristics. In the second section, we use those categories to synthesize prior research and build nomological nets for the antecedents of virtual team performance. In the third section, based on our analysis of the extant literature, we develop a generalized model that identifies key elements of virtual teams, how they are interrelated, and how they directly and indirectly affect different dimensions of team performance. We use the framework to synthesize the empirical evidence and guide future research. We conclude with a discussion of implications for research and practice.

POSITIONING WITH RESPECT TO PRIOR REVIEWS

Given the aforementioned increase in the use of virtual teams and the corresponding interest in scholarly interest in virtual teams it is not surprising that since the late 1990's, and particularly since 2000, there have been numerous reviews of research relevant to virtual teams (see Table 1). Many of these reviews do, in fact overlap in with this review in terms of the studies they include. To date, however, none has emerged as a single, widely-accepted overview of our current understanding of virtual teams. We believe any review must strive towards two key goals with respect to their treatment of the existing literature: exhaustiveness and objectivity.

Insert Table 1 about here

In order to provide a basis for understanding the large body of research on virtual team effectiveness, a given review must assess the full set of relevant research. This is particularly difficult for research on virtual teams given that virtual teams are complex systems affected by and in turn affecting widely ranging factors including technology, social dynamics, and social

structure. In addition, virtual teams are used in a wide range of domains including business, the military, and education. While numerous prior reviews have been conducted, many have chosen to restrict their scope to certain factors (e.g., studies of participation Bannan-Ritland 2002; of GSS effectiveness Dennis et al. 2001; or of social presence Nash et al. 2000). Others have restricted the domain within which they studied virtual team dynamics (e.g., online classes Bannan-Ritland 2002). A consequence of this limitation is that it is the various syntheses performed in these review themselves remain difficult to integrate. This suggests a need for an integrated review that looks at extant knowledge across all domains and addresses all aspects of such teams.

Numerous approaches exist for comparing findings across multiple studies, ranging along a continuum of increasing quantification: from narrative reviews to true statistical meta-analysis (Guzzo et al. 1987; King et al. 2005). As noted by King et al., increasing quantification decreases subjectivity (2005). As shown in Table 1, to date, the majority of prior reviews on virtual teams (7/12) have been narrative in nature and as such vulnerable to subjective biases (Guzzo et al. 1987). Of the remaining five, four are descriptive – providing some more objectivity, but still falling short of that provided by either vote-counting or true meta-analyses. This suggests a need for an objective review of virtual teams research that rests on a set of systematic procedures for structuring the empirical evidence. Taken together, we see a need for an objective and exhaustive review of literature on virtual team dynamics and performance to serve as a basis for integrating our current understanding on the topic.

THEORETICAL BACKGROUND

The work of Ilgen et al. (2005) and Marks et al. (2001) suggest that virtual teams elements can be grouped into three distinct categories: design factors (e.g., geographical

dispersion, IT features and infrastructure, or the nature of the task), emergent team processes (e.g., managing conflicts, exerting specific styles of leadership, using computer-mediated communication, or relying on formal behavioral control mechanisms), and emergent team states (e.g., level of trust, cohesion, shared understanding of IT usage, or shared mental models). In virtual teams, each category is composed of three sub-categories: information technologies (IT), interpersonal, and task, which is also often referred to as action processes (Kirkman et al. 2005; Marks et al. 2001). Team design factors can affect different types of performance directly and/or indirectly, through emergent team processes and states.

Virtual Team Performance

Numerous scholars have stressed the importance of viewing team performance as composed of three distinct dimensions: productivity, viability, and personal development (Cohen et al. 1997; Guzzo et al. 1996; Hackman 1987; Sundstrom et al. 1990). Differentiating among these dimensions allows us to capture the distinct interactions and interdependencies that exist among different antecedents of a specific dimension of performance, providing us with a more nuanced and accurate understanding of virtual team performance drivers.

The first, productivity is the extent to which a team's output meets or exceeds the standards of those receiving it and includes measures like quantity, efficiency, output quality, timeliness, and creativity. The second, viability, is the extent to which carrying out its work permits or enhances a team's ability to continue working together and includes factors like satisfaction and willingness to work together in the future[2]. Finally, personal development is the

[2] While there are certainly other interpersonal factors which are closely related and impact viability (e.g., conflict, cohesion, inter-member coordination, mature communication & problem solving, and clear norms and roles (Sundstrom et al. 1990) in the context of this analysis, we consider them antecedents rather than aspects of viability.

extent to which a team's experience fulfills the personal needs and contributes to the growth and personal well-being of its members and includes factors like learning.

Team Design Factors

Team design provides the initial project configuration, setting the stage for the team to begin to work and providing the structural context within which the team evolves. It supplies the situational opportunities and constraints that affect the occurrence and meaning of virtual teamwork (Johns 2006). Team design affects three aspects of the team, namely interpersonal, task, and IT-related factors (Campion et al. 1993; Janz et al. 1997).

Interpersonal factors (also referred to as membership factors) are the characteristics of individual team members as well as the resulting team-level structural properties shaped by those individuals attributes. They include personality traits (Balthazard et al. 2004), expertise (Malhotra et al. 2001), geographical dispersion (Hinds et al. 2003), temporal dispersion (Cramton 2001), cultural diversity (Maznevski et al. 2000), functional diversity (Jarvenpaa et al. 2004), team size (Majchrzak et al. 2005), and other properties of the team directly related to its membership.

Task factors refer to both the nature and characteristics of the task being performed. Examples include the required degree of interdependence (Lipnack et al. 1997), complexity (Maznevski et al. 2000), and non-routineity (Malhotra et al. 2004), the task's managerial structure – such as self or formally managed (Jarvenpaa et al. 1999; Jarvenpaa et al. 2004), and the task itself, for example software development (Malhotra et al. 2004), new product development (Malhotra et al. 2001), or research & development (Hinds et al. 2005).

IT factors involve the technologies used by a team to accomplish its work. They include the types of information technologies used to support virtual team collaborative processes such

as computer-conferencing systems (Cass et al. 1992), electronic mail (Mortensen et al. 2001), and audio/videoconference systems (Andres 2002). IT factors also include the respective attributes of IT like degree of feedback immediacy (Dennis et al. 1998) and synchronicity (Maruping et al. 2004). Together, interpersonal, task, and IT-related elements of the team design form the overall situational opportunities and constraints facing virtual team members and managers as they pursue their collaborative task, which can have both subtle and powerful effects on work unit/team performance (Johns 2006).

Emergent Team Processes

Emergent processes are the interdependent cognitive, verbal, and behavioral activities that convert inputs into outputs (Marks et al. 2001). Emergent processes capture how people act, do their job, interact with other members, and use IT. In the realm of actions, team processes are dynamic and typically transient. As team members interact and engage in ongoing activities, new emergent processes are created and existing ones are reinforced and/or incrementally changed. As with design factors, we distinguish three types of emergent team processes: interpersonal, task, and IT-related.

Interpersonal emergent processes are the activities performed by members of virtual teams to manage relationships among them (Marks et al. 2001). They include strategies for managing conflict (Montoya-Weiss et al. 2001), building trust (Jarvenpaa et al. 1998; Walther et al. 2005), and other cognitive, verbal, and behavioral activities used to manage socio-emotional and affective dynamics within the team (Kayworth et al. 2001).

Task emergent processes are the activities performed by members of virtual teams to structure, organize, control, and monitor work within virtual teams. They include exchanging task-related information and knowledge (Majchrzak et al. 2000; Maznevski et al. 2000), relying

on structured processes (Huang et al. 2002; Piccoli et al. 2003), and using formal team coordination mechanisms (Massey et al. 2003).

IT emergent processes are the cognitive, verbal, and behavioral activities related to IT use and capabilities. These include using computer-mediated communication (Maznevski et al. 2000; Robey et al. 2000; Yoo et al. 2001) and adapting IT to the context of the team (Majchrzak et al. 2000). Taken together, the three types of emergent processes capture members' interdependent actions aimed at converting inputs into outputs.

Emergent Team States

Emergent team states are the properties of virtual teams that are typically dynamic and vary as a function of the team context, inputs, emergent processes, and outcomes (Marks et al. 2001). In contrast to processes, emergent states do not denote interactions but reflect the characteristics of a team at a given point in time (Ilgen et al. 2005; Marks et al. 2001; Mathieu et al. 2006). As with design factors and processes, we differentiate between three types of states: interpersonal, task, and IT.

Interpersonal emergent states refer to the affective and socio-emotional properties of virtual teams. At the broadest level, they are collaborative climate within which a virtual team operates at a given time. Specific examples include shared team identity (Hinds et al. 2005), amount of conflict (Hinds et al. 2005), degree of trust (Jarvenpaa et al. 1999), and team cohesion (Chidambaram et al. 1993).

Task-related emergent states represent team members' attitudes, values, cognitions, and motivations related to task activities. They include shared mental models and collective minds (Baba et al. 2004; Yoo et al. 2001, transactive memory systems {Mortensen, 2001 #916), and team awareness (Espinosa et al. 2007; Marks et al. 2001).

Finally, IT-related emergent states are a team's attitudes, values, cognitions, and motivations about IT and its roles in supporting the team's activities. IT states include shared IT knowledge (Bassellier et al. 2003), media sensitivity (Trevino et al. 1990), computer self-efficacy (Compeau et al. 1995; Staples et al. 1999), and perceived technology spirit (DeSanctis et al. 1994).

METHOD

We identified empirical articles on virtual teams[3] by searching peer-reviewed journals published between 1990 and 2008 for papers with the following terms in their titles or abstracts: *virtual team(s)/group(s), distributed team(s)/group(s), and dispersed team(s)/group(s)*[4]. Based on the results, we generated a list of 13 relevant journals where research on virtual teams was being published. We then went to the journals themselves to generate the exhaustive list of all articles meeting the search criteria outlined above that were published between 1990 and 2008. This search process resulted in a total of 97 published empirical studies on virtual teams. A list of article counts by journal is provided in Table 2.

Insert Table 2 about here

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[3] It is important to clarify some points with respect to the definition of "virtual teams" given earlier as: 1) interdependent individuals physically separated from one another and 2) relying on information technologies to communicate, collaborate, and coordinate work 3) to achieve a common goal. Based on this definition, it is important to provide some further clarification of the first two points. First, as per the first criteria, we included all studies that reported any geographical dispersion, including group members at the same site but in different rooms/workspaces. Second, as per the second criteria, we considered IT to refer to any technology used by virtual team members to perform their task/project.

[4] We used ABI/INFORMS to perform our preliminary search.

First, to gain an overview of the current state of research on virtual team performance, we classified all papers in the sample with respect to both methodological approach and content. A summary of this data is provided in Table 3 and the complete table as Appendix 1.

Insert Table 3 about here

Categorization of findings

As a key objective of this review was to identify the main direct and indirect drivers of virtual team performance, we designed our analysis to connect concepts together in a nomological net based on Webster and Watson's (2002) concept-centric approach.. Our first step was to systematically identify and categorize the constructs and relationships found in the studies in our sample. To do so, we read each study, identifying all measured constructs and all tested relationships among them. Constructs were identified as either: metrics of performance, design factors, emergent processes, or emergent states, and among the latter three, as primarily interpersonal, task, or IT-related. Each relationship was categorized as either "+' if a positive relationship was reported, '-' if a negative relationship was reported, or 'o' if no relationship was found. It is important to note that unlike many previous reviews, we include quantitative, qualitative, and multi-method studies in our analysis and consider all published findings within the sample as having the same validity, irrespective of the methodology used. All findings reported in any study meeting the inclusion criteria outlined above were included in our analyses.

Not surprisingly, given the breadth, interdisciplinary nature, and relative youth of the topic, in many cases it was difficult to find multiple studies addressing any given construct or relationship. We therefore aggregated findings into broader constructs based on what we

perceive to be the broader underlying themes or drivers of the particular effects. Many of these constructs were, in turn, aggregated into higher-level constructs, resulting in a hierarchy of nested constructs, allowing us to examine and compare findings at multiple levels when appropriate[5]. The conceptual categorization was carried out independently by all three authors classification inconsistencies (less than 5%) were resolved through discussion.

Analyses

Numerous approaches exist for comparing findings across multiple studies, ranging along a continuum of increasing quantification: from narrative reviews to true statistical meta-analysis (Guzzo et al. 1987; King et al. 2005). As noted by King et al., (2005) increasing quantification decreases subjectivity, a key and often cited vulnerability of narrative analyses (Guzzo et al. 1987). Our decision to include qualitative research eliminates the possibility of conducting a "true" meta-analysis which requires the comparison of effect sizes. Thus, we conduct a vote-counting analysis, in which each finding is considered a vote in support of a positive, null, or negative relationship between two constructs. In his review of meta-analytic procedures, Rosenthal (1989) suggests a nonparametric sign test as a means to compare obtained versus expected frequencies of votes when the sample of findings describing a relationship between two variables is small. Thus, we use the formula:

$$z = \frac{x - np}{\sqrt{np(1-p)}}$$

[5] In this process of aggregation, multiple instances of support for a given relationship provided by a single study were combined into a single data point. This was done to control for differing levels of precision across studies. For example, whereas one study may have separately tested and found support for negative relationships between affect, task, and process conflict and team output quality, another may only have tested the link between overall conflict and quality. Rather than count the former as three distinct instances, they were considered a single instance data point.

As with standard z statistics, a 90% confidence interval is achieved when |z| > 1.645 and 98% when |z| > 2.326.

To produce meaningful results, however, this method requires a value of np greater than 5 (Keller et al. 1994). Given a p value of 1/3 (conservatively assuming equal probability of positive, negative, or null relationships) a sign-test requires any tested relationship to have at least 15 data points. Even aggregating to the highest meaningful level, only four of the 162 distinct relationships in the sample had been studied enough times for a sign test to yield meaningful results.

The systematic categorization of studies outlined above does, however, allow us to conduct a non-statistic vote-counting in which we compare the relative number of positive, negative, or null relationships found in the literature and from them identify suggestive trends. To determine a reasonable threshold for considering a given path supported, we build on Light and colleagues' (Light et al. 1984; Light et al. 1971), rule that reasonable evidence of a path exists if:

$$\left(\frac{number\ of\ findings}{total\ number\ of\ findings}\right) > {}^{1}/_{3}$$

This rule, however, has two relevant limitations. First, the $1/3$ rule does not differentiate among our three categories of findings: positive, null, and negative and the potential for contradictory results. Second, it does not set a threshold value for the minimum number of studies required before one can assess support. We modify Light and colleagues rule and find support if:

$$\left(\frac{|number\ of\ positive\ findings - number\ of\ negative\ findings|}{total\ number\ of\ findings}\right) > {}^{1}/_{3}$$

$$and$$

$$max(number\ of\ positive\ findings, number\ of\ negative\ findings) \geq 3$$

Starting from the assumption that supportive and contrary findings are equal in validity and importance, the first condition discounts the number of supportive findings (be they positive or negative) by the number of contradictory findings. It is important to note that null findings increase the denominator, thereby diluting the strength of all evidence in support of a valenced relationship. The second condition, sets the threshold value for inclusion at three studies or more based on the number of directional findings – thereby avoiding artificial inflation of counts by null findings. In order to assess the validity of our three study threshold value, we re-ran our analyses with a threshold of 2 studies and found that the pattern of findings did not change, but the overall trends were less clearly visible and more difficult to interpret. We therefore maintained the threshold value of 3 studies.

In the following section we discuss the trends identified in our review of the literature. In the few cases it is meaningful, we provide the results of a sign test analysis. In the remaining cases, we assess support using the metric outlined above. For all reported relationships we provide the number of positive, null, and negative findings as [+,o,-] respectively (e.g., 3 positive, 2 null, and 4 negative would be reported as [3,2,4]. Given the large number of relationships covered in the sample, we report only supported relationships (meeting the criteria outlined above). We also discuss small number of interesting counterintuitive or "suggestive" relationships that do not meet the criteria above.

RESULTS

We first turn to the broad trends regarding the state of research on virtual team performance. As indicated in Table 3, there has been a rapid increase in the number of published empirical studies of virtual teams. While 27 papers were published between 1990 and 1999, 26

articles were published between 2000 and 2004, and 44 between 2005 and 2008 alone – a trend suggesting that research on virtual teams is not only alive and well, but increasing rapidly.

We find no difference in the number of studies conducted in a natural as opposed to an experimental setting (48 studies vs. 49 studies respectively). Interestingly, however, these proportions changed substantially over time, with experimental settings used more than natural settings in the 90's (78% vs. 22% between 1991 and 2000), while after 2000, the reverse is true, as experimental studies decreased relative to those in natural settings (39% vs. 61% respectively between 2000 and 2008). This may reflect a large number of early laboratory studies aimed at understanding the effects of technology mediation on interpersonal interaction. With respect to their samples, the majority of studies relied on student subjects rather than employees within organizational contexts (64 studies vs. 34 studies respectively)[6]. Though in the majority of cases, experimental studies used student subjects, and studies in natural settings used organizational employees, there were a number of field studies conducted using student subjects (e.g., Cramton 2001). We view this balance between field and experimental studies to be a great strength of research on virtual teams.

With respect to level of analysis, the majority of analyses have been conducted at the level of the team (80), followed by individuals (38) and lastly the organization (5). Three points are worth noting here. First is the scarcity of research on organizational-level antecedents and consequences of virtual team use. Second, apart from a few exceptions (e.g., Munkvold et al. 2007; Polzer et al. 2006), we lack also research on subgroup-level factors (e.g., as defined by location or demography). Third, while 21 studies have covered more than one level of analysis simultaneously, 19 of those studies have considered the levels independently and consequently

[6] One study used both students and organizational employees.

have not integrated the effects of factors occurring at different levels. Thus, while such research has been multi-level, it has not performed cross-level analyses (exceptions are Caldwell et al. 2008; and Strijbos et al. 2004). Lastly, with respect to causal structure (Markus and Robey 1988), 71% of the studies have used variance models as compared to 29% that have used process models (69 studies vs. 28 studies respectively). We now turn to the specific relationships tested in these studies.

To make sense of the complex mapping of studies and relationships that exist, we organize our findings around the outcomes we have identified and the causal paths leading to them. First, we discuss findings identifying the antecedents of each of the dimensions of team performance in terms of design factors and emergent properties and states. Second, we identify the constructs that have, in turn, been found to lead to those antecedents.

Direct antecedents of performance

As noted, scholars stress the importance of recognizing three distinct, but equally important dimensions of performance: productivity (e.g., output quality, output quantity), viability (e.g., satisfaction), and development (e.g., learning) (Hackman 1987).

Antecedents of virtual team productivity

Productivity captures how effectively a team converts inputs into outputs in terms of quality and quantity (Adler et al. 1991). We also include output creativity as a sub-dimension of output quality. While distinct from quality of output, creativity has been well-studied and can be considered a criterion of output quality, as more creative solutions provide benefits above and beyond less creative ones.

Antecedents of output quality

With respect to the direct antecedents of performance in virtual teams, we find the most existing research (46 unique studies) examining the antecedents of output quality.

Examining the relationship between team design and output quality, not surprisingly, we find support for a positive relationship between levels of expertise and quality of output [3,0,0]. We also find a positive relationship between media richness and quality [4,3,0]. Breaking down the construct of media richness, there is stronger, but still suggestive, support for a positive link between the use of multiple media and quality [2,0,0] than for feedback immediacy and quality [1,1,0] or multiplicity of cues [1,3,0].

More research has examined the effects of emergent processes on output quality. We find evidence of a positive link between collaborative orientation (e.g., collaborative behaviors, collaborative conflict management, accommodating behaviors) and output quality [3,1,0]. Similarly, effective coordination, and communication quality both related to higher quality output ([6,1,0] and [4,1,0] respectively) as is effectiveness of coordination [6,1,0]. We also find positive interpersonal climate (in the form of trust, cohesion, and low conflict) is positively related to output quality [3,3,0]. Interestingly, though by far the most plentiful, research on the link between mediated communication and output quality remains ambiguous [2,11,7] ($z = 0.16$). Thus, across 20 findings, unique studies on the topic, the majority of findings indicate no relationship between the use of CMC and quality of output.

With respect to emergent states, we find a strong link between output quality and shared team mental models of both task and IT [6,0,0]. We also find positive links between output quality and both efficacy beliefs [3,1,0] and positive interpersonal climate [3,3,0] – as evidenced by low conflict and high trust.

Two additional relationships are suggestive, having only two congruent points of support each. We find suggestive positive links between output quality and both active leadership and the adaptation of technology to fit the team's needs (both [2,0,0]). With only a single point of corroboration, we do not consider these to be well-supported findings, but they are certainly suggestive and worth noting.

Finally, although not definitionally linked to output quality, we view creativity, particularly as it comes to exist in real teams, as one of the dimensions along which the quality of a given virtual team output can be, and often is, judged. Evidence of the antecedents of creativity in virtual teams is minimal. We find only five studies examining antecedents of virtual team creativity all but one of which focus on the effects of IT. We find mixed evidence of the link between media richness and creativity [2,1,0] and only minimal evidence on the links between creativity and both mediated communication [1,1,0] and IT adaptation [2,0,0]

Antecedents of output quantity

The second aspect of productivity, output quantity, includes studies predicting both volume of output and speed of output. Closely intertwined, these two constructs assess the conversion of inputs into outputs over a fixed period of time. Surprisingly, we find little consistent evidence of predictors of virtual team productivity. Coming from eleven distinct studies, with the exception of negative links between more demanding tasks and virtual team productivity [0,3,3] and between mediated communication and productivity [0,1,5], we find no other relationships supported by more than 2 findings. Of the remainder, while scholars have studied the links between output quantity and structural diversity, team size, resource availability, communication quality, and coordination effectiveness, only the suggestive positive relationship between media richness and output quantity [2,0,0] has multiple points of support.

Antecedents of virtual team viability

Though many factors may be considered as contributing to virtual team viability (e.g., satisfaction, intent to remain, willingness to collaborate in the future), satisfaction is the construct that has been most frequently studied in virtual teams.

We lack clear evidence of a link between virtual team design and satisfaction. Of the seven findings addressing this relationship, five find no direct relationship, breaking down into the relationships between satisfaction and media richness [1,2,0] and structural diversity [0,2,1]. The latter finding is especially surprising given the large amount of existing theory arguing that working in dispersed and cross-cultural teams yields unpleasant dynamics.

Turning next to emergent processes, by far the most studied is the link between mediated communication and satisfaction which again finds mixed results [3,8,8] (z=0.81), with similar patterns for emergent team process and outcome satisfaction. Results are slightly stronger for the relationship between mediated communication and communication satisfaction [0,3,5], suggesting that the negative impact of technology mediation may be limited to the act of communication itself. A smaller number of findings connect satisfaction to the use of multiple media [2,2,2], but these findings are ambiguous and again largely consistent regardless of the object of the satisfaction. We also have some suggestive evidence of links between satisfaction and both effective coordination [2,0,0] and collaborative orientation [2,0,0].

Also contributing to viability is research on predictors of intention to remain in the team. To date, however, we have only one study examining this construct and finding a positive relationship to perceived self-efficacy. Uncorroborated, we need further evidence of this before reaching conclusions about predictors of intention to remain in the team. Nevertheless, studies

examining the link between satisfaction and interpersonal or task-related factors are surprisingly rare.

Antecedents of virtual team development

The final dimension of performance in any team, be it virtual or face-to-face, is team development – growth on the part of team members. A number of potential constructs can be placed under the category of development, including learning, affiliation, and personal growth. We find, however, only two studies examining antecedents of development, measured as learning and that study finds a positive link between information and knowledge sharing and learning within virtual teams (Hightower and Sayeed, 1996; Majchrzak et al., 2005). This, therefore, remains an area for future research.

Indirect antecedents of performance

While these findings illustrate a number of direct predictors of performance, by examining the antecedents of those team design elements, emergent processes and emergent states that we know affect team performance, we are also able to identify causal chains that lead to productivity through these intermediate steps. As we found no strong evidence of predictors of either virtual team viability or development, we cannot draw causal chains to either of those dimensions of performance. Thus, in the remainder of this section, we focus on causal chains leading to virtual team productivity. Though we will discuss them as mediators, in some cases, these intermediate factors may operate more as moderators of these relationships.

Turning first to output quality, although we identified eleven antecedents of virtual team output quality, evidence of predictors of four of the eleven: level of expertise, engaged leadership, adapted technology, and use of multiple media was largely absent, leaving us with seven testable paths to virtual team output quality: efficacy beliefs, collaborative orientation,

positive interpersonal climate, effective coordination, communication quality, and shared mental models.

While some research exists on the antecedents of collaborative orientation in virtual teams - another predictor of output quality – those studies provide no consistent trends in their results. Individual studies have found negative relationships between high levels of individualism and collaborative conflict management [0,0,1], a lack of a relationship between diversity and collaborative conflict management [0,1,0], and mixed results for the link between mediated communication and collaborative conflict management [1,1,1]. Research on efficacy beliefs is similarly inconsistent in its findings, with individual studies linking such beliefs to individualism [1,0,0], communication effectiveness [1,1,0], role assignments [0,1,0], and amount of feedback [1,2,0]. Due to the lack of corroboration of these findings, we do not include predictors of either collaborative orientation or efficacy beliefs in our final model.

We do, however find evidence of antecedents of positive interpersonal climate (in the form of cohesion, trust, and lack of conflict) in virtual teams, from 36 studies yielding 87 distinct findings. We find a sizeable number of studies finding a negative relationship between such dynamics and structural diversity (in the form of geographic dispersion, the existence of subgroups, and diversity with respect to culture, function, and age) [0,3,10]. Covering a wide range of types of diversity and forms of positive interpersonal climates, the most consistently found relationships are the negative relationship between subgroups and trust [0,0,3], and the positive relationship between conflict and both cultural diversity [4,0,0] and subgroups [3,0,0]. We also find positive relationships between positive interpersonal climate and media richness [3,1,0], interpersonal as opposed to task-based communication [4,0,1], and communication

quality [3,1,0]. The largest amount of research exists for the link between positive dynamics and mediated communication [3,7,10] ($z = 1.58$) which suggests a negative relationship.

We also find consistent evidence of antecedents of the effective coordination of work and expertise, also a predictor of virtual team output quality. Turning first to research linking virtual team design to effective coordination, we find that having structures in place that support coordination – such as temporal coordination mechanisms or knowledge brokering mechanisms – increases the likelihood of effective coordination in virtual teams [3,0,0]. Moving on to emergent states and processes, effective coordination is positively related to shared mental models [4,1,0] – particularly those relating to the task [3,0,0] and negatively to mediated communication [0,2,3]. We find a suggestive negative relationship to structural diversity (temporal and functional) [0,0,2] and findings are mixed for the link between effective coordination and the use of multiple media [2,0,1].

Distinct from the effective coordination, we find evidence of a negative relationship between quality of communication and structural diversity (primarily with respect to geographic dispersion) [1,3,6]. Shared mental models also appear to be positively linked to communication quality [3,0,1] while mediated communication again reduces it [2,3,7]. Related, though not directly measuring the quality of communication, a large number of studies have examined the antecedents of sharing particular types of information, such as interpersonal or task-based. Though examining a wide range of antecedents including structural diversity, active leadership, media richness, and mediated communication, these findings have, to date, yielded conflicting results.

Also contributing to the quality of virtual teams' output is the existence of a shared team-level mental model. Research has found structural diversity to be negatively related to shared

team-level mental models in virtual teams [0,0,3] this is attributable to a range of factors including unshared experience and reduced information about the distant location. We find a positive relationship between communication quality and shared mental models [4,1,0] and we find suggestive evidence for a positive relationship between cognitive sensemaking processes and shared mental models [2,0,0]. Surprisingly, only two studies explored the link between IT factors and shared mental models in virtual teams, with ambiguous results.

Turning next to output creativity and quantity, while we find a number of factors that can be indirectly linked to virtual team productivity through output quality, we the lack corroborated evidence needed to draw causal chains leading to creativity or output quantity through adapted technology, media richness, mediated communication, or demanding tasks. With respect to causal chains leading to viability, as noted, we identified a number of predictors of shared mental models, but we lack consistent evidence of the antecedents of collaborative orientation.

DISCUSSION

Over the past twenty years, scholars have generated a substantial body of knowledge regarding the impacts of various design and emergent factors on team performance. While substantial, this knowledge remains fragmented, with little exploration of the relationships and interactions among these antecedents of virtual team performance. Further confounding our understanding is the fact that we have studied different dimensions of performance, which makes the comparison and integration of findings across studies complex.

To make sense of this complexity, we differentiate constructs with respect to three key taxonomies: dimensions of performance; design, emergent processes, and emergent states; and interpersonal, task, and IT factors. This approach yields a number of important benefits. First, this approach provides a more precise understanding of the synergistic, complementary, and

sometimes opposing effects of different types of factors on different aspects of performance that may or may not themselves be complementary. Second, grouping individual constructs into categories of design factors, emergent processes and states, and differing dimensions of performance allows us to identify broader patterns of inter-category dynamics and relationships, the recognition of which allows us to correctly attribute effects to either individual factors or the broader classes to which they belong. Third, this approach also allows us to map the nomological net linking different virtual team design, emergent process, and emergent state factors to performance and provides both insights into what we know about virtual team performance and what we have yet to learn. Fourth, differentiating among these constructs in our models allows us to disentangle and more accurately measure key factors. Given their dynamic nature, emergent processes and states may require more frequent sampling or longitudinal data to accurately assess.

The empirical evidence reviewed provides support for these distinctions, as they were found to differently influence virtual team performance. Beyond the broad benefits gained by taking a differentiated and integrated view of performance, design factors, emergent processes, and emergent states; and interpersonal, task, and IT-related factors, differentiating each dimension itself yields valuable insights which we outline below.

Insights gained from a differentiated view of performance

We build on Hackman (1987) and others who identify three orthogonal dimensions of team performance – productivity, viability, and development – and stress the importance of all three in determining the ultimate success of a team. In the case of research on virtual teams, however, the corroborated evidence focuses solely on virtual team productivity. While we have some suggestive evidence that effective coordination and a collaborative orientation contribute to

the long-term viability of the team (in the form of team member satisfaction), with only two findings in support of each relationship, further research is needed. Even more striking, we find only one study in our sample that predicts member development (in this case learning) in virtual teams, and two others that look at learning-related antecedents of other performance outcomes. Within the extant research on virtual team productivity, the evidence focuses heavily on antecedents of output quality. Apart from negative effects of demanding tasks and mediated communication, there is a surprising lack of evidence for antecedents of output quantity.

This focus on virtual team productivity in many ways reflects similar trends in the traditional team literature, which also initially focused on productivity. This focus is not surprising, given that productivity is the most obvious managerial metric for assessing the success or failure of a team. Nevertheless, it is important to recognize that absent research on virtual team learning and viability scholars' ability to theorize, and practitioners' ability to manage, are limited. For both scholars and practitioners, a model of virtual teams that focuses solely on output may not capture many of the factors that motivate individual team members like satisfaction or personal growth. It also risks focusing on short-term gains (in the form of more or better output) at the cost of long-term benefits in terms of stability or the development of members as future resources. For this reason, future research on the in the domains of virtual team development and viability is needed.

Insights gained from a differentiating among design factors, emergent processes, and emergent states

We also build on Marks, Mathieu, and Zaccaro (2001), who argue that a key impediment to the team literature is the lack of distinction between emergent team processes and states. In this review, we differentiate among three types of constructs: design factors, emergent processes,

and emergent states. Evidence supports the importance of all three, as research is evenly balanced across examinations of design factors, emergent processes, and emergent states. We find that design factors play an important role in virtual team performance, but that their impact on team performance occurs primarily through their effects on emergent processes and states. Those emergent processes and states, in turn, are closely interconnected, reinforcing the model put forth by Marks et al. (2001) which highlights the close and often mutually reinforcing relationship among emergent states and processes. As they note, states "are products of team experiences (including emergent team processes) and become new inputs to subsequent processes and outcomes" (Marks et al. 2001 p 378). Our review supports this close interaction, as we find substantial interconnection among the emergent processes and states that have been studied in virtual teams.

Insights gained from differentiating among interpersonal, task, and IT-based factors

Finally, in addition to differentiating among construct types, we also differentiate among construct domains. Looking at the body of research relating to virtual team performance, we find a large number of constructs that are interpersonal in nature. A large amount of research has also been carried out on IT-related factors. Many of the tested relationships, however, are not visible in Figure 1 because their results were inconclusive. Constructs related to virtual team tasks, in contrast, were by far the least frequently studied. However, given the direct links between task-related constructs and both output quality and quantity, it is clear that the design of virtual team tasks as well as emergent task-based processes and states play an important role in virtual team performance. We therefore believe the role of tasks, and their relationships to interpersonal and IT-related factors within virtual teams, remains an important and understudied domain for virtual teams research.

Toward a Generalized Model of VT Performance

Differentiating among these distinct categories of constructs highlights broader patterns of inter-category dynamics and relationships and allows us to develop a general model of virtual team performance. As illustrated in Figure 2, team design provides the initial team context that shapes the future direction of teams and allows, facilitates, constrains, or prevents the subsequent emergence of processes and states. Team design factors can thus influence team performance directly and indirectly, because they facilitate, stimulate, or hinder the emergence of some processes and states.

Insert Figure 2 about here

This differentiation also allows us to explore relationships between and within emergent factors. Take, for example, the relationships between emergent processes and states, which influence one another, sometimes reinforcing or modifying existing states or processes and at other times creating new ones (Ilgen et al. 2005; Marks et al. 2001). Emergent processes, through members' repeated actions, contribute to emergent states by facilitating state formation, maintenance, and transformation. Emergent states, in return, affect emergent processes by influencing the team selection, routinization, optimization, and structuration of processes. The framework also highlights the recursive relationship between outputs and team characteristics (Ilgen et al. 2005; Marks et al. 2001). The feedback loops, represented in the framework by dashed arrows, indicate that variables treated as output factors at time *t* can become antecedents of contextual and/or emergent process and state variables at time *t+1*. Beyond more simply representing consistent relationships among classes of constructs, this generalized model also

serves to highlight domains with high potential for future research. Having such a generalized model, in turn, allows us to better plan future research and to better situate its findings within the body of extant knowledge.

Contributions and Future Research

The work contributes to both research and practice. First, for scholars, the paper provides an integrative framework designed to highlight key differences among constructs. It thereby allows us to identify the key elements of virtual team performance and understand how they relate to each other. By differentiating between dimensions of performance, between designed and emergent factors, and between processes and states, while at the same time examining the complex nomological network connecting these disparate factors, we are able to more accurately situate and integrate extant virtual teams research. This increased precision and recognition of interrelationships is particularly important in cases where we have wrestled with contrary findings. Second, beyond improving understanding of our extant knowledge, this framework helps us recognize and identify key gaps in our understanding, and thus serves as a roadmap for future research opportunities. Third, the recognition of theoretical and methodological similarities within, and differences across, categories further helps us as scholars and researchers to better design (both theoretically and methodologically) those future studies. Fourth, and more generally, this work highlights the importance of recognizing interconnections among constructs and helps reinforce the prevalence and importance of mediation and moderation roles of emergent team processes and states and explain the differences between, and the interrelationships among different types of virtual team performance.

Turning to practice, by differentiating among performance outcomes and highlighting the unique antecedents of each, this framework opens the proverbial black box and allows managers

of virtual teams to prioritize their actions and decisions to focus on the outcomes that are most important to them. Our model also provides managers with a model of virtual team performance that can help them make sense of the complex interrelationships and interdependencies among those factors set at the start of the team (in many cases outside their control) and those that arise over the life of the team (over which they may have more influence).

As an example, our review highlights how the initial design and set up of virtual teams can trigger the emergence of particular processes and states, which in turn affect performance. Managers need to consider the implications of design decisions not only immediately (such as higher-quality output produced by expert teams), but also as they continue to affect subsequent emergent dynamics (such as the negative effects of structural diversity on communication quality, shared mental models, and a positive interpersonal climate – all of which in turn affect quality). Our model also reinforces the importance of managers recognizing the interconnections among their efforts to manage ongoing team dynamics throughout teams' lifecycles (such as the negative effects of increased reliance of mediated communication on communication quality) and the potential to use these dynamics to offset one another (such as working to establish teamwide shared mental models in an effort to reduce those negative effects).

Our model also identifies a few factors as having more wide ranging effects than others, suggesting they might be the most effective managerial levers. These include structural diversity, with its negative effects on climate, communication quality, and shared mental models; communication quality, with its effects on climate and shared team mental models; shared mental models, with its effects on communication quality and effective coordination; and mediated communication with its effects on communication quality and interpersonal climate.

Efforts to mitigate the negative effects - and enhance the positive effects – of these factors are likely to have further-reaching ripple effects than will efforts to address other factors.

Future Research

Despite having accumulated a large body of knowledge on virtual team performance over the past twenty years, we are far from having exhausted all the interesting questions. While it is not feasible to outline and discuss all such suggested future research topics, there are a number of broader questions and more macro-level topics for future research that we will address here.

Corroboration and integration of findings: First, in conducting our analyses, it became evident that a large number of findings, while conceptually interesting and based on solid empirical research, could not be meaningfully corroborated and combined to yield higher-level theories. In other cases, individual findings could be meaningfully combined, but the resultant relationships could not be connected either directly or indirectly to virtual team performance. The result of all such cases is that there exists a large body of research that remains unintegrated with our overall understanding of the drivers of virtual team performance[7].

Scholarship on virtual teams has been in a state of divergence of ideas, theories, methods, and reference disciplines. The benefits and drawbacks of such divergence and diversity have been hotly contested on a larger scale in two of the reference disciplines on which virtual teams research draws: organization science (Pfeffer 1993; Van Maanen 1995a; Van Maanen 1995b) and information systems (Benbasat et al. 1996; Robey 1996). Though by no means a discipline, a number of the benefits and concerns raised in these debates are relevant to research on virtual teams. Without arguing for or against diversity, we wish to highlight the importance of a balanced approach to diversification, and agree that the lack of a cumulative research history is

[7] We recognize that not all studies in our sample claimed to be about virtual team performance, but for teams within organizational contexts, performance – particularly as defined by Hackman and others, is a key goal.

problematic for future, cumulative research (Benbasat et al. 1999). For this reason, we believe some consolidation and replication of key findings to contribute to a validated and verified body of knowledge on virtual teams on which future research can build. Furthermore, as our existing theories drive perceptions of what phenomena are important (Kuhn), establishing a more integrated body of knowledge will in turn drive a richer and more cohesive body of future research.

We therefore find a need for research intentionally designed to support and relate many of the currently disconnected findings. Of particular note are the numerous "suggestive" findings reported here – those with two points of support. These include the relationships between engaged leadership (emergent process) and output quality and between output quality and numerous IT-related factors including the availability of multiple media (design), media richness (design), and adapted technology (state). Also of note are suggestive findings predicting viability - in the form of satisfaction - as a result of collaborative orientation (state) and effective coordination (emergent process). Building on these initial findings would allow scholars to assess their scope and generalizability.

Dimensions of performance: Second, based on the literature on traditional teams (Cohen et al. 1997; Guzzo et al. 1996; Hackman 1987; Hackman 1990), we identified distinct dimensions of performance (productivity, viability, and personal development) and argued that virtual team performance needs to be differentiated. Our findings indicate that research has been unbalanced across these dimensions of performance. Research is heavily weighted toward productivity, within which efforts have been focused on output quality. There have been comparatively few studies of other aspects of productivity such as creativity and innovation or production efficiency, which suggests the need for further research on other measures of team

productivity to provide a more complete picture. In contrast, there is far less research on team viability and on personal development, both of which are critical to understanding the long-term effects of virtual teams.

Team viability (i.e., the degree to which carrying out work enhances a team's ability to continue working together in the future), is an important construct to better understand the long viability of virtual teams and potentially how working in virtual teams might affect members' willingness to work in traditional teams in the future. More research is needed on this topic. For instance, interpersonal states like conflict or cohesion are likely to affect team viability through the creation of mutual antagonism or bonding respectively. Also, more research is needed to study whether increased reliance on mediating technologies creates persistent tensions, thereby inhibiting members' ability to work together in the future.

With respect to personal development, one key understudied area involves the links between interpersonal, task, or IT-related factors and individual learning within virtual teams. More research is needed to determine whether members of virtual team learn as do those in collocated teams; what forms of learning occurs (incidental versus intentional learning); and how learning is distributed among members. Beyond individual learning, future work might also examine the ability of the virtual teams to fulfill other personal needs like those for safety, control, relatedness, autonomy, and affiliation. There is also a need for research on the impacts of IT (either emergent processes or states) on personal development outcomes (e.g., how IT affects social processes and individual achievement of personal needs).

Although obviously related, there have been no studies explicitly examining the relationships and tradeoffs within and between different dimensions of virtual team performance. It is, however, easy to see how teams may sacrifice high productivity for individual growth or

team viability. A better understanding of these relationships would allow us to better predict ultimate performance, as a combination of multiple dimensions. Taken together, this suggests a need for further research on as yet understudied dimensions of performance as well as the relationships within and between performance dimensions. More research is therefore needed to further unpack these performance dimensions.

Role of IT: Third, despite being extensively studied, the relationship between IT and performance in virtual teams remains unclear. Though scholars have studied the effects of mediated communication on output quality, of mediated communication and media richness on satisfaction, of media richness on innovation, and of IT-related factors on a wide range of emergent processes and states (status, task-related information exchange, interpersonal communication) their findings have been inconclusive. In each case, numerous studies have found positive, negative, or no relationships between them.

To make sense of these findings, we looked at how authors operationalized the IT artefact within studies that led to inconsistent effects of IT on team performance. We found that in general, the majority of studies have conceptualized the IT artefact broadly by dichotomizing the usage of IT (virtual teams using IT vs. face-to-face teams not using IT). For instance, when we analyzed the evidence regarding the effect of computer mediated communication on output quality [2,11,7], we found that 19 out of 20 findings have been obtained through comparisons between face-to-face teams (without IT) and computer-mediated dispersed teams. Thus, computer mediation has mainly been operationalized through an experimental condition that contrasts with the non-usage of IT. The observation is even more striking when we look at the effect of computer mediated communication on satisfaction [3,8,8], where all the empirical evidence was generated by comparing face-to-face vs. computer-mediated dispersed teams.

Although this observation does not clarify the inconsistent results about the role of IT in virtual teams, it does suggest that adopting more precise and focused conceptualizations of the IT artefact might lead to a better understanding of the effect of IT on virtual team performance. For instance, Majchrzak et al. (2005) assessed the effect of IT on collaborative know-how development by looking at its capacity to enable contextualization of virtual teams' work inputs and strategy. Jarvenpaa et al. (2005) assessed the IT artefact by measuring the number of emails exchanged between members of virtual teams over the course of their project, thus conceptualizing continuously rather than dichotomously as use vs. non-use. Interestingly, both studies found support for their respective conceptualization of IT on the performance of virtual teams. Unfortunately, to date, the number of empirical finding for such conceptualizations remains too small to provide significant insights to understand IT effects in virtual teams. We therefore encourage researchers to perform additional empirical validation for such conceptualizations and develop new ones in order to gain better understanding of the effect of IT on virtual teams performance.

The benefits of structural diversity: Fourth, our analysis highlights the effects of structural diversity on virtual team performance. By pooling evidence from across studies, the review strongly suggests that structural diversity is detrimental for the performance of virtual teams because of its negative effects on communication quality, the development of positive interpersonal climate, and the establishment of shared team mental models. In fact, the substantive amount of findings in regards to the different types of structural diversity show consistent detrimental effects of diversity on emergent processes and states. However, the conceptual work of Johns (2006) on organizational context suggests that the structural elements that shape the overall context in which work is performed are likely to present both situational

constraints and opportunities for organizational members. In the context of virtual teams, this means that the context shaped by structurally-diverse virtual teams would not only raise collaboration constraints, but are also likely to present some opportunities. To date, however, we have minimal research on the potential benefits of structural diversity in virtual teams, either directly or indirectly. One rare exception can be found in the work of Haas (2006), who finds that structurally-diverse teams in which a balance exists between cosmopolitans and local members have higher quality output because these members provide different types and quantities of applicable knowledge to the team. Again, this finding remains fairly isolated from the wider body of empirical evidence on the effects of structural diversity, which leads us to suggest more research on the potential opportunities raised by structural diversity within virtual teams.

Approaches to conducting research on virtual team performance: Fifth, in surveying the extant empirical research, we discovered some notable gaps in our approaches to studying virtual teams that we believe can and should be addressed with future research. Though it is not surprising that the majority of studies have focused on team as opposed to individual, subgroup, or organizational factors when assessing virtual team performance, the relative lack of organizational and subgroup level analyses suggests a need for future research at these levels. Organizational level factors like culture, structure, and infrastructure (as well as higher level factors like industry) on virtual team dynamics and performance provide the context within which virtual teams function. At the same time, understanding the effect of virtual teams on organizational outcomes is equally important as it will allow us to better assess the cost-benefit tradeoffs inherent in the use of virtual teams. Similarly, more research is needed on the role of subgroups in determining virtual team effectiveness and their interaction with other virtual team

dynamics. Recent research finds that subgroups, which occur in almost all virtual teams, have wide-reaching effects (O'Leary et al. 2009). Strong subgroups also raise the possibility of team members focusing primarily at the level of the subgroup over that of the team, raising larger questions about the validity of the overall virtual team as a construct in certain situations. Given the powerful effects of organizational and subgroup-level factors on team dynamics, more research exploring factors at these levels is therefore warranted.

Bringing these together, along with extant research at the level of the team and individual, we need more cross- and multi-level research in order to better understand how factors at the individual, subgroup, team, and organizational levels interact and either reinforce or counteract one another. Individual member traits and actions have obvious repercussions on team dynamics and team-level factors, be they designed or emergent, interpersonal, task, or IT-related, will likewise affect outcomes for both the organizations in which they are embedded and the individuals they contain. Thus, research is needed to further understand the relationships between these factors at different levels.

Also, our emphasis on cross-sectional studies and variance analyses has two key consequences. First, in cross-sectional field studies, and variance analyses, causality is impossible to empirically validate. This poses a significant impediment to correctly mapping how the constructs and processes interrelate. Second, the lack of longitudinal analyses makes it impossible to assess the evolution of virtual dynamics (i.e., relationships among team design, emergent processes, and emergent states) over time. The frameworks of both Marks et al. (2001) and Ilgen et al. (2005) highlight the importance of recursive feedback loops that necessitate understanding how dynamics unfold and interrelate over time. Thus, we consider these important shortfalls in our existing knowledge and strongly suggest a need for more longitudinal and

process-oriented studies in order to definitively identify causal structures and evolving dynamics (Markus et al. 1988).

CONCLUSION

In this paper, we present a synthesis of the extant literature into the integrative framework in order to help us better understand what drives performance in virtual teams. By using a differentiated approach to performance, we provide scholars and practitioners with a means of disentangling what are otherwise often confusing and seemingly contradictory findings. By clarifying the roles of design factors as well as emergent processes and states, this paper helps scholars and managers understand the importance of, and distinctions between, initial team configuration decisions and the continuing management of on-going dynamics. At the same time, through this analysis, we have expanded our theoretical understanding of distributed teamwork, complementing prior frameworks of virtual team effectiveness (Martins et al. 2004; Maznevski et al. 2000; Powell et al. 2004) and highlighting understudied areas that warrant more research.

By combining Hackman's (1987) model of the antecedents of team performance with Marks et al.'s (2001) Input-Mediator-Output-Input model, we provide a framework for assessing the current state of knowledge with respect to virtual team performance. We are not aware of existing examinations of research in the larger teams literature that draws on such an approach. Given the clear trends in empirical findings found using our approach, the theoretical and methodological gaps identified, as well as suggestions for future research, we believe this approach may prove beneficial in other domains as well. In particular, the framework and approach used in this review can be used as a template or starting point for a much larger review of research on traditional teams.

As is often the case in new domains of scholarship, over the past twenty years, we have rapidly accumulated a large body of knowledge on virtual team dynamics and performance. To date, this knowledge has remained largely unstructured, and maintaining a complete understanding of it is becoming increasingly difficult for both scholars and practitioners. As a result, it is becoming increasingly difficult to effectively use or build upon that knowledge. By providing an integrative synthesis of research on virtual team performance, we to provide academics and managers with the tools required to do so.

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TABLES AND FIGURES

Table 1. Reviews grouped by scope and in order of decreasing level of quantification

Authors (year)	Review Focus	Focal Unit	Sample Scope	Analysis Type[1]
Comprehensive review and model				
[Names redacted for review] (2009) *(this review)*	I-M-O-I Model of VT Performance	Virtual Groups / Teams	All empirical	Vote Counting
Martins, Gilson, Maynard (2004)	I-P-O Model of VT Dynamics	Virtual Groups / Teams	All empirical	Descriptive (light quantification)
Axtell, Fleck, & Turner (2004)	Differentiating virtual from collocated teams	Virtual Groups / Teams	Unspecified	Narrative
Powell, Piccoli, Ives (2004)	I-P-O Model of VT dynamics	Virtual Groups / Teams	Unspecified	Narrative
Pinsonneault & Caya (2005)	I-P-O Model of VT dynamics	Virtual Groups / Teams	All empirical	Narrative
Limited to specific inputs, outputs, or dynamics				
Denis et al. (2001)	GSS vs. Non-GSS Effectiveness	Groups [2]	All empirical	Meta-Analysis
Fjermsted & Hiltz (1998)	GSS Effectiveness (technology focus)	Groups [2]	Experimental	Descriptive
Fjermsted & Hiltz (2000)	GSS Effectiveness (technology focus)	Groups [2]	Case & Field	Descriptive
Gallivan & Benbunan-Fich (2005)	GSS & e-collaboration	Groups [2]	All empirical	Descriptive
Bannan-Ritland (2002)	Interactivity and Participation in distance education	Online class	Empirical and theoretical (distance education)	Narrative/ Descriptive
Nash, Edwards, Thompson, Barfield (2000)	Presence and Performance (Micro / sensory)	Virtual *Environments*	Unspecified	Narrative
Hertel, Geister, Konradt (2005)	Management	Virtual Teams	Unspecified	Narrative
Curseau (2008)	Information Processing Effectiveness	VirtualTeams	Unspecified	Narrative

Notes:
[1.] As per the taxonomy provided by King and He (2005) [2.] Study does not differentiate between "group" and "team"

Table 2. Article counts by journal

Journal	Count
Academy of Management Journal	3
Admin. Science Quarterly	2
Group Decision and Negotiation	7
Information and Management	8
Information Systems Research	11
Journal of Applied Psychology	4
Journal of Management Information Systems	11
Journal of Organizational Behavior	2
Management Science	2
Management Information Systems Quarterly	13
Organizational Behavior and Human Decision Processes	2
Organization Science	8
Small Group Research	24
Total	**97**

Table 3. Article counts by classification

Classification Criteria	Count
Year	***97***
1990-1994	13
1995-1999	14
2000-2004	26
2005-2008	44
Research Setting	
Natural	48
Experimental	49
Research Subjects	
Employees	34
Students	64
Data source	
Surveys (member)	66
Measurable output data	48
Communication logs	40
Interviews	20
Observations	14
Documentation	7
Existing case data	1
Single-data sources	31
Multiple data sources	66
Level of Analysis	
Individual	38
Subgroup	5
Team	80
Organization	5
Single level	76
Multiple levels	21
Causal Structure	
Variance	69
Process	28

Topic	Count*
Design factors	***99***
Interpersonal	50
Task	26
IT	23
Emergent factors	***242***
Processes	145
Interpersonal	22
Task	67
IT	56
States	97
Interpersonal	47
Task	35
IT	15
Performance dimension	
Unspecified	12
Output Quality	55
Output Quality (Creativity)	5
Output quantity	15
Development	2
Viability	21

** The numbers in this table represent the frequency at which a given factor has been analyzed in the studies surveyed. A single study can address multiple factors and categories are not necessarily mutually exclusive.*

Figure 1. Map of antecedents of virtual team performance

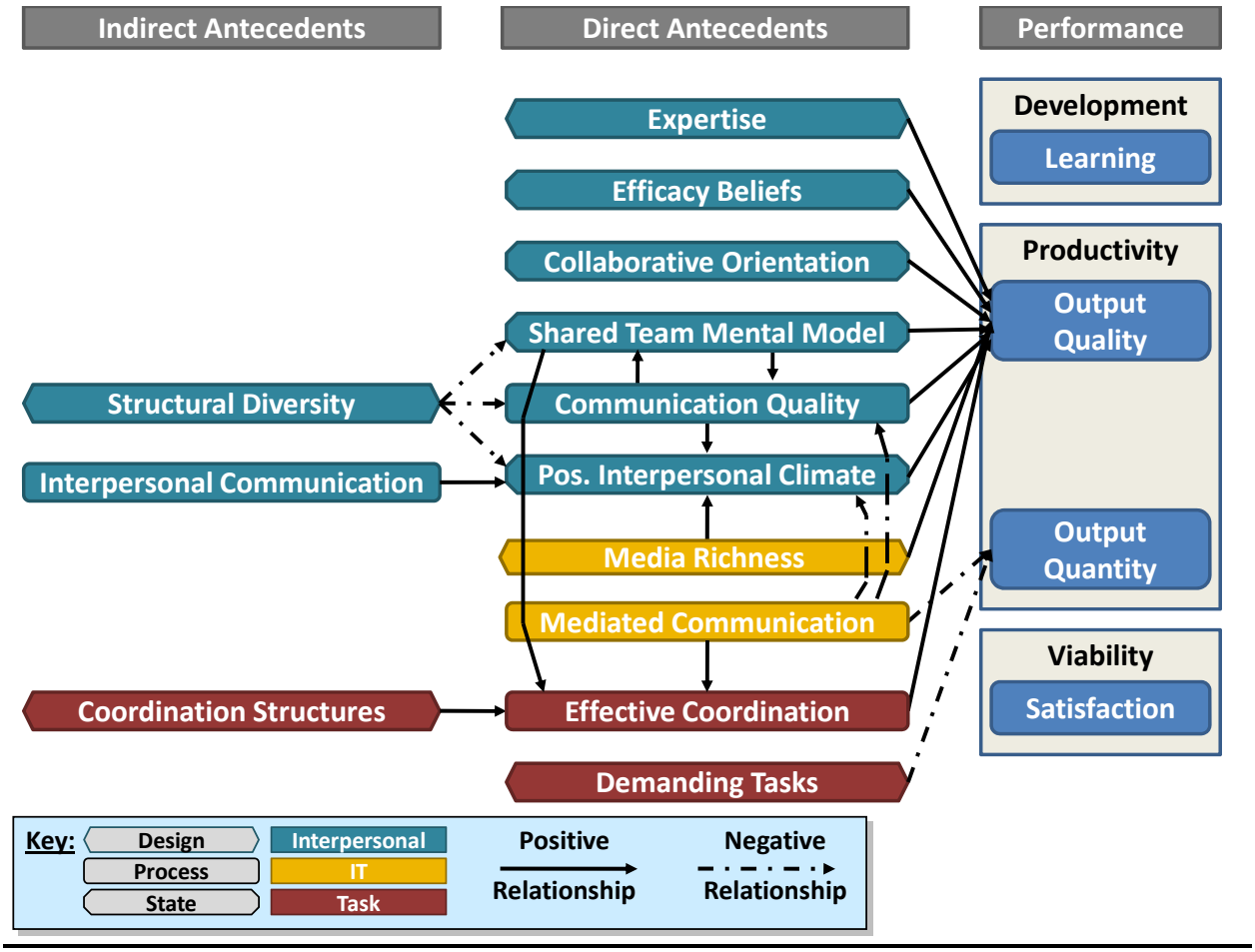
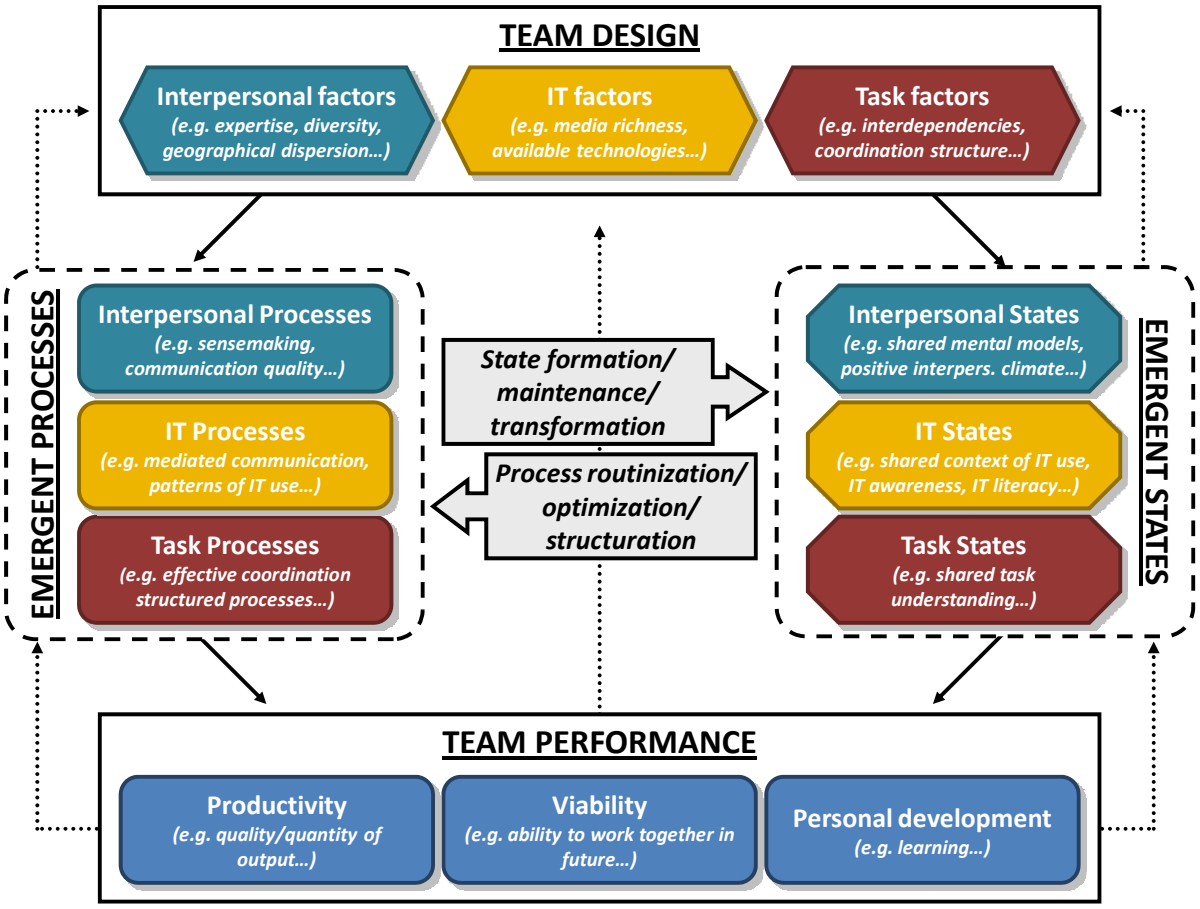


Figure 2. Generalized Model of Virtual Team Performance



APPENDIX 1

LIST OF STUDIES

	Authors	Year	Journal	Setting	Sample	Data sources	Analysis level	Causal structure	Design			Processes			States			Performance					
									Interpersonal	Task	IT	Interpersonal	Task	IT	Interpersonal	Task	IT	Generic	Output Quality	Output Quality Creativity)	Output Quantity	Development	Viability
1	Smith & Vanecek	1990	Journal of MIS	E	E	S, E, L	T	V					x	x	x				x				
2	Gallupe & McKeen	1991	Information and Management	E	S	S, E	T	V	x				x	x					x		x		
3	Cass et al.	1992	Information and Management	E	S	S	T	V	x					x					x				x
4	Zack	1993	Information Systems Research	N	E	S, I, O, L	T	P			x		x	x		x							
5	Chidambaram & Jones	1993	MIS Quarterly	E	S	S, E	T	V	x				x	x	x				x		x		
6	Turoff et al.	1993	MIS Quarterly	N	E	C	T	P		x	x		x	x									
7	Hollingshead et al.	1993	Small Group Research	E	S	S, E	T	V	x	x				x					x				x
8	O'Connor et al.	1993	Small Group Research	E	S	S, E	T	V	x	x				x	x				x				x
9	Orlikowski & Yates	1994	Admin. Science Quarterly	N	E	L, I	I	P		x	x		x	x			x						
10	Galegher & Kraut	1994	Information Systems Research	E	S	S, E, L	T	V			x	x	x	x					x		x		x
11	Straus & McGrath	1994	Journal of App. Psychology	E	S	S, E	T	V		x				x	x				x		x		x
12	Farmer & Hyatt	1994	Small Group Research	E	S	E	T	V		x	x		x	x					x				
13	Valacich et al.	1994	Small Group Research	E	S	E, L	T	V	x				x						x				
14	Ocker et al.	1995	MIS Quarterly	E	S	E	T	V	x				x	x					x	x			
15	Walther	1995	Information Systems Research	E	S	L	T	V				x		x	x								
16	Zack & McKenney	1995	Organization Science	N	E	S, I, O, L	T	P		x	x		x	x		x			x				
17	Hightower & Sayeed	1996	Information Systems Research	E	S	L, E	T	V	x				x	x								x	
18	Chidambaram	1996	MIS Quarterly	E	S	S	T	V	x					x	x				x				x
19	Aiken & Vanjani	1997	Information and Management	E	S	S, E, L	T	V	x				x	x					x				x
20	Dennis & Kinney	1998	Information Systems Research	E	S	S, E	T	V		x	x			x					x		x		x
21	Ocker et al.	1998	Journal of MIS	E	S	S, E	T	V	x		x			x					x	x			x
22	Jarvenpaa et al.	1998	Journal of MIS	N	S	S, L	T	V	x				x		x	x							
23	Graetz et al.	1998	Small Group Research	E	S	E, S	T	V			x			x		x			x		x		
24	Weisband & Atwater	1999	Journal of App. Psychology	E	S	S, L	I	V					x	x	x								
25	Burke & Chidambaram	1999	MIS Quarterly	E	S	S, E	T	V			x		x		x				x				x
26	Jarvenpaa & Leidner	1999	Organization Science	N	S	S, L	T, I	P	x			x	x	x	x								
27	Burke et al.	1999	Small Group Research	E	S	S, E	T	V	x		x		x	x	x				x				
28	Majchrzak et al.	2000	MIS Quarterly	N	E	I, O, L, S	O, T, I	P	x		x		x	x		x	x		x	x	x		
29	Maznevski & Chudoba	2000	Organization Science	N	E	I, O, L, S, D	O, T, I	P	x	x	x		x	x	x	x	x		x				
30	Montoya-Weiss et al.	2001	Academy of Manag. Journal	E	S	S, E	T	V				x	x						x				
31	Lurey & Raisinghani	2001	Information and Management	N	E	S	I	V	x	x	x	x	x	x				x					x

32	Kayworth & Leidner	2001	Journal of MIS	N	S	S, E	T, I	P				x	x	x					x					x
33	Malhotra et al.	2001	MIS Quarterly	N	E	I, O, S, L	O, T, I	P	x		x		x	x		x	x		x	x	x			
34	Cramton	2001	Organization Science	N	S	L, E	T, I	P	x	x	x		x	x	x	x			x					x
35	Colquitt et al.	2002	Journal of App. Psychology	E	S	S, E, L	T	V						x	x	x			x					
36	Rasters et al.	2002	Small Group Research	N	E	I, O, L, D	I, T	P					x	x	x									
37	Zornoza et al.	2002	Small Group Research	E	S	L	T	V		x		x		x										
38	Topi et al.	2002	Small Group Research	E	S	S, E	I, T	V	x				x	x	x						x		x	
39	Pauleen	2003	Journal of MIS	N	E	I, O	O, T, I	P	x	x	x	x	x	x	x									
40	Massey et al.	2003	Journal of MIS	E	S	L, E	T	V					x						x					
41	Ahuja et al.	2003	Management Science	N	E	E, L	I	V	x				x						x		x			
42	Piccoli et al.	2003	MIS Quarterly	E	S	S, L	T	P					x		x	x								
43	Aubert & Kelsey	2003	Small Group Research	E	S	S, E	I	V	x				x		x				x					
44	Graham	2003	Small Group Research	N	S	I, O, D	I, T	P	x	x			x	x	x	x								
45	Kirkman et al.	2004	Academy of Manag. Journal	N	E	S, E	T	V		x					x	x			x					
46	Paul et al.	2004	Journal of MIS	E	S	S	T	V	x			x	x						x					x
47	Baba et al.	2004	Journal of Org. Behavior	N	E	O, L, I, D	T	P	x	x			x		x	x		x						
48	Paul & McDaniel	2004	MIS Quarterly	N	E	I	T, I	P							x				x					
49	Jarvenpaa et al.	2004	Information Systems Research	N	S	S, E, L	I	V					x	x	x				x					x
50	Cummings	2004	Management Science	N	E	S, E	T	V	x				x					x						
51	Paul et al.	2004	Information and Management	E	S	S	T	V	x			x	x			x			x					x
52	Strijbos et al.	2004	Small Group Research	E	S	S, L	T,I	V		x			x			x		x						
53	Kerr and Murthy	2004	Group Decision and Negotiation	E	S	L, E, S	T	V					x	x					x		x		x	
54	Jarman	2005	Group Decision and Negotiation	N	E	I, L, O	T	P		x			x						x		x			
55	Majchrzak et al.	2005	Information Systems Research	N	E	S	I	V		x							x					x		
56	Chidambaram and Tung	2005	Information Systems Research	E	S	S, L, E	T, I	V	x	x			x		x				x					
57	Hinds & Mortensen	2005	Organization Science	N	E	S	T	V	x					x	x	x		x						
58	Becker-Beck et al.	2005	Small Group Research	E	S	S, E, L	I	P			x	x	x	x										
59	Polzer et al.	2006	Academy of Manag. Journal	E	S	S	T	V	x						x									
60	Gibson & Gibbs	2006	Admin. Science Quarterly	N	E	S	T	V	x					x	x					x				
61	Carte et al.	2006	Group Decision and Negotiation	N	S	E, L	T	V				x	x						x					
62	Sivunen	2006	Group Decision and Negotiation	N	E	I, O, L	O, T, I	P				x	x		x	x	x							
63	Staples & Zhao	2006	Group Decision and Negotiation	E	S	S, E	T	V	x		x			x	x				x					x
64	Querishi and Vogel	2006	Group Decision and Negotiation	N	S	O, L	T, I	P					x	x		x								
65	Belanger & Watson-M.	2006	Group Decision and Negotiation	N	E	I	I	P					x	x		x	x							
66	Heninger et al.	2006	Information Systems Research	E	S	E	I	V					x	x					x					
67	Kirkman et al.	2006	Journal of App. Psychology	N	E	S	T	V	x				x	x					x					
68	Kankanhali et al.	2006	Journal of MIS	N	S	S, I, O, L, E	T	P	x	x		x		x	x				x					
69	Fuller et al.	2006	Journal of MIS	N	S	S, E, L	T	V					x		x	x	x	x	x					
70	Stewart and Gosain	2006	MIS Quarterly	N	E	S, E	T	V		x			x		x	x					x			
71	Wilson et al.	2006	OB and Human Dec. Processes	E	S	L, S	T	V				x		x	x									
72	Metiu	2006	Organization Science	N	E	O, I, D	T	P	x				x		x	x								

73	Haas	2006	Organization Science	N	E	S	T, I	V	x				x							x				
74	Krebs et al.	2006	Small Group Research	N	S	S	I	V	x						x		x							
75	Hardin et al.	2006	Small Group Research	N	S	S, E	T	V							x	x	x	x	x					
76	Lowry et al.	2006	Small Group Research	E	S	S	T	V	x			x	x	x										
77	Geister et al.	2006	Small Group Research	E	S	S, E	T, I	V				x	x		x	x	x	x	x					x
78	Zhou and Zang	2006	Small Group Research	E	S	E, L	I	V	x			x	x											
79	Thatcher et al.	2007	Information and Management	N	S	S	I	V				x				x	x							
80	Munkvold & Zigurs	2007	Information and Management	N	S	D, L, S	T	P	x	x					x	x	x		x					
81	Zhang et al.	2007	Journal of MIS	E	S	E	T	V	x				x		x									
82	Espinosa et al.	2007	Journal of MIS	N	E	I	T, I	P	x	x			x			x								
83	Caldwell et al.	2008	Journal of Org. Behavior	N	E	S	T, I	V	x				x							x				
84	Kanawattanachai & Yoo	2007	MIS Quarterly	E	S	S, E, L	T	V					x			x				x				
85	Hambley et al.	2007	OB and Human Dec. Processes	E	S	S, E	T	V			x	x		x	x					x				
86	Espinosa et al.	2007	Organization Science	N	E	E, L	T	V	x	x											x			
87	Rutkowski et al.	2007	Small Group Research	E	S	S	T,	V			x			x	x	x	x	x						
88	Staples & Webster	2007	Small Group Research	N	E, S	I, S	I	V					x			x		x						x
89	Li et al.	2007	Small Group Research	E	S	E, S, L	I, T	V				x	x	x		x				x				
90	Rockmann et al.	2007	Small Group Research	E	S	L	I	V	x		x				x									
91	Hardin et al.	2007	Small Group Research	N	S	S	T	V	x					x	x	x	x	x						
92	Shachaf	2008	Information and Management	N	E	I	T, I	P	x		x		x	x	x					x				
93	Robert Jr. et al.	2008	Information Systems Research	E	S	E, S	T	V					x	x	x	x				x				
94	Wakefield et al.	2008	Information Systems Research	N	E	S	I	V				x	x	x	x			x						
95	Vlaar et al.	2008	MIS Quarterly	N	E	I, S	T	P	x	x			x			x								
96	Ramasubbu et al.	2008	MIS Quarterly	N	E	E, D	T	P					x							x		x		
97	Lount Jr. et al.	2008	Small Group Research	E	S	E	I	V	x							x				x				

Key

Method		*Data sources*		*Analysis Level*		*Sample*		*Causal Structure*	
Natural setting	N	Surveys	S	Individual	I	Employees	E	Process	P
Experiment	E	Interviews	I	Dyad	D	Students	S	Variance	V
		Observations	O	Team	T	Unspecified	U		
		Communication logs (content and/or frequency)	L	Organization	O				
		Objective evaluations (grades, amount of time, lines of codes)	E	Multilevel	M				
		Case analyses	C						
		Documentation	D						

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