07-029

Three Perspectives On Team Learning: Outcome Improvement, Task Mastery, And Group Process

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October 20, 2006

Edmondson, A.C., J.R. Dillon, and K.S. Roloff (forthcoming, 2007). Three perspectives on team learning: Outcome improvement, task mastery, and group process. In A. Brief and J. Walsh (Eds.), *The Academy of Management Annals, Volume 1.*

ABSTRACT

The emergence of a research literature on *team learning* has been driven by at least two factors. First, longstanding interest in what makes organizational work teams effective leads naturally to questions of how members of newly formed teams learn to work together and how existing teams improve or adapt. Second, some have argued that teams play a crucial role in *organizational learning*. These interests have produced a growing and heterogeneous literature. Empirical studies of learning by small groups or teams present a variety of terms, concepts, and methods. This heterogeneity is both generative and occasionally confusing. We identify three distinct areas of research that provide insight into how teams learn to stimulate cross-area discussion and future research. We find that scholars have made progress in understanding how teams in general learn, and propose that future work should develop more precise and context-specific theories to help guide research and practice in disparate task and industry domains.

INTRODUCTION

Organizations increasingly rely on teams to carry out critical strategic and operational tasks. By implication, an organization's ability to learn—that is, to improve its outcomes through better knowledge and insight (Fiol & Lyles, 1985)—is dependent on the ability of its teams to learn (Senge, 1990; Edmondson, 2002). Teams, defined as work groups that exist within the context of a larger organization and share responsibility for a team product or service (Hackman, 1987), are a design choice for accomplishing work. In many of today's organizations, teams develop strategy, design and produce new products, deliver services, and execute other key tasks that influence organizational performance. When teams change what they do or how they do it—in support of organizational goals—an organization maintains or enhances its effectiveness in a changing world. How do teams learn, and what factors are most important to team learning? This article reports on current perspectives and findings that address these questions.

Team learning research builds upon and complements decades of research on *organizational learning* in the management literature. Both topics originate from an assumption that collectives – not just individuals – can be said to learn. Many have argued that organizations must learn to succeed in a constantly changing world (Garvin, 2000; Senge, 1990), yet, the topic of organizational learning has received more theoretical than empirical attention (Weick & Westley, 1993). This imbalance can be explained by at least two causal factors. First, conceptual disagreement about what it means for an organization to learn limits systematic progress (Edmondson & Moingeon, 1998; Fiol & Lyles, 1985). Second, the methodological challenges associated with measuring learning in multiple organizations at the same time are considerable. Although finding multiple teams to study is also challenging, the practical obstacles are surmountable. As a result, a growing number of empirical studies on team learning are helping to ameliorate the shortage of data relative to theory on collective learning in organizations.

Research explicitly focused on team learning emerged as a topic in the management literature in the 1990s, and expanded in volume and variety in the early 2000s and beyond.

Perhaps the best known early use of the term “team learning” is found in Peter Senge's (1990) book, *The fifth discipline: The art and practice of the learning organization*, a managerial look at insights drawn primarily from the field of system dynamics. Although the theories and tools of *systems thinking* (the "fifth discipline") constitute the book's core contribution, team learning is presented as one of the other four disciplines enabling an organization to learn. Researchers in organizational behavior later elaborated Senge's notion that teams are the fundamental unit of learning in organizations (e.g., Edmondson, 2002), as described below.

In this paper, we review selected empirical studies on team learning from three research traditions: learning curves in operational settings (outcome improvement), psychological experiments on team member coordination of task knowledge (task mastery), and field research on learning processes in teams (group process). Our review includes articles published in leading management research journals, along with a few current unpublished studies that came to our attention. Given the large number of issues related, or potentially related, to team learning, including those covered in extensive literatures on team effectiveness, learning and education, organizational change, and other relevant topics, we chose to limit our focus to peer-reviewed articles in the management research literatures that explicitly used the terms *team learning* or *group learning*, and to emphasize empirical studies – those that analyzed quantitative or qualitative data collected in the field, classroom, or laboratory. Even with these criteria to narrow our search, space constraints preclude an exhaustive review of all articles that might qualify. Some will have been overlooked due to ignorance, others due to an imperfect attempt to draw a boundary that allows us to describe the studies we do include in enough detail to be useful. Thus, we have traded completeness for depth; when appropriate and possible, we have attempted to describe methods and findings in ways that allow readers to view a study's conclusions critically. Overall, our aim was to characterize the nature of research that has been conducted and to begin to assemble what is known and unknown about the theoretically and practically important topic of team learning.

RESEARCH ON TEAM LEARNING

In this section, we review studies in manufacturing, social psychology, and organizational behavior that provide intellectual and empirical underpinnings for theories of team learning in the management literature. We organize our review into three reasonably distinct bodies of work, each offering unique results and implications for the future of team learning research. One area owes its methods and intellectual roots to research on new processes in manufacturing and service operations. A second originates in the social psychology laboratory and pursues questions related to how members of small groups coordinate their knowledge and actions to accomplish interdependent tasks. The third area, situated in micro-level organizational behavior research, emphasizes interpersonal climate and group processes, and relies heavily on methods developed in organizational research on team effectiveness. Although not devoid of cross-fertilization, the three areas have remained surprisingly separate during the time in which research on team learning has developed as a distinct topic of inquiry. They offer distinct lenses on the varied phenomena of team learning; each addresses a different fundamental question, and each offers different conceptualizations of team learning. These distinctions are summarized in Table 1.

[Insert Table 1 about here]

These areas of prior work vary in size and importance for theory on team learning. In particular, learning curve studies that explicitly involve teams are few in number, yet this work is sufficiently distinct in approach from other team learning research to warrant separate attention. Moreover, we learn from different approaches by including a range of methods and contexts, despite differences in relative impact. Below, in a roughly chronological sequence, we review the three areas, starting with learning curve research, followed by psychological studies of task mastery, and then by research on learning processes in work teams in real organizations.

Outcome Improvement: Learning Curve Research at the Group-Level

Recent studies of learning curves in teams introduced a subfield into a longstanding body of research on improvement rates in manufacturing facilities. Since Wright's (1936) observation that unit costs decrease with experience (or cumulative volume), the "learning curve" has been the subject of much research in the fields of operations management, economics, competitive strategy, and technology management. Overall, this work documents a robust link between cumulative production experience and some measure of operational performance improvement (e.g., cost reduction, yield improvement, productivity improvement). Research in health care delivery similarly finds that performance on a new technology or procedure improves with increased experience (e.g., Ramsay et al., 2000). In health care, a service context, the dependent variable is often procedure time, an important measure of process efficiency in services. In both manufacturing and service contexts, the core theme in this work is the benefit of experience for efficiency, whether measured as cost or time.

Background

The existence of learning curves implies that organizations improve with experience, or that "practice makes perfect." Yet, some studies show homogeneous learning curves (similar slopes for the same amount of experience) across sites (e.g., Wright, 1936; Baloff, 1971) and others show heterogeneity (different rates) across sites (e.g., Dutton & Thomas, 1984; Hayes & Clark, 1985). The observation of slope differences suggested that unmeasured factors – such as how the learning process is managed – affect the rate of learning (Pisano, Bohmer, & Edmondson, 2001), such that cumulative experience is a necessary but insufficient explanatory variable. For example, Argote, Beckman and Epple (1990) analyzed historical data on shipbuilding during World War II, and found significant differences across shipyards in rates of productivity improvement. Lacking detailed process or other organizational data, the authors speculated that factors such as turnover might help explain the learning curve differences.

More generally, many studies have analyzed longitudinal data from one or more sites producing similar products, but very few have included first-hand knowledge of sites that might help explain differences. Proposed explanations related to turnover or better management thus were inferred from at a distance. A noteworthy exception can be found in Adler's (1990) study of several plants in a high tech manufacturer. By collecting qualitative data on managerial and communication processes to supplement quantitative analysis of production data, Adler was able to attribute differences in learning curves to (1) how sites handled the development-manufacturing interface, (2) transfer processes between a primary location and sites that started up later, and (3) ongoing cooperation among sites. These ideas suggested the possibility of differences in teamwork explaining improvement rates and called attention to the cooperative nature of production work, opening up a line of inquiry explicitly focused on learning curves at the group level. Building on this insight, Argote, Insko, Yovetich and Romero (1995) designed a laboratory experiment that showed that both turnover and task complexity reduced the benefits of team experience on task improvement.

Learning curves in teams

Learning curves in small-group production processes thus constitute a late entry into a longstanding research tradition, which thus far presents only a few articles. Selected studies are shown below in Table 2. One of the earliest group learning curve studies took place in a retail setting. With data from 36 pizza stores, Darr, Argote and Epple (1995) found that unit costs improved significantly with cumulative experience, but at different rates across stores. They proposed that knowledge acquired through experience-based learning would transfer across stores owned by the same franchisee but not across stores owned by different franchisees. Communication across same-franchisee stores was presumed to be the mechanism explaining this difference, but was not measured.

Subsequent research in the manufacturing setting collected field data from 62 quality improvement projects at a Belgian steel wire manufacturer, using a detailed coding system to assess project activities. From these data, factor analysis identified two dimensions of learning. Substantive results showed that improvement – in this case waste reduction – occurred in projects characterized by both operational and conceptual learning activities (Lapre, Mukherjee, & Van

Wassenhove, 2000).

In another service setting, Pisano, Bohmer and Edmondson (2001) showed that 16 surgical teams learned to use a radical new cardiac surgery technology at significantly different rates (where the outcome was procedure time reduction, a measure of surgical team efficiency). The authors speculated that how teams were managed affected the rate of learning and provided two case studies to illustrate this possibility.

Edmondson, Winslow, Bohmer and Pisano (2003) examined two distinct learning curves simultaneously – procedure time reduction and breadth of use– with data on coronary artery bypass graft (CABG) surgery from 15 teams in as many hospitals. Comparing improvement for these two dimensions, the authors found that when the dimension of improvement required acquisition of *tacit knowledge* (as was the case for procedure time reduction) teams at different sites learned at significantly different rates. In contrast, for breadth of use, a dimension of improvement supported by *codified knowledge*, the learning curves were homogenous across sites. Tacit knowledge is difficult to transfer across sites, generally requiring individuals to accompany the knowledge, such as to demonstrate how to coordinate team member actions in smoother ways; whereas codified knowledge, in this case, a type of surgery, could be readily transferred without face-to-face interaction. Moreover, for improvement that relied on tacit knowledge, team composition stability was associated with faster learning. Team members that stayed together, improved more quickly. Teams with members that were quickly substituted in or out took longer.

In a similar context, Reagans, Argote, and Brooks (2005) studied joint-replacement surgery in teaching hospitals and found that increased experience working together in a team promoted better coordination and teamwork. Increased organizational experience also was found to help individuals access each other's knowledge. In short, *learning by doing*, the authors argued, has several pathways – including one supported by team stability and sustained coordination at the team level, and one created by increased familiarity with how one’s organization works, through organizational membership stability. Selected studies are shown in Table 2.

[Insert Table 2 about here]

Summary

Research in this area has clear methodological and conceptual similarities. The notion of a learning curve is relevant at or near the beginning of a new initiative (product or process), and learning curves document improvement with experience. Over time, learning curves flatten as new learning subsides. Studies rely on longitudinal quantitative outcome data from manufacturing or service organizations and regression analyses to model learning curves. The dependent variable is a measure of efficiency such as cost, productivity, or time. With access to data from multiple groups taking on the same learning goal, recent research has been explicit about the role of teamwork – especially communication and coordination – in fostering improvement. A common theme in this work is testing for and explaining differences in rates of improvement across teams.

Studies of learning curves in teams have built on – and added to – an established research paradigm, by introducing new field-based research methods to supplement the traditional analytic approach in the learning curve literature. Through site visits, interviews, and the collection of data on organizational variables such as worker turnover, team learning curve research has begun to identify factors that explain differences in improvement. Core findings, summarized in Figure 1, suggest that team stability, knowledge sharing, common ownership, co-location, codified knowledge, and organizational experience promote efficiency improvement. In sum, the way learning is managed affects the rate of improvement.

[Insert Figure 1 about here]

A notable strength of research in this area is its high quality data and emphasis on outcomes with clear practical importance. These studies thus offer refreshingly objective outcome variables and the advantage of data from multiple groups learning the same thing at roughly the same time, allowing comparability across teams despite the complexity of the contexts in which they work. At the same time, the work focuses narrowly on efficiency improvement in repetitive operations as the measure of learning, and offers little insight into today's most prevalent team challenges related to innovation and various kinds of knowledge work that do not involve repetition of similar tasks.

Task Mastery: Coordinating Team Member Knowledge in Interdependent Tasks

A second area of research emphasizes task mastery by teams and studies how team members learn to accomplish interdependent tasks. This area views team learning as an *outcome* of communication and coordination that builds shared knowledge by team members about their team, task, resources and context. More specifically, team learning is conceptualized as task mastery, and how well a team has learned its task is a typical measure of success.

Research in this area examines how teams leverage their members' knowledge and skills to increase the quality and amount of knowledge available for task execution. A central focus in this work is encoding, storing, retrieving, and communicating information in teams (Wilson, Goodman, & Cronin, forthcoming). Simply put, this work has found that teams with members who know what each other knows (collectively and individually) are better able to perform interdependent tasks. Although learning was not explicitly defined in most of the task mastery papers we reviewed, researchers implicitly treated learning as an outcome best measured in terms of task performance, paying particular attention to mastering new tasks. A related area of research – on effects of shared cognitive schemas' on group decision-making (e.g., Walsh, Henderson, & Deighton, 1988; Gruenfeld, Mannix, Williams, & Neale, 1996) – is outside the scope of our review, but develops similar arguments and empirical results.

In general, this research focuses on the relationship between team cognitive systems and team task performance, and relies primarily on laboratory experiments for data. Researchers have assembled teams of university students, assigned them a task such as assembling a transistor radio or completing a flight simulation, and tested their ability to complete the task under different experimental conditions. Most of the teams studied in this way consisted of strangers convened to complete an isolated task before disbanding. These laboratory studies have allowed causal inferences about particular features of team learning but left open questions about how the results generalize to real-world settings.

Our review focuses on more recent research in this area, starting in 1995; (for a review of earlier research, see Klimoski & Mohammed, 1994 and Walsh, 1995). Researchers in this area have emphasized team-level cognitive constructs, using terms such as *shared mental models* (Cannon-Bowers, Salas, Converse, & Castellan, 1993), *transactive memory systems* (Wegner, 1987), and *social cognition* (Larson & Christensen, 1993), among others. Conceptually, these constructs are similar; all are team-level cognitive systems that encode, store, retrieve, and communicate knowledge and all are used to predict task performance (e.g., Hollingshead, 2001; Wegner, 1987).

Effects of Knowing Who Knows What in a Team

Early work on transactive memory systems focused on the relationships between group training, transactive memory systems, and task performance. Liang, Moreland, and Argote (1995) studied laboratory-based experimental teams assembling transistor radios, and measured the transactive memory system (TMS) by coding videotapes of the teams assembling radios to assess: memory differentiation, task coordination, and task credibility[1]. Including factors (task motivation, group cohesion, and social identity[2]) previously related to group performance in their model, the authors found that teams that trained together developed a stronger TMS and a stronger social identity, performed better on the task (fewest assembly errors), and recalled more assembly

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[1] *Memory differentiation* was "the tendency for group members to specialize in remembering distinct aspects" of the task, *task coordination* was "the ability of group members to work together smoothly" and *task credibility* was "how much the group members trusted one another's knowledge" about the task, all of which characterized a strong TMS (Liang et al., p. 388-389).

[2] T*ask motivation* was "how eager the group members were to win the award" for task completion, *group cohesion* was "the level of interpersonal attraction among group members, and *social identity* "the tendency for subjects to think about themselves as team members rather than individuals" (p. 389).

information than teams of individuals trained separately. Furthermore, the researchers maintained that group training did not directly predict task performance, but rather its effects were mediated by the development of a TMS.

Moreland, Argote and Krishnan (1998) conducted two follow-up studies, replicating the findings and ruling out alternative explanations. In the first, they used the same research design but added two new training conditions: an individual-training condition followed by a team-building exercise, and a reassignment condition in which teams trained together were shuffled into new teams prior to task execution. The results indicated that groups trained together performed better that the other three training conditions, and this relationship was again mediated by the existence of a TMS. Interestingly, groups in the team-building condition matched the group development and social identity scores of the group-trained condition, but still underperformed them. Groups in the reassignment condition performed no better than the individual training condition, illustrating turnover's detrimental impact on task performance.

In the second experiment, the researchers examined the content of team TMSs (complexity, accuracy, and agreement) and investigated whether social loafing would occur when teams were trained together (Moreland, Argote, & Krishnan, 1998). Teams of undergraduates were trained together or individually, but instead of completing the task in teams, as anticipated, each subject was asked to complete the task alone. In advance, subjects completed a questionnaire on beliefs about their team members' task-related knowledge and skills. Although teams trained together demonstrated greater complexity, accuracy, and agreement in *beliefs* about each other's expertise, there were no significant *performance* differences between individuals trained together or apart. Thus, if social loafing had occurred when teams trained together, it did not lead to subsequent individual performance differences.

Stasser, Stewart, and Wittenbaum (1995) also sought to understand how shared cognitive representations of members' task knowledge impacted team performance. A laboratory study showed that explicit recognition of members' task-relevant expertise improved a team's task performance more than simply mentioning differences in member expertise on the team. The authors concluded that having frank knowledge of each individual's expertise -- knowing who knows what -- leverages a team's ability to develop informal schemas of accountability such that "experts" in a given domain are called upon to use their expertise and to store new related knowledge. Although teams in this study were not trained together, they developed shared understanding of members' expertise through explicit discussion, and achieved similar results. A later study suggested that when team members know each other, uniquely-held tacit knowledge is more likely to make it into the conversation than when they are unacquainted (Gruenfeld, Mannix, Williams, & Neale, 1996).

Not surprisingly, communication has been studied as the critical mechanism explaining transactive memory and other cognitive systems development. In particular, research showed that communication was a predictor of task performance (word recall) among intimate partners (Hollingshead, 1998b, , 1998a). Moreland and Myaskovsky (2000) also studied communication, collaborative training, and TMSs, and found that teams assembling transistor radios that trained together performed no better than teams that did not train together but were given specific information on individual team member's expertise. They concluded that, although training together is an antecedent of TMS development, the underlying mechanism is not communication per se, but rather the opportunity to get to know each team member's specific knowledge and skills.

To better understand the relationship between communication and knowledge-encoding in teams, Rulke and Rau (2000) compared teams that trained together and apart, and showed that the former developed better TMSs than the latter. Further, teams with the most functional TMSs – and best task performance – engaged in specific conversations about individual expertise early in the team's life and continued to have conversations about expertise over time. The authors proposed TMS formation follows a pattern of initial expertise declaration, followed by expertise evaluation by the team, and finally expertise coordination for task execution.

Types and Content of Shared Memory Systems

Some researchers proposed the existence of multiple simultaneous TMSs in teams, such as those focused on tasks, routines, or resources (Klimoski & Mohammed, 1994; Cannon-Bowers, Salas, Converse, & Castellan, 1993). In a study of teams engaged in a flight simulation task, Mathieu, Heffner, Goodwin, Salas, and Cannon-Bowers (2000) found statistical support for two conceptually distinct types of shared mental models, one related to *task* work and one related to *team* work. They also examined the effect of *sharedness* of metal models – degree of overlap in members' perceptions of team mental models – on task performance. The relationship between the degree of sharedness (for both task-work and team-work) and the outcome of task performance was mediated by team processes, including strategy formation and coordination, cooperation, and communication.

Rentsch and Klimoski (2001) likewise proposed that *schema agreement*, or sharedness, is critical for task performance. Taking their hypothesis to a field setting, they tested relationships between antecedents (such as composition), teamwork schema agreement, and team effectiveness. Antecedents, including educational similarity, teaming experience, team member recruitment, and team size (negative), were related to team member schema agreement, which in turn mediated the relationship between the antecedent variables and team effectiveness. In the same journal issue, Smith-Jentsch, Campbell, Milanovich, and Reynolds (2001) reported that rank and experience among navy personnel significantly predicted the overlap of shared mental models; the higher the rank or the greater the experience, the greater the degree of similarity between team member mental models. However, the authors argued that these antecedents were not deterministic; with training, team members who had lower ranking or less experience were able to develop shared mental models similar to those of the "experts."

In addition to mental model *agreement*, Moreland et al. (1998) determined that teams with TMSs had a greater degree of complexity and *accuracy* in their beliefs about each other's expertise. In a field study of teams in a consumer products organization, Austin (2003) found that transactive memory accuracy (the extent to which group members accurately identify each other's knowledge) was a better predictor of task performance (financial goal achievement) than other dimensions of a team TMS, including team knowledge, mental model convergence, and member specialization. Austin also proposed a new type of TMS related to knowledge about each team member's external relationships, and suggested that successful task performance leverages not only unique team-member knowledge but also the knowledge uniquely available to them from outside the team's boundaries. A theory paper by Brandon and Hollingshead (2004) introduced *validation* as a third dimension of a team TMS, and defined it as the extent to which team members participate in the TMS. The paper argued that TMS *convergence*, defined as high levels of sharedness/agreement, accuracy *and* validation, was optimal for teams.

One study noted the difficulties of importing extra-team knowledge. Studying undergraduate work groups in a semester-long class project, Gruenfeld, Martorana, and Fan (2000) investigated how teams leverage knowledge introduced from other teams. They found that when a team member left his or her original team to visit another ("foreign") team, the visitor's ideas were used in the foreign team, while unique ideas proposed by the foreign team's "indigenous" members decreased. In addition, indigenous team members failed to utilize their own returning member's ideas, yet they did generate more unique ideas than they did in their original formation. The authors concluded that that the process of knowledge-transfer between teams is complex because various team-level social influences influence how knowledge is integrated into a team's memory systems.

How Shared Memory Systems Develop

Rather than assume the team mental model development process was linear, researchers began to examine how members' knowledge of each other's skills and abilities evolved over time in response to changing task demands (Brandon & Hollingshead, 2004; Liang, Moreland, & Argote, 1995). Levesque, Wilson, and Wholey (2001), in a study of undergraduate students engaged in a software development project, found that one dimension of a team's shared mental models (mental model convergence) decreased over time, while another dimension (role differentiation) increased over time. They posited that role differentiation led to an increase in specialization, prompting more independent work drawing from individual expertise, leading to less interaction, and hence less convergence in shared knowledge. They did not tie these changes over time to differences in task performance, but suggested that interaction is critical for maintaining shared mental models in a team.

Lewis (2004) also studied how a team's TMS evolves over time, building on Levesque et al.'s (2001) observation that interpersonal communication patterns developed *early* in a team's collaboration affected how a team's TMS matures. Lewis found that interpersonal processes such as face-to-face communication during the planning phase were particularly important for TMS maturation. A team's ability to fine-tune an existing TMS depended on the extent of face-to-face communication. Implementation-phase TMSs were positively related to both task performance and team viability, suggesting the need to maintain a TMS over the entire course of a task.

Lewis, Lange, and Gillis (2005) studied undergraduate teams engaged in three similar tasks over time. Teams were initially trained together and then asked to assemble an electronic device – a telephone. For some teams, the experimenters imposed a reshuffling in which half of the members on a team were swapped with those of another team before beginning the task, a move that effectively dismantled the TMSs. As predicted, intact teams performed better on the task than disrupted teams. Before performing the second task – assembling a stereo – some teams were again randomly reshuffled to dissolve their TMSs. Thus, for the second task, there were three groups: those with (1) intact, (2) previously intact but now dismantled, and (3) never intact TMSs. Contrary to prediction, the results showed no statistically significant performance differences between groups on the second task. Further analyses revealed an interesting interaction effect between expertise stability and task performance; teams that developed TMSs before the first task (and whose members maintained the same domain of expertise for both tasks) performed the best. Finally, the third task called for teams to describe in writing how they would assemble an electronic stapler. Intact teams with stable TMSs showed evidence of having developed more abstract, generalized knowledge about the task and the underlying principles associated with electronic assembly, compared to those with a disrupted TMS. Developing abstract knowledge was seen as evidence of a higher order learning process, through which teams were processing and accommodating new information in their repertoire of behaviors.

Studies on team memory systems have included few organizational variables, although some noted the likelihood that context would influence the shape of team memory systems over time (Druskat & Pescosolido, 2002). Ren, Carley and Argote (2006) studied the effects of organizational context in a computer simulation study of hypothetical team situations. The authors examined the effects of team TMSs on two performance outcomes: time and quality. The effects of a TMS on both outcomes depended on the organizational context (dynamic vs. stable)[3] and on team size. With a TMS in place, teams in dynamic contexts or large in size achieved improved time outcomes, while those in stable contexts or small in size reaped better quality outcomes. Although all teams performed better with a TMS, the study suggested that effectiveness is contingent upon team context and size.

<u>Barriers to Task Learning in Teams</u>

The extent to which a TMS is useful in a team depends largely upon how accurately it reflects reality. In addition to team size and turnover, other barriers to TMS development identified include *collaborative inhibition* (an observed tendency for teams to perform worse than individuals on recall tasks; (Basden, Basden, Bryner, & Thomas, 1997; Hollingshead, 1998b) and *mutual enhancement* (a tendency to discuss shared knowledge rather than knowledge held by only one member (Stasser, Stewart, & Wittenbaum, 1995; Wittenbaum, Hubbell, & Zuckerman,

[3] Task environment was defined as volatile if a team frequently switched tasks; knowledge environment was defined as volatile if team members quickly forgot unutilized knowledge. The organizational context was rated “stable” if a team was low on both dimensions and “dynamic” if it was high on both dimensions.

1999)).

Some researchers find team mental model building is implicitly political; members selectively negotiate content based on perceived relevance as opposed to simply adding team member knowledge together (Walsh, Henderson, & Deighton, 1988). Taken-for-granted socialized perceptions play a vital role in shaping a team's TMS. In one study, Hollingshead and Fraidin (2003) found that team members assessing their own expertise relative to others (in the absence of explicit information) relied on stereotypes about salient identity characteristics such as gender. Furthermore, when such stereotypes were activated, individuals tended to assign expertise according to stereotypes and also to act in ways that fulfilled stereotypes about themselves. For example, in male-female dyads, males or females might act as knowledge “experts” in stereotypically male or female domains. The authors suggested that, without additional knowledge about individuals or an explicit effort to act against them, TMSs play a role in perpetuating harmful stereotypes. These studies thus demonstrated cognitive and social forces that inhibit TMS development. Candid information sharing in teams can be seen to be difficult and yet critical for the emergence of a TMS. Table 3 highlights a selected subset of task mastery studies.

[Insert Table 3 about here]

Summary

This area of research recognizes that teams need a way to organize and retain a shared understanding of who knows what, and who can do what, to interact effectively to do their work. The construct of transactive memory systems captures a means for coordinating action in teams, minimizing the need for discussion. The shared knowledge embedded in TMSs allows task mastery by: (1) ensuring that unique individual knowledge is used, (2) allowing specialization, (3) reducing redundant information, and (4) developing informal structures for accountability. For teams that do not require diverse member expertise or knowledge to do their work, a TMS may not be necessary, Finally, researchers suggest that TMSs require continuing communication to be maintained, an area that merits further investigation.

This work presents a few general conclusions about generic team memory systems and task performance on novel tasks, as depicted in Figure 2. First, certain *team characteristics*, notably team size and expertise diversity, promote or inhibit TMS development, agreement, and accuracy. Second, features of the *organizational context* may affect TMS development. Third, *barriers* inhibit TMS development, such as team size and turnover. Fourth, *transactive processes* (Lewis, Lange, & Gillis, 2005) foster TMS development, in the form of interpersonal interaction and communication eliciting knowledge about members' expertise (Liang, Moreland, & Argote, 1995; Moreland & Myaskovsky, 2000; Rulke & Rau, 2000; Stasser, Stewart, & Wittenbaum, 1995), and transactive processes mediate the relationship between context, team characteristics, and outcomes (Liang, Moreland, & Argote, 1995). Fifth, different types of team-level *memory systems* operate in teams at any given time, capturing member knowledge, task knowledge, teamwork knowledge, and knowledge about members' external relationships. Finally, team processes mediate the relationship between TMS and *task performance* (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000).

[Insert Figure 2 about here]

Reliance on laboratory methods in this research has limited knowledge of how context affects team learning. Thoughtful discussions of TMS research methods have suggested that more field research is needed to investigate many of these lab-based conclusions (Mohammed, Klimoski, & Rentsch, 2000). In summary, this work informs us that coordinated ways of storing knowledge at the group level help teams master new tasks and that developing shared team mental models is an essential aspect of this learning process.

Group Process: Understanding Learning Behavior in Real Teams

A third area of research conceptualizes team learning as a group process – rather than as a group or team outcome. Building on models, constructs and methods from research on organizational learning and on team effectiveness, studies in this area typically investigate real work groups in field settings. Team effectiveness research typically employed an input-process-output (I-P-O) model in which group interaction processes mediate the relationship between group inputs (e.g., context, structure, composition) and group outputs (e.g., quality, innovation, performance) (e.g., Hackman, 1987; McGrath, 1984, and see Ilgen, Hollenbeck, Johnson, & Jundt, 2005, for a review). Organizational behavior researchers interested in team learning thus naturally turned to group process for evidence of learning.

A growing number of field-based studies examine learning processes in teams, and how they are affected by managerial and contextual factors (such as team climate, goals, and identity) and, in turn, affect team performance. In its nascent stages, identifying the process of learning in real teams involved qualitative, exploratory methods (Edmondson & McManus, forthcoming). In later work, constructs have become more formalized, and validated survey measures are growing in number. These field studies describe learning behaviors in ways that were not possible in quantitative learning-curve studies, and also develop insight about organizational context not available in the psychology laboratory. In general, in this work, researchers attempt to observe or measure the processes of learning rather then relying on performance improvement as evidence that learning has occurred.

Team Climate and Learning Behavior

Early field research on learning in teams focused on effects of leader behavior and group climate. Using a case study design with four cross-functional process-improvement teams in a large high-tech manufacturing firm, Brooks (1994) classified group processes into two types of learning behaviors: those that took place within team meetings (e.g., posing problems, sharing and discussing new ideas or information) and those that took place outside team boundaries (e.g., gathering and sharing information outside the team). In these teams, members' perceptions of the interpersonal risk created by within-team power differences appeared strongly related to learning behavior. Further, those teams lacking in learning behavior found it difficult to span team boundaries, and members "described the climate at the team meetings as 'stifling,' 'intimidating,' and ‘damaging,’” with leaders “publicly ridiculing them” for voluntary contributions to meetings (pp. 223). In contrast, in other teams, leaders encouraged member participation and deemphasized power differences.

In another field study, Edmondson (1996) uncovered differences across eight hospital work groups in a specific learning behavior—speaking up about mistakes. Unexpectedly, survey data suggested that teams with better team leaders, higher quality team interpersonal process, and greater team effectiveness had higher – rather than lower – detected error rates. Interview and observational data, collected by an independent researcher blind to the surprising quantitative results, reinforced Edmondson’s *ex post* explanation that better teams were more likely to report (rather than hide) errors, which she reasoned was essential for team learning. Just as Brooks (1994) had found, some team leaders (nurse managers, in this setting) had fostered a climate of openness that fostered willingness to engage in learning behavior.

To test this accidental finding more systematically, Edmondson (1999) studied climate and learning behavior in 53 teams of four types in a manufacturing firm, collecting both qualitative (interview and observation) and quantitative (survey) data. The study introduced the construct of *team psychological safety* to predict team learning behavior. Psychological safety (the shared belief that a group is safe for interpersonal risk-taking) was found to mediate the effects of team-leader coaching and context support on team learning behavior. Learning behavior, in turn, mediated the effects of psychological safety on performance. Edmondson concluded that team learning behavior helped translate effective team design and leadership into team performance.

Subsequent studies took a closer look at the effect of team leaders on learning behaviors. Edmondson (2003) described ways that team leader actions promote and inhibit psychological safety and hence learning behaviors in surgical teams. Effective team leaders (surgeons) fostered “speaking up in the service of learning” (p. 1419) by motivating the need for learning and deemphasizing power differences. Edmondson argued (but did not test) that learning processes should be expected to vary by team type; notably, learning in *interdisciplinary action teams*, in which real-time improvisation and coordination is critical to performance, was not likely to be explained by the same variables as in routine production teams.

Also focusing on team leaders, Sarin and McDermott (2003) surveyed 52 product development teams in six high-tech companies and identified team leader behaviors that facilitated team learning: involving members in decision making, clarifying team goals, and providing bridges to outside parties via the leader's status in the organization.[4] Context also mattered; team learning was more extensive when the project was important to the organization. Team size was negatively related to learning, possibly because of the additional challenge of coordinating and communicating among more people. Finally, learning was related to team performance (speed to market and innovation). Although Sarin and McDermott presented learning as a first-order outcome[5] (rather than a process), we include the study in this section because it demonstrated additional ways that team leadership promoted learning, and in turn enhanced performance, a second-order outcome.

Unbundling Team Learning Behavior

As process studies of team learning became more numerous, researchers took a more detailed look at specific learning behaviors. Building on the observation of process differences across teams (Brooks, 1994; Edmondson, 1996), later work categorized learning behaviors to refine understanding of their effects on learning and performance outcomes. For example, in their qualitative study of surgical teams, Edmondson, Bohmer & Pisano (2001) identified four steps of the learning process (enrollment, preparation, trials, and reflection) in which each surgical case

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[4] Other leader and team characteristics did not predict learning: leader consideration, leader initiation of process structure, product complexity, and team functional diversity.

[5] Survey items measured members' anticipated behavioral change on future product development teams or on work in other areas of the organization.

was a "trial" from which to learn (through collective discussion, or reflection). Gibson and Vermeulen (2003) similarly conceptualized team learning as “a cycle of experimentation, reflective communication, and knowledge codification” (p. 222) in which all three processes must be present, and thus measured team learning as the product of these three factors. An exploratory study (Sole & Edmondson, 2002) of seven globally dispersed ("virtual") product development teams in a multinational corporation discovered that team learning in this setting involved figuring out how to recognize and access *situated knowledge* embedded in different facilities and locales.

Related studies examined whether different types of team learning behaviors have differential effects on team performance. A qualitative study of 12 manufacturing company teams of varying types (management, product development, service, production) identified the different implications for organizational performance of teams engaged in *incremental learning* (improvement) versus *radical learning* (innovation) (Edmondson, 2002). The article proposed that when teams responsible for innovation (e.g., developing new strategies or products) fail to learn, the organization may miss critical market opportunities that threaten future competitiveness; when teams engaged in production fail to learn, cost and other inefficiencies could threaten the organization's near-term profitability and competitiveness. Both types of teams, however, appeared to benefit from a similar process of iterating between action and reflection.

Wong (2004) surveyed 73 teams from multiple organizations and industries, measuring both *local learning* (learning from interactions within a group) and *distal learning* (learning by seeking ideas, help, or feedback from external parties). Group cohesion (strength of intrateam relationships and support) promoted both local and distal learning behaviors (as Brooks’s (1994) exploratory analysis had suggested), which in turn showed differential effects on performance: Local learning predicted efficiency of team operations and mediated the effects of group cohesion on efficiency (consistent with Edmondson, 1999); in contrast, distal learning predicted team innovativeness, had a negative moderation effect on team efficiency, and actually suppressed local learning on a team. Based on these results, Wong recommended that teams responsible for task mastery should focus on local learning (and even avoid excess external contact), while those charged with innovating should focus on distal learning.

Building on team boundary-spanning research (Ancona & Caldwell, 1992), recent qualitative work identified a need for *vicarious team learning* with data from pharmaceutical "in-licensing" teams (Bresman, 2006). Survey data from 43 teams in six firms were then analyzed to show that several team learning behaviors (*experiential team learning behavior*, *vicarious team learning behavior*, and *contextual learning behavior*) were empirically distinct, and all contributed to externally rated team performance. Exploring related issues in a very different context, and arriving at different conclusions, Tucker, Nembhard and Edmondson (2006) used surveys and interviews to study 23 process improvement teams in hospital intensive care units, and found that *learn-what* (activities that identify current best practices, requiring boundary spanning to draw from the experiences of other teams, hospitals, or the research literature) and *learn-how* (activities that operationalize practices in the work setting) were distinct team learning factors. Learn-how was associated with process improvement, but learn-what (the boundary spanning behavior) was not. One possibility was that all teams studied were engaging in high levels of learn-what, restricting the explanatory power of the variable. Another possibility was that the learning in intensive care units requires more learn how – the internally focused learning behavior – because of the importance of attention to specific work processes and relationships in producing change.

A closely related stream of research studies *team reflexivity*, "the extent to which teams reflect upon and modify their functioning" (Schippers, Den Hartog, & Koopman, in press; West, 1996, 2000). Team reflexivity has much in common with the team learning concepts discussed above. Research on reflexivity has emphasized its positive effects on team performance (Schippers, Den Hartog, Koopman, & Wienk, 2003), consistent with other findings that show team learning behaviors to be related to team performance or effectiveness (e.g., Edmondson, 1999). A study by Schippers (forthcoming) tested an intervention, in which teams of educators managing schools in Holland, trained by the author to engage in more reflexivity, subsequently showed better performance. The study stands as a preliminary but important attempt to produce the team behaviors proposed as valuable by the theory.

Shared Learning Goals

Several researchers have studied how common goals or purposes on a team affect learning behavior. Ely and Thomas (2001) conducted extensive observations and interviews of one team at each of three firms, in law, non-profit consulting, and financial services. The authors analyzed their qualitative data to identify shared perspectives about interracial relations. Successful integration of diverse experiences in a team seemed to them to require an *integration and learning perspective* about team diversity—viewing diversity as a "resource for learning and adaptive change" (p. 240). Teams with an integration and learning perspective appeared more willing to spend time talking about and working through differences of opinion and conflicts. The other two perspectives (attitudes and goals related to diversity) identified were: diversity can be leveraged to gain *access and legitimacy* in a market by matching employee-customer demographics, and facing diversity requires overcoming *discrimination* to create *fairness*. The integration and learning perspective appeared to help team performance; teams without this perspective tended to avoid discussing different viewpoints, stifled minority perspectives.

Two recent survey studies investigated shared goals related to learning. Bunderson and Sutcliffe (2003) measured *team learning orientation* (an emphasis on proactive learning and skill development in a team) in 44 business-unit management teams in a large consumer products company. The results found learning orientation to be a significant predictor of team performance (business unit profitability) but with a curvilinear relationship – such that a mid-range level of learning orientation was optimal for performance. Further, the optimal level was higher for teams with lower prior-period performance. The authors concluded that learning orientation was useful to correct performance deficits but hurt performance if taken too far.

Surveying members of 107 teams from a variety of Chinese companies and industries, Tjosvold, Yu, and Hui (2004) found that teams with *cooperative goals* were more likely to engage in learning behavior[6] (than teams with *competitive* or *independent goals*) and more likely to report learning from their mistakes (measured as an outcome). Learning behavior only partially mediated this relationship.

<u>Team Identification</u>

Team identity provides another antecedent of learning behavior in teams. Studies have investigated members' identification with their team as a moderator of the effects of context and group composition on learning; measures of interest included both overall team identification and "faultlines" between demographically overlapping subgroups of a team. First, Gibson and Vermeulen (2003) studied 156 teams in five pharmaceutical and medical products firms and analyzed survey and interview data to argue that *subgroup strength* (the degree to which some pairs of team members share demographic characteristics not shared with others) was an important moderator of contextual factors such as the performance management efforts of an external leader, team empowerment (autonomy), and the availability of an organizational knowledge-management system. Finding a non-monotonic relationship between subgroup strength and learning behavior, such that a moderate level of subgroup strength was optimal for learning, the authors suggested that performance management efforts of external leaders partially compensated for either weak or strong subgroups, but that "teams with moderate subgroups display a high level of learning behavior to start with and increase this behavior much less as a result of performance management actions" (p. 228). They also reported that subgroup strength was a better predictor of performance than simple group heterogeneity (average pairwise demographic overlap between team members). In sum, the degree of member identification with the team rather than with a particular subgroup influenced a team's ability to put its diversity to good use.

Studying a concept similar to subgroups, Lau and Murnighan (2005) measured the effect

[6] The authors called this variable a *problem solving orientation*, but the items used in the measure clearly related to what team learning researchers have called learning behaviors.

of demographic *faultlines* (dividing lines between demographic subgroups) on team learning behavior in 79 groups of undergraduates working in assigned teams to complete a course project. Analysis of survey data suggested that team learning benefited from cross-ethnicity and cross-sex communications, but this effect was negatively moderated by faultline strength. Stronger faultlines offset, but did not entirely reverse, the positive effects of diverse communication for learning.

In a related study of 57 multidisciplinary teams in the oil and gas industry, Van der Vegt and Bunderson (2005) measured the strength of emotional identification with the team as a whole, rather than identification with subgroups. They found that *collective team identification* moderated the effects of expertise diversity on learning behavior and performance. Teams with stronger collective team identification were more successful at tapping the expertise diversity in the room, while those with low collective identification allowed diversity to inhibit learning behavior and team performance. The authors suggest that this phenomenon occurred because collective team identification stimulated otherwise difficult learning behaviors across expertise lines. These three studies illustrate how subgroup and faultline strength, or low identification with the team as a whole, make it harder to capture the benefits of diversity for learning.

Effects of Context

Recent studies introduce the context in which a team operates as a fundamental influence on team learning. To begin with, a team's context can present (or preclude) the opportunity to engage in learning behaviors. Examining the adoption of new routines in teams, one survey study of 90 teams from three pharmaceutical and medical-products firms measured *knowledge transfer effort* to acquire new routines, as well as the *knowledge acquisition* outcome itself (Zellmer-Bruhn, 2003). The results showed that both process *interruptions* and *external contact* (exposure to other teams) predicted team engagement in knowledge-transfer learning behaviors, but only interruptions predicted actual knowledge acquisition. Knowledge transfer efforts partially mediated the relationship between interruptions and knowledge acquisition, and exploratory analyses suggested that different types of interruptions affected both engagement in learning behavior and successful adoption in different ways. Interruptions in the flow of work provided opportunities to exercise reflection – creating an opening for learning to occur.

Zellmer-Bruhn and Gibson (2006) studied 115 teams in five multinational firms, collecting survey data supplemented with interview and archival data, and found that a learning outcome —“the extent to which the team created new processes and practices” (p.22)—was more likely to occur in less-centralized organizations where teams are granted decision-making autonomy by the local and global organizations. In contrast, teams with less product and process discretion or those in organizations with a strategy of global integration were more likely to conform to prescribed practices and thus showed less learning behavior. Although not counterintuitive, these results are important in highlighting the necessity of considering context when measuring team learning behavior and outcomes. Table 4 summarizes selected studies.

[Insert Table 4 about here]

Summary

Field research on team learning has focused on group process, initially emphasizing interpersonal constructs and later expanding the lens to examine effects of multiple antecedents, including aspects of the organizational context in which teams work. Early team learning studies established learning behavior as a mediating process between structure and performance; subsequent work examined the nature and types of learning behaviors more in more detail. Recent work has recognized that team type and context matter, but with limited systematic attention to measuring either, and future studies are likely to push the frontiers of such contingent theorizing still further. Thus, theory in this field-based work is becoming both more contextually detailed and more contingent over time, as discussed further in the next section.

Figure 3 summarizes our discussion of research in this area by illustrating the principal relationships found in this research, with a couple of relational alterations among variables. Although individual studies tended to assess main effects of team climate and context on learning behavior (e.g., Brooks, 1994; Edmondson, 1996, 1999, 2003; Zellmer-Bruhn & Gibson, 2006), consideration of a fuller set of studies suggests different possibilities. Thus, our summary model suggests that the influence of context on learning behavior is mediated by variables such as team leader behavior, team goals, task characteristics and team composition, and that intra-team climate is a moderator (Edmondson, 2003) – not a mediator (cf. Edmondson, 1999; Wong, 2004) – of the other antecedents of learning behavior. This proposal is consistent with results that show main effects on learning behavior, because the mediated and moderated effects shown here could not be tested in studies that did not measure all the variables. Figure 3 uses dashed lines show the untested relationships we propose, rather than solid (main effect) lines that depict previously tested relationships.

Team task (e.g., task routineness) is included in Figure 3, even though empirical support for task effects on team learning is limited. Although task attributes occasionally have been included in studies (e.g., Edmondson (1999) included four types of team tasks and Wong (2004) measured task routineness), more commonly, task type is implicit in the choice of research setting or subjects. Not surprisingly, in these different studies, different variables explained learning (e.g., leader behavior, vicarious learning behavior, and team identification, respectively), suggesting that future research should pay more explicit attention to developing and testing theory about how task attributes affect team learning. Finally, studies rarely measure comprehensive sets of variables, such as those depicted in Figure 3, and so relative effect sizes of antecedents remain an area for future research.

[Insert Figure 3 about here]

Figure 3 synthesizes major contributions of research reviewed in this area. Most notably, team learning in this research is a verb. Researchers observe or otherwise measure learning as group behaviors and activities, rather than inferring that learning has taken place from observed outcomes. This emphasis on process derives both from roots in team effectiveness research, as well as from a reliance on field-based methods to understand how teams learn. This growing body of work also directly examined the relationship between learning behavior and performance in teams, a noteworthy endeavor for two reasons. First, the learning-performance relationship is not always positive (Bunderson & Sutcliffe, 2003; Wong, 2004); second, different types of learning are seen as relevant for different types of performance outcomes (Edmondson, 2002; Wong, 2004). In contrast, the first two areas of research position performance-type outcome measures (efficiency improvement, task mastery) as primary measures of learning.

This area also offers diverse and detailed portraits of team learning processes that can only be obtained through field research. Qualitative data has provided the texture and detail necessary for illuminating process and clarifying mechanisms in a variety of settings, while quantitative results have strengthened confidence in a small but growing number of measures and relationships. Moreover, a growing number of studies use multilevel concepts and analytic techniques to reflect the reality of individuals nested in teams and teams in organizations (e.g., Edmondson, 1999; Zellmer-Bruhn & Gibson, 2006).

Limitations

Important limitations of this work must be noted. Despite some consistent measures and themes, overall the constructs and measures of team learning and its antecedents are remarkably inconsistent across studies. For example, none of the studies of team identity, team goals, or organizational context use the same terminology or measures, although they addressed similar issues. While many studies characterized intra-team climate – usually referring to climate attributes related to perceptions of interpersonal openness or caring about the team, attributes potentially captured by the term psychological safety (e.g., Edmondson, 1999; Kahn, 1990; Schein & Bennis, 1965)– climate terms and measures still show only partial convergence. In measures of team learning behavior—the central variable in this work—we observed a trend of growing convergence as studies moved toward greater use of survey methods, but even here consistency (when the latent variable is in fact the same) would facilitate theory development (e.g., the items in problem solving orientation Tjosvold, Yu, & Hui, 2004) related clearly to group process or learning behavior and less to goals). Consequently, it is difficult to compare results and to build knowledge. Future research would benefit from convergence on terms and measures when possible, or clarity about how and why a construct is different from competing terms. We return to this theme in our discussion section.

In conclusion, despite many insights and a growing number of studies, further conceptual development and additional empirical work are needed to better specify relationships among constructs. Few prior studies include enough variables to sort out moderating relationships, requiring some extrapolation in Figure 3 to include reasonable possibilities.

DISCUSSION

In this section, we reflect on what we have learned from our review of research on team learning. We identify a small number of well-supported relationships, as well as some that are slightly more speculative. We also identify problems and limitations in this literature, and propose specific areas for improvement. In general, we call for clarity and consistency of constructs and variables, but advocate continued inclusiveness in what is considered relevant to team learning. We start by a brief review of findings, followed by an overview of research trends, and then discuss differences and similarities in the three areas of research as a foundation for discussing what the term team learning means.

Key Findings

Across the studies reviewed, several variables stand out as sufficiently supported in prior work to remain essential for inclusion in future research – at least within a given range of settings. These include team stability, team leader behavior, and psychological safety or other aspects of interpersonal climate. Other factors, including task attributes, need further theoretical development and empirical research; that is, we have preliminary evidence that they matter, but not enough data to know exactly how and under what conditions.

First, we consider factors that almost certainly matter. At least some studies in all three areas included *team stability* as a variable. Although stability did not affect learning in all studies, in most it did, particularly in the learning curve and task mastery areas. Moreover, the extent to which members have worked together is clearly an important issue for understanding how well they share their knowledge, skills, and actions to achieve collective aims.

For teams that have leaders, *leader behavior* has been shown consistently in field research to be an important factor in shaping the climate of the team and in motivating learning. Power dynamics present an important theoretical relationship with learning behavior, due to the interpersonal risks involved in asking questions or discussing mistakes, some of the activities emphasized in the group process area. Social psychologists have long recognized that people look to leaders for cues on appropriate behavior in a social setting (e.g., Tyler & Lind, 1992). The team leader is also a focal point for coordination of effort (e.g., Edmondson, 2003) a role that deserves greater attention in the future. *Psychological safety*, or interpersonal climate more generally, is not only importantly related to leader behavior, but also merits consideration in its own right as a focal construct in the group process area.

With less empirical support to back our arguments, we suggest that team learning is shaped in important ways by the nature of the task. The task attributes that matter most remain under-theorized, however. Possibilities include the nature of the team's goals (short term, achievable goals may not be conducive to extensive learning behavior, for example), as well as the *level of discretion* over task-based action encountered by a team (e.g., an assembly line task vs. pure brainstorming); *task interdependence, knowledge intensiveness*, or the degree of interpersonal risk in the work (e.g., are mistakes a salient feature of the task.) The theoretical centrality of team task for learning argues that more research should investigate specific kinds of teams facing specific challenges with real world importance. Bresman's (2006) study of pharmaceutical in-licensing teams is one such example.

The context in which a team works, such as that created by the industry or by the resources available to the team from inside and outside the organization, can have an important influence on team learning processes and outcomes, as shown by very recent research (Zellmer-

Bruhn & Gibson, 2006). Going forward, context must be investigated more systematically. In healthcare, for example, the intrinsic importance of goals such as patient safety contrasts with goals such as cost reduction, and could have an effect on the types of learning observed and on the role of various antecedents. Pressure (or opportunity) for innovation, change, and learning from the broader context could be an important antecedent of team goals, processes and outcomes.

Finally, as we look for more contextually specific models, collaborations between organizational researchers and people with domain expertise present cross-fertilization opportunities. Both the learning curve and group process areas have been the beneficiaries of such successful collaborations with health care researchers. More such partnerships are needed for contextually specific research in areas like public organizations (with scholars of government), schools (with educational scholars), and top management teams (with executives).

Trends

Team-learning research exhibits two dominant trends over the past decade. First, as with many maturing literatures, the work has shifted from more exploratory and simple models that identify issues, constructs, and possibilities to more quantitative, mature, and precise models (Edmondson & McManus, forthcoming). Thus, over time, models of team learning are more likely to include mediators that test mechanisms translating antecedents into outcomes, and moderating variables that help specify precise conditions under which particular antecedents produce a desired outcome. Models that include moderators recognize that treating all teams and all contexts the same way is unlikely to reflect the realities of team learning accurately.

Moderators tested thus far include task type (Van der Vegt & Bunderson, 2005) and industry context (Zellmer-Bruhn & Gibson, 2006); moderators suggested but not formally tested include team type (Edmondson, 2003, , 1999) and knowledge tacitness (Edmondson, Winslow, Bohmer, & Pisano, 2003). That is, some work recognizes that the fundamental challenge of learning in teams is different for different tasks. For some tasks (particularly in real work settings), multiple learning challenges are relevant, and antecedents and performance implications may be different for each.

Within this trend, the term *team* is becoming insufficiently specific as the task, context, and learning process necessarily differ -- possibly in theoretically important ways -- for different types of teams. For example, when task constraints or organizational strategy do not allow local autonomy, teams are less free to engage in learning behavior (Zellmer-Bruhn & Gibson, 2006). Similarly, due to the nature of their task, innovation teams will engage in more learning behaviors than routine production teams. Thus, by proposing models of team learning that are universal, we lose conceptual and predictive accuracy. In contrast, models that pertain to specific kinds of teams, identified along theoretical dimensions (e.g., knowledge versus action, expertise diversity), or specific kinds of contexts, are needed to advance team-learning research. We return to this theme below, in discussing specific possibilities for new research.

Commonalities and Differences Across Areas

Although the research areas we reviewed are substantively different along several dimensions, as highlighted above in Table 1, noteworthy commonalities connect pairs of areas. First, the learning curve and group process areas share a methodological foundation in field research, both collecting field data and examining learning challenges in real work settings in organizations. The task mastery area, in contrast, draws almost exclusively from the laboratory.

Second, the learning curve and task mastery areas both conceptualize learning as improved task performance. This agreement may be driven by the type of task studied—typically a (constrained) production task for which successful completion is well defined and execution is the team's primary focus. In contrast, the group-process area explores a wide array of team tasks – often unconstrained or creative, with multiple successful outcomes possible -- and focuses on adaptive behaviors that enable team success in the face of uncertainty or change.

Third, despite differences in methodology and research setting, the task-mastery and group-process areas share a disciplinary foundation in the psychology of group dynamics, and both investigate how team member knowledge and interpersonal relationships affect group outcomes. In contrast, learning curve studies examine efficiency improvement with little attention to group member perceptions or behaviors.

The rubric of team learning – as an abstract concept – may be the only commonality tying all three areas together, as reflected in low levels of cross-area citations. As a result, researchers with a common interest in how organizational teams learn lack a coherent body of accumulated knowledge about different kinds of teams facing different kinds of challenges. A lack of shared terminology is partly to blame; however, differences across areas go deeper than word choice.

What is Team Learning?

From one study to another – even within research areas – how team learning is conceptualized varies considerably, including task mastery, process improvement, expanded understanding, discussing mistakes and failures, experimenting, and innovation -- to name a few. This variety reflects the range of phenomena and activities being studied – from product assembly to strategy formation. Although this breadth reflects the natural range of collaborative work in organizations, it limits the precision of the term team learning. Perhaps surprisingly, we will not try to correct this imprecision in this paper, arguing instead that team learning should remain an encompassing rubric.

We propose that team learning is a useful abstraction that cannot be thought of as a single specific organizational phenomenon. On its own, the term team learning does not refer to product development, new product assembly, or more efficient cardiac surgery. The processes, antecedents and outcomes of learning in these different team contexts can vary dramatically, requiring more precise descriptions and theories to inform practice in meaningful ways. This is consistent with our earlier point that theoretical models require greater specificity and precision about team type and organizational context – to be both more accurate and more useful.

In the paragraphs that follow, we point to methodological and disciplinary causes and implications of the proliferation of concepts, methods, and activities in this growing body of work. We then call for consistency of constructs and measures, without seeking to constrain the meaning of team learning.

Sources of Conceptual Variety

First, methodological choices influence how team learning is conceptualized. Methods limit data sources and study settings, which in turn determine the types of phenomena observed. Researchers using one method may be studying a legitimately different phenomenon from those associated with another method. Surveys, interviews, observations, lab experiments, and archival data each measure certain aspects of group behavior or outcomes and ignore others, regardless of what might be present in a phenomenon or research setting. For example, a large archival data set from a production facility can reveal changes over time in operational efficiency but not in coordination of operators' skills or group discussion of errors, and so a study relying on such data is likely to measure (and thus conceptualize) learning as efficiency improvement. In this way, the varied methods discussed here support different contributions to theory about learning in teams.

Related to methods, disciplinary training is also clearly an important source of conceptual variety. For example, those trained to examine service and manufacturing processes systematically will tend to look to measures that matter to operations managers, such as time or cost. Experimental social psychologists care deeply about establishing causality, and must examine factors that can be operationalized and assessed in a short-term task. Organizational behavior researchers seek to learn from and theorize naturally occurring sources of variance in social settings, which are often subjective and imprecise. In each group, we read our own literatures and cite those who have preceded us in similar endeavors.

Away from Unity

Several authors have proposed unitary definitions of team learning (Gibson & Vermeulen, 2003; Wilson, Goodman, & Cronin, forthcoming), advocating convergence on a single (but differing) concept. Our review uncovers diversity that does not lend itself to a uniform definition of team learning. We find that team learning is not a unitary concept at this point in the development of several related literatures, and we are reluctant to argue that it should be otherwise.

First, a pragmatic reason. A single concept is unlikely to cover all that constitutes team learning because the work carried out by real teams in organizations varies so broadly. Even the term team is imprecise, and definitions are shifting to encompass new realities (e.g., Ancona, Bresman, & Kaeufer, 2002), and whether the word learning refers to process or outcome has long remained ambiguous. Second, we argue that diversity is generative. The inclusion of different phenomena under an encompassing rubric can stimulate cross-fertilization among research areas that otherwise would not learn from each other. Third, our view of the inclusiveness of team learning is tied to the prior work on *organizational* learning, which has traditionally encompassed a range of real-world phenomena, from innovation to process improvement to planned system change (Edmondson & Moingeon, 1998). Attempting to promote a single concept of organizational learning would be unlikely to succeed after fifty years of well known research from different schools of thought (Argyris & Schön, 1978; Levitt & March, 1988; Huber, 1991) In our view, the term team learning is sufficiently abstract that limiting it to one operational definition is impractical if not counterproductive. Instead, we argue that team learning, like organizational learning, is a useful rubric, an umbrella term encompassing a variety of loosely related theories and studies

<u>Toward Consistency.</u>

Despite our reluctance to mandate a single definition of team learning, we strongly advocate greater consistency in constructs and measures used in empirical research. As the team learning literature matures, theory development will be enabled by consistent terms and measures for highly similar concepts, helping researchers to clearly differentiate new findings from prior work, and enabling researcher communication and progress.

The relative simplicity of the three figures in our review belies the confusing proliferation of terms in this research. Prior work is replete with examples of close conceptual cousins called by different names and measured by sets of remarkably similar survey items. This problem is particularly prevalent in the group process research area, as was noted above, but also appears in the task-mastery area, where similar phenomena are variously referred to as team mental models, transactive memory systems, or shared cognition.

All three areas also display confusion about the concept of learning itself. In learning curve research, for example, reductions in product cost or production time may happen because the team learned, which is not to say that these outcomes are themselves learning. Task mastery studies rarely make a "before" and "after" comparison, instead comparing "treatment" and "control" groups to demonstrate that certain "treatments" cause improvements in coordination of skills and knowledge. In the group process area, an example of this confusion is the use of similar measures by Zellmer-Bruhn & Gibson (2006), Wong (2004), and Gibson & Vermeulen (2003) to measure *learning, innovation*, and *experimentation*, respectively.

Measures of learning also vary across studies, making it difficult to systematically accumulate evidence (see also Wilson, Goodman, & Cronin, forthcoming). Even in streams of work that agree in conceptualizing learning as a process, researchers include different types or measures of that process, and draw conclusions about learning as if it were a unitary construct. It is possible that different aspects and hence measures of learning might help explain disparate findings[7]. For example, if multiple learning processes operate in a team, and a study measures only one, results are unlikely to be replicated in different settings. Similarly, cases in which learning only partially mediates between antecedents and performance (e.g., Van der Vegt & Bunderson, 2005; Zellmer-Bruhn, 2003) may occur because only one aspect of learning behavior was measured. We are unlikely to agree on a single measure or definition of team learning, and so it

[7] For example, two studies find opposite effects of low-to-moderate subgroup strength on learning behavior (Gibson & Vermeulen, 2003; Lau & Murnighan, 2005). Likewise, some find a learning orientation to be consistently good for performance (Ely & Thomas, 2001) while others find it good only in small doses (Bunderson & Sutcliffe, 2003)

may be more fruitful to begin to define sub-categories and measures that are shared and used, going forward.

In short, given the inclusive nature of team learning, clearly specifying the phenomenon being studied may help knowledge develop systematically. Notably, studies should clearly identify whether they are examining a learning behavior or a learning outcome, and label variables accordingly (e.g., knowledge transfer *behavior*, knowledge acquisition *outcome*). Many articles in the past have sought to contribute to "team learning" in general, while using a narrow measure. It might be more accurate for an article to claim to contribute to knowledge of vicarious learning in interdisciplinary health care teams, for example, rather than knowledge of team learning.

Convergence of terms and measures for *antecedents* of team learning would be particularly helpful to advance theory. The task mastery literature has tested a variety of team characteristics as predictors of TMSs, but has not tried to consolidate them into a useful framework.[8] The variety of names for learning orientation and team identification in the group-process area was discussed above. Likewise, in the task mastery area, there is little agreement on the overall terms to describe team mental models (Cannon-Bowers, Salas, Converse & Castellan, 1993; Larson & Christensen, 1993; Liang, Moreland, & Argote, 1995) and definitive terms within the area such as "sharedness" versus "agreement" (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Rentsch & Klimoski, 2001).

In contrast, explicit attempts to assess an alternative conceptualization of a prior variable are useful. For example, Tjosvold and colleagues (2004) expected (but did not find) that *blaming orientation* would curb learning behavior in teams and thus could be used as an alternative to *psychological safety* (Edmondson, 1999). Such efforts could help clarify the boundaries of existing constructs, or replace them if better constructs and explanations are developed. However,

[8] As noted above, Hackman's (1987) model provides an exemplar of how to cluster sets of related variables (effort, knowledge and skills, action strategies) into an actionable and theoretically useful framework.

this refining process is limited by the variety of data sources and contexts studied; it is just as likely that Tjosvold et al.'s (2004) Asian teams differed in important ways from Edmondson's (1999) Midwestern teams as that psychological safety is a "better" predictor. With more precision about context, discussed below, and more consistency of terms, as advocated here, future researchers can sharpen the set of variables that best explain precise phenomena of interest.

Finally, we welcome the heterogeneity studied under the team-learning rubric, but suggest that some conceptual boundaries are essential. More specifically, everything related to change is not learning. Creativity, for example, is not a conceptual match to learning. Communication is not one and the same as learning. A common theme shared by the three research areas discussed above is that learning implies some kind of positive change (created or intended by certain activities), whether in understanding, knowledge, ability/skill, processes/routines, or systemic coordination. We thus propose that conceptualizations of team learning be limited to both processes and outcomes that include this element of positive change produced by investments in developing shared insight, knowledge, or skill.

Moving Forward

Team learning research has tackled some of the most fundamental challenges teams face – including how teams improve performance in repetitive operations, how members learn to work together on novel tasks and how they manage the face threats implied by admitting ignorance or uncertainty. Reflecting on the articles reviewed above, we can identify useful insights about coordination and interpersonal processes for academic discussions of teams, teamwork, and learning in organizations. Little of this literature thus far has sought to solve specific practical problems (such as improving product development, enriching strategic decision making, or reducing medical errors) in which teams play a role. Although most of the research can be said to have *implications* for practice, managerial imperatives are rarely a driver of the questions and data selected in this work. This attribute is not unique, or even unusual, in management studies. Nonetheless, it appears to us particularly noteworthy in this instance given the potential relevance of teams and teamwork for organizational effectiveness. Thus, the question of what team learning researchers can say to managers remains an important motivating concern. We suggest relevance should be a crucial driver of future research.

<u>New Directions For Team Learning Research</u>

We identify three opportunities for research that would advance knowledge of team learning in crucial ways. First, we call for field research designed to explore the range and nature of team learning challenges in today's organizations. Comparative case studies of diverse situations in which teams faced a need for learning could help shape subsequent theory development and empirical research to reflect the realities of current team-based work. Lacking systematic knowledge of team learning challenges in different industry contexts, it is difficult to identify the key variables that might serve as boundary conditions for theoretical relationships such as those depicted in Figures 1, 2, and 3. To illustrate, the challenges faced by cross-disciplinary, inter-organizational teams in health care delivery (e.g., Nembhard, 2006) are likely to differ from those faced by geographically dispersed process development teams in polymer production (e.g., Sole & Edmondson, 2002), and universal models of team learning do not capture these. Clearly, we do not seek unique models for every industry or task, but rather we hope to specify critical variables differentiating contexts and how these variables would alter existing theoretical models. In sum, we propose that field-based research to understand context-specific factors and relationships is an important next step.

Second, we call for quantitative research on samples that include more than one type of team and/or more than one type of context (varying on theoretically relevant dimensions). As noted above, despite awareness that team type is important, prior research has rarely tested its effects systematically. However, logic, together with preliminary research (e.g., Wong, 2004), suggests that focused hypotheses related to task type and to certain features of the work context, could be developed. We should be able to predict effects of certain team and task variables, such as those discussed above, and to test them in studies that deliberately include variance in these dimensions of interest. Research on such samples would contribute to the development of mid-level models that are neither too narrow to be relevant to theory nor too general to be useful to practice.

Third, recognizing that team boundaries in many organizations are both temporary and permeable (Ancona, Bresman, & Kaeufer, 2002; Edmondson & Nembhard, forthcoming), we call for research on *systems* of teams or teamwork in organizations. As this possibility lies beyond current conceptions of team learning, we discuss it further below in a section on broader implications.

The above opportunities necessarily involve multiple methods. As our ideas and models become more mature, laboratory studies can establish causality and test proposed boundary conditions – to the extent that reasonable facsimiles of the conditions can be created and manipulated. Laboratory research can produce general statements about social phenomena but offers a limited approximation of real world conditions; field observations uncover complexity and relevance but lack precision. These complementary strengths and weaknesses have given rise to the idea of full-cycle research, in which researchers include both lab and field research over time (Chatman & Flynn, 2005), and multi-method hybrid studies (Edmondson & McManus, forthcoming) that integrate qualitative and quantitative data in a single project. Both of these approaches would be of value in future team learning research.

Choosing a Path Forward

Research on team learning is at a crossroads. One path forward involves more of the same – a growing number of empirical studies often introducing novel, even if conflicting, terms and approaches, published in varied journals with little cross-fertilization. Another path requires researchers to use similar terms for similar constructs, while becoming more accurate (accepting the need to make narrower claims) about a reasonably diverse and highly relevant set of real world challenges. The latter path would likely attract more practitioner attention, while risking seeming less scholarly to some.

BROADER IMPLICATIONS

Team learning research has developed constructs and models that shed light on essential everyday collaborative activities in organizations. By and large, this research has investigated organizational antecedents of team learning. Here, we briefly consider team learning's consequences. We first discuss what learning in and by teams does for the organizations in which they work; in so doing, we go up a level of analysis to put these various team-learning models into a broader perspective. We then examine team learning's consequences for individuals, as well as for other teams in an organization.

We began this review with the premise that team learning has value for organizations. Much has been said about the capacity of a learning organization to create and execute superior strategy (e.g., Senge, 1990). Learning in teams is seen as a key mechanism through which learning organizations become strategically and operationally adaptive and responsive. This implies that organizations can set the stage for strategic responsiveness by putting in place factors that enable team learning. In other words, strategic and operational responsiveness is enabled top-down so it can emerge bottom-up.

How the learning of individual work teams translates into organizational learning is not well understood, however. It is clear that teams carry out both innovation and improvement in organizations, producing both new products (Sarin & McDermott, 2003) and processes (Tucker, Nembhard, & Edmondson, 2006). But how are team learning processes and outcomes coordinated between teams to ensure that the *organization's* goals are met? How do teams configure and reconfigure over time to accomplish organizational work (and learning)? We know little about how *coherent patterns of team learning* can be created in an organization, so that individual teams can learn independently in support of common organizational aims. On the one hand, left to their own devices, teams may learn in ways that do not support organizational goals. On the other hand, if senior management provides individualized learning goals to each team, the learning processes are likely to be overly scripted and constrained, so as to hardly qualify as learning.

The literature offers few insights into this problem. As noted above, suggestive qualitative research identified two learning types, incremental and radical, and argued that particular organizational teams were positioned to engage in one more than the other (Edmondson, 2002). Radical learning is likely to involve much higher levels of uncertainty and more experiments that fail, compared to incremental learning, while ultimately being the source of much that is innovative in organizations. Incremental learning, in contrast, should involve activities that were knowable in advance and lead either to gradual improvement of work processes or mastery of *known* tasks (those previously executed by others). The former is akin to exploration; the latter to both exploitation (March, 1991) and execution of tasks that may be new to the team but not new to the world.

Knowledge about how teams that explore new knowledge differ from those that exploit existing knowledge, as well as about what factors are essential to success in each, is also limited. Studies tend to include one type or the other, but not both. Thus, we lack data on which factors matter most for which types of teams. Research that examines the context in which team learning takes place (e.g., Zellmer-Bruhn & Gibson, 2006) is a step toward the development of such contingent and accurate models in the future. Another important area for future research is how organizations integrate radical and incremental learning effectively; despite theory recognizing the need for such balance, manifested in ambidextrous organizations (Duncan, 1976; Tushman & O'Reilly, 1996), the micro processes through which this is accomplished remain under explored. Additional micro and meso-level field research on these issues is needed, which could contribute to better integration of organizational and team learning theory.

We propose attention to intra-organizational networks of teams that learn, in which an essential part of that learning involves boundary spanning to coordinate interdependent activities. Following Edmondson and Roberto (2003), we refer to this as a *team-based learning infrastructure* and suggest that it explains how organizations can and do learn, especially when pursing important aims for which no prior blueprint exists. An example of such an aim is patient safety in hospitals; patient safety is clearly important, but no one knows exactly how to achieve it in today's complex health care organizations (Edmondson, 2004). Boundary spanning occurs naturally in cross-functional teams, whose members are motivated to communicate with both team members and functional colleagues (Sarin & McDermott, 2003); the same is true in dispersed teams (Sole & Edmondson, 2002). When teams combine knowledge or adopt processes across boundaries, members become familiar with knowledge, routines, and cultures in other areas of the organizations, possibly strengthening their ability to cross such boundaries in the future. How this happens in a broader variety of organizational work teams remains under-studied. Future research could investigate the durability and utility of team-based networks for the organization as a whole.

Finally, we consider two other outcomes of team learning. First, learning in teams almost necessarily plays a role in developing the knowledge and skills of individuals who compose the team (Edmondson & Nembhard, forthcoming). Team learning thus can benefit the organization, a level up, and the members, a level down. More research is needed on how individuals benefit from their team learning experiences in terms of intellectual, career, and personal development goals. Second, we suggest attention to the effects of team learning on future teams that are composed of some, but not all, of the same members. Many work teams have permeable boundaries and transient membership, disbanding and reforming frequently (Ancona, Bresman, & Kaeufer, 2002) How does one team's learning affect the team fragments that emerge in later teams? Organizations stand to benefit when ideas are cross-fertilized and diverse individuals learn to work together. For example, research reviewed in this paper identified benefits of diverse experiences on a team (Lau & Murnighan, 2005; Van der Vegt & Bunderson, 2005; Ely & Thomas, 2001), and the value of ideas an outsider can bring to a team (Sole & Edmondson, 2002). Other research, however, showed that some types of learning acquired as a team may not be portable to other group or individual contexts.[9] Such conflicting evidence merits additional research into the circumstances under which team learning's benefits are portable and whey they are not – research that would have practical implications for the design and management of teams, especially temporary project teams. A kind of “cross-functional learning” could take place in teams, so that teams composed of people with experience working in teams with similar functional composition will organize, learn, and execute their tasks more quickly and easily than those lacking such experience. These and other issues remain ripe for additional field research.

We conclude with the reminder that learning by its nature involves facing uncertainty, acknowledging ignorance, and being willing to generate variance, entertain false starts and reach dead ends along the way. Embracing this mindset requires moving beyond traditional management tools and mindsets, which seek to organize and simplify the complex reality of organizational life by creating smaller, more certain and more predictable tasks. In this way, learning and execution are often at odds. Team learning in organizations must be recognized not a mechanism for implementing planned change but a strategy for tolerating forays into the unknown.

[9] Similarly, recent careers research (e.g., Groysberg, Nanda, & Nohria, 2004) found that the performance of “star employees” suffered when they moved to new organizations (and hence new teams).

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TABLE 1. Comparison of Three Research Streams

Concepts	**Outcome Improvement**	**Task Mastery**	**Group Process**
Motivating Concern	At what rate do groups improve their efficiency?	How do team members coordinate knowledge and skill to accomplish tasks?	What drives learning-oriented behaviors and processes in organizational work groups?
Concept of Team Learning	Learning is performance improvement – usually efficiency improvement	Learning is task mastery	Learning is a process of sharing information and reflecting on experience
Dominant Independent Variables	Codified knowledge Collocation or shared ownership Team stability Knowledge sharing	Group members trained together or separately, transactive memory system, communication	Team leader behavior, psychological safety, team identification, team composition, Organizational context
Dominant Dependent Variable	Rate of cost or time reduction	Performance on a novel task	Team effectiveness or Learning behavior
Findings	Amount of experience working together improves team performance outcomes. In later work, how people work together and dimension of improvement affect rate of learning.	Having coordinated ways of codifying, storing and retrieving individual knowledge is necessary to access individual knowledge for coordinated task performance.	Team leadership and shared beliefs about team psychological safety, goals, or identity promote or inhibit team learning behaviors and, in turn, team performance.
Methods	Field research: Collection of quantitative data from teams producing a product or a service	Lab experiments: Small teams of students as subjects; Random assignment to conditions to establish causality	Largely field research: Qualitative and quantitative data that provide observations of real organizational work teams

TABLE 2. Selected Studies from Learning Curve Research at the Teams Level of Analysis

Authors	Data	Context	Aspect of Team Learning	Key Findings
Adler (1990)	Cost data from 3 multi-national plants of an electronic product manufacturer.	Manufacturing plants/ Manufacturing-R&D interface.	Cost decreases with volume following launch of new product lines.	Intensive knowledge sharing between R&D and plant engineers before start up and after start up led to more rapid cost decreases.
Darr, Argote, & Epple (1995)	Cost data from 36 similar service organizations.	Pizza stores, some owned by same franchisee, some not.	Unit cost decreases with experience (volume).	All stores improve with experience. Stores with same owner share ideas, which do not transfer across stores with different owners.
Pisano, Bohmer, & Edmondson (2001)	Procedure time data from dozens of surgical operations.	16 cardiac surgery teams implementing radical new surgical procedure in leading health care centers.	Surgical procedure time decreased with experience (number of procedures conducted).	Different teams learned at different rates. How teams were managed appeared to differ.
Edmondson, Winslow, Bohmer & Pisano (2003)	Procedure time data and number of grafts completed in each operation.	15 cardiac surgery teams implementing radical new procedure for coronary artery bypass graft surgery in leading health care centers.	Procedure time decreased while number of grafts (complexity or challenge of procedure) increased with experience.	Different teams learned at different rates when the procedure involved *tacit* knowledge and same rate when it involved *codified* knowledge. Team stability improved rates.
Reagans, Argote, & Brooks (2005)	Procedure time and number of procedures completed (individual and team).	Joint replacement surgery in teaching hospitals.	Procedure time decreased while number of procedures increased with experience.	Increased experience both working on the team and within the organization improved outcomes.

TABLE 3. Selected Studies from Task Mastery Research

Authors	Data	Context	Aspect of Team Learning	Key Findings
Liang, Moreland, & Argote (1995)	Data on assembly quality, observations, and surveys of 30 teams.	Lab: three-person undergraduate teams assembling AM/FM radios.	Development of a transactive memory system (TMS).	Training together resulted in better assembly quality predicted the development of a TMS.
Moreland & Myaskovsky (2000)	Data on assembly quality, observations, and surveys of 63 teams.	Lab: three-person undergraduate teams assembling transistor radios.	Teams trained together or given explicit information about each other's expertise had better assembly quality.	Training together promoted TMS development, largely due to the opportunity to determine team member specialization.
Mathieu et al., (2000)	Flight mission success (points), observations and surveys of 56 teams.	Lab: two-person teams engaged in flight-simulation task.	Degree of similarity of team mental models, team processes such as coordination.	Team processes mediated the relationship between mental models and performance.
Lewis (2004)	Surveys of 64 teams and client organizations.	Lab: four to six-person teams of MBA students engaged in a semester-long consulting project.	Development and maturation of a TMS over time.	Transactive processes such as communication early in a team's existence supported the TMS maturation in later phases.
Lewis, Lange, & Gillis (2005)	Data on assembly quality, coded qualitative data, and surveys of 100 teams	Lab: three-person student teams assembling electronic devices.	Applying TMSs to multiple, similar tasks.	Teams with TMSs developed during training learn and apply knowledge to other similar tasks.
Ren, Carley, & Argote (2006)	Virtual experimental data from 60 computer modeled teams.	Lab: computer simulation/modeling of three-person team performing multiple tasks.	Influence of environmental context on TMS development.	A team's TMS is contingent on organizational environment, team size, task characteristics.

TABLE 4. Selected Studies from Group Process Research

Authors	Data	Context	Aspect of Team Learning	Key Findings
Edmondson (1999)	Surveys, interviews, and observations of 51 teams.	Four types of teams (functional, self-managed, cross- functional product-development or project teams) at a single manufacturer.	*Team learning behavior*: asking for help, experimenting, discussing errors, seeking information and feedback from customers and others.	Team design and leadership can foster *psychological safety*, which enables learning behavior, and thus team performance.
Bunderson & Sutcliffe (2003)	Surveys of team leader and members. Team performance and demographic data from corporate records.	Management teams of 44 operating units (equally divided among high-, average-, and low-performance) in a large consumer products firm.	*Team learning orientation*: the extent to which a team encourages proactive learning and competence development among its members.	Overemphasizing learning can compromise team performance. The optimal level of learning orientation is higher for low performers, lower for high performers.
Wong (2004)	Surveys of team members and managers in 73 teams.	Teams from four organizations (a financial services firm, a hospital, an industrial company, and a high-tech company).	*Local learning*: intragroup speaking up, opinion seeking, reflection. *Distal learning*: seeking outside ideas, help, and feedback.	Different types of team learning can have distinct antecedents and produce separate effects on performance.
Van der Vegt & Bunderson (2005)	Surveys of members and supervisors on 57 teams; archival data.	Multidisciplinary teams from a company in the oil-and-gas-industry in the Netherlands.	*Learning behavior*: open sharing, evaluation, and combining of the team's ideas and work.	Collective team identification moderates the effects of diversity on learning behavior and performance.
Zellmer-Bruhn & Gibson (2006)	Surveys of 115 teams and their external supervisors; archival data.	Wide range of teams from 5 multinational pharmaceutical and medical products firms.	*Learning*: "the extent to which team created new processes and practices" (p.22).	The autonomy granted by the organizational context can constrain or enable team innovation and learning.

FIGURE 1. Key Constructs and Relationships in Outcome Improvement Area

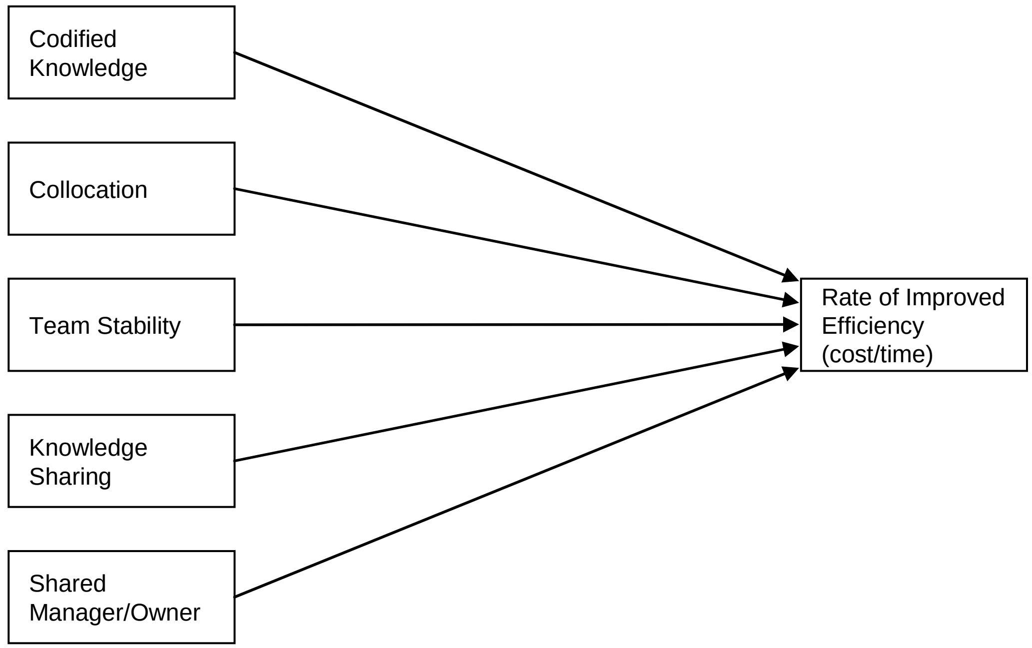
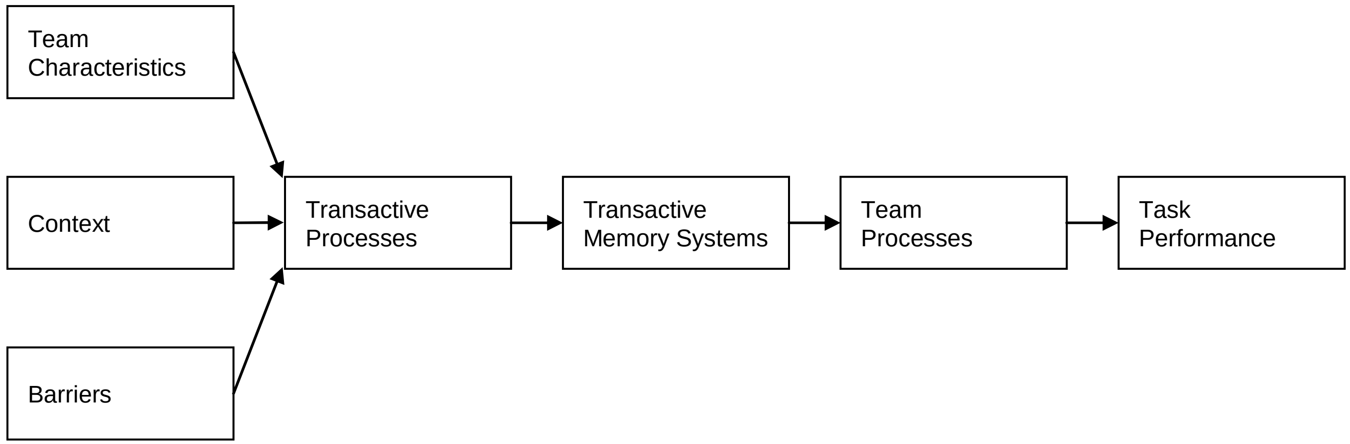


FIGURE 2. Key Constructs and Relationships in Task Mastery Area



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