Speaking Up in the Operating Room: How Team Leaders Promote Learning in Interdisciplinary Action Teams

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Speaking Up in the Operating Room: How Team Leaders Promote Learning in Interdisciplinary Action Teams

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ABSTRACT This paper examines learning in interdisciplinary action teams. Research on team effectiveness has focused primarily on single-discipline teams engaged in routine production tasks and, less often, on interdisciplinary teams engaged in discussion and management rather than action. The resulting models do not explain differences in learning in interdisciplinary action teams. Members of these teams must coordinate action in uncertain, fast-paced situations, and the extent to which they are comfortable speaking up with observations, questions, and concerns may critically influence team outcomes. To explore what leaders of action teams do to promote speaking up and other proactive coordination behaviours – as well as how organizational context may affect these team processes and outcomes – I analysed qualitative and quantitative data from 16 operating room teams learning to use a new technology for cardiac surgery. Team leader coaching, ease of speaking up, and boundary spanning were associated with successful technology implementation. The most effective leaders helped teams learn by communicating a motivating rationale for change and by minimizing concerns about power and status differences to promote speaking up in the service of learning.

INTRODUCTION

Teams come in a staggering variety of forms, from self-managed production teams to product development teams, cockpit crews, and sports teams. The technical-rational conception of team effectiveness that has dominated research on teams does not adequately speak to this range of opportunities for teamwork (West, 2000). Most studies have emphasized stable teams with well-defined static tasks and promoted theories in which team structures such as task design, member composition, and organizational support are designed in advance to achieve specific

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objectives (Campion et al., 1993; Cohen and Ledford, 1994; Hackman, 1987; Wageman, 2001). As noted by West, the resulting models do not explain outcomes for teams with changing goals (McGrath and O'Connor, 1996), multiple or competing objectives (Brodbeck, 1996), or tasks that require constant responsiveness to unpredictable situations (Sundstrom et al., 1990). Such teams face task variability that eludes a static, structural solution (Edmondson et al., 2003).

A team in a fast-paced action context thus might have a clear goal (putting out fires, saving patients' lives, landing an aircraft), the right mix of experience and skills, adequate resources, and a task that calls for teamwork – structures that support effectiveness (e.g., Hackman, 1987) – yet still suffer a devastating breakdown in coordination due to miscommunication, interpersonal conflict, or poor judgment in the heat of the moment. Weick (1993), for example, attributed a tragic fire-fighting failure to a collapse in mutual sensemaking in a group that had in place basic structural supports for effectiveness.

Team leaders[1] can help coordinate action when members otherwise might not know what to do. The literature on team effectiveness has downplayed the role of team leaders and provided little insight into the dynamics of team interaction in intense and uncertain situations. Although a number of recent papers have proposed models to describe the team leader role (Kozlowski et al., 1996), empirical research has long emphasized self-managed and leaderless teams and explicitly promoted team self-management (e.g., Manz and Sims, 1993; Wageman, 2001).

In other literatures in which teams play a central role – such as new product development (Wheelwright and Clark, 1995) and medicine (Shortell et al., 1994) – research shows leader behaviour to critically influence team performance. These teams face higher demands for ongoing learning and problem solving and encompass larger differences in power between leaders and other members than self-managed work teams in production, service, or sales. Power differences in teams intensify the interpersonal risk faced by members who wish to speak up with ideas, questions, or concerns. Leader actions thus may affect whether or not people are willing to speak up (Edmondson, 1996). The interpersonally safe route is to remain silent, but this poses technical risk if the context calls for learning. Not speaking up can protect individuals but harm the team.

Much research on speaking up has focused on extra-role behaviour, studying when people are willing to speak up about aspects of the organization or work context that go beyond the demands of their jobs (Morrison and Milliken, 2000; Morrison and Phelps, 1999; Van Dyne et al., 1994). Yet, how people view their roles affects what is seen as discretionary behaviour (Morrison, 1994). When roles are in transition, expectations for speaking up may shift, and the distinction between in-role and extra-role behaviour may be hard to draw. When new roles demand speaking up but old did not, what factors influence members' ability to make this shift?

This paper explores this question by studying speaking up in the context of in-role behaviour while learning new tasks and coordination routines. I analyse data from a study of 16 operating room teams learning to use a new technology and find that ease of speaking up helps explain learning outcomes and that team leaders shape others' beliefs about speaking up. Further analysis of qualitative data examines *how* leaders promote speaking up both within and outside of their teams.

SPEAKING UP IN INTERDISCIPLINARY ACTION TEAMS

This section introduces the concept of interdisciplinary action teams (IATs) and theorizes causes and consequences of speaking up and other proactive learning behaviour in these teams. Traditional perspectives on group effectiveness have identified organizational supports and team design factors as critical inputs that affect group processes and outcomes (Hackman, 1987; Kent and McGrath, 1969). In this paper, I explore team leadership, organizational context and other influences on team process, in part to develop theory for explaining variance in team effectiveness when team structures are constrained by technological context or regulations, such as in the cockpit or operating room.

Interdisciplinary Action Teams

Action teams are defined as teams in which members with specialized skills must improvise and coordinate their actions in intense, unpredictable situations (Sundstrom et al., 1990). Some sports teams, such as those playing basketball or hockey, exemplify this definition, as do emergency medical teams, operating room teams, and cockpit crews. Although most of these groups are composed of individuals with similar training such as pilots or basketball players, some action teams, notably in the operating room, are interdisciplinary. Action teams, by definition, must respond to unexpected events in a coordinated way, often requiring a free and open transfer of information to enable real-time, reciprocal coordination of action.

This openness is particularly challenging for teams that include different disciplines because associated differences in status, training, language, and norms can impede communication and shared understanding. Disciplinary differences can lead to communication problems due to specialized training and terminology and to differences in what is taken for granted by individuals in a given specialty (Dougherty, 1992). In interdisciplinary teams, the team leader is often in the unique position of seeing the whole picture and understanding how different sources of expertise fit together in the project (Wheelwright and Clark, 1995), and so team leaders in such situations can help teams create shared meaning about the situations they face.

Coordination facing uncertainty. The fast-paced reciprocal coordination (Thompson, 1967) that occurs in action teams creates a need for real-time communication that cannot be scripted in advance. Research on high-reliability organizations has emphasized the role of shared cognition or mental models for effective coordination in action contexts because team members can anticipate each other's moves and be responsive in unexpected situations (Weick, 1993; Weick and Roberts, 1993). This work has not investigated the challenge such teams face when they must alter their coordination routines to accommodate major changes in procedures, equipment, context, or members – that is, when they must develop new or modify existing mental models. Altering team routines may be particularly difficult in the action context because they become habitual (Gersick and Hackman, 1992).

Learning new practices in IATs. The challenges faced by IATs are likely to be intensified when coping with an external change in addition to their usual need to coordinate and improvise. The introduction of a new technology, for example, may require both new skills and new routines. The need for coordination is likely to be intensified during a transition, and implementation of new equipment, new members, or new practices can fail if teams are unable to adjust. Implementation is thus a learning process that involves collective discussion and experimentation with new behaviours (Edmondson et al., 2001), sharing both technical knowledge and social knowledge about who knows what (Moreland, 1999).

Speaking Up in IATs

IATs in which members speak up with observations, concerns, and questions should be better able to learn new routines than those in which members are reluctant to voice what they are thinking. Speaking up is integral to experimentation in this context (trying new actions and reflecting on the results) and to building a repertoire of shared experiences of what works and what doesn't. Speaking up thus should facilitate regaining smooth coordination of actions following a transition period, while also building confidence in and commitment to a new technology or other significant change. This open dialogue also may spark ideas, suggestions, and innovative new procedures that improve team processes. In sum, successful implementation – defined as ongoing incorporation of new practices into the team's repertoire of capabilities (Yin, 1977) – should be aided by members' perceptions that speaking up is easy, desirable and feasible.

> *Proposition 1*: Ease of speaking up in IATs facilitates implementation of new practices.

Boundary Spanning in IATs

Action teams in organizations often need to coordinate objectives, schedules, and resources with those outside team boundaries. Implementing significant changes in IAT processes thus may imply a need for external coordination in addition to new within-team communication. Referred to as boundary spanning (Ancona, 1990), this external communication allows teams to obtain and provide additional information they need to execute new practices effectively. Without boundary spanning, teams may make decisions that are inconsistent with other organization goals or constraints or fail take advantage of available support or resources. For example, an information technology implementation team must talk to multiple organizational groups to coordinate schedules, service disruptions, or training. When new team practices have implications for others in the organization, effective boundary spanning by a team should promote implementation success.

Proposition 2: Boundary spanning in IATs facilitates successful implementation of new practices that affect, or require input from, others in the organization.

The above arguments are consistent with theories of team learning that relate psychological safety to team learning behaviour (Edmondson, 1999a) and boundary spanning (Edmondson, 1999b).[2] This congruence reflects the salience of interpersonal risk for team learning in general and for IATs specifically, given the uncertainty, need for new behaviours and near inevitability of error in both contexts. Next, I explore factors that affect the extent to which members of a team view speaking up as feasible.

Team Leader Behaviour

When action teams must learn new routines, members may feel anxious about the change, reducing willingness to speak up openly with questions and concerns (Schein, 1985). This anxiety can be exacerbated or mitigated by those in positions of relative power.

Power, defined as the capability of one organization member to direct the behaviour of others (Kanter, 1979; Pfeffer, 1981), inhibits the upward flow of information in organizations (Lee, 1993). In groups, members with less power defer to those with more power, protecting themselves through self-censorship to avoid being rejected or marginalized (Estrada et al., 1995; Maier, 1961). In contexts in which formal power differences are present and speaking up matters for performance, it is incumbent upon those with power to find ways to minimize its silencing effects (Depret and Fiske, 1993; Lee, 1993).

Although the very notion of teamwork suggests a group working together as peers, in some teams, leaders have an unusual degree of power or authority relative to other members. For example, leaders of 'heavyweight' product development teams have both positional authority and the ear of senior managers (Wheelwright and Clark, 1995). Similarly, in operating room (OR) teams, surgeons have enormous organizational power relative to other team members. Such large power discrepancies in IATs may adversely affect low-power members' perceptions of the ease of speaking up, inhibiting open discussion.

A second barrier to speaking up is team members' lack of conviction that their input is explicitly needed and desired by others. Without a clear and compelling reason to offer one's views, the effort and risk involved in speaking up make it unlikely – even without large power differences.

Team leaders of IATs are in a position to address both barriers through coaching. Team leader coaching is direct interaction with the team intended to shape individual and team activities to promote desired outcomes (Wageman, 2001). Coaching includes providing clarification and feedback, seeking members' input, listening to concerns, and being accessible and receptive to others' ideas and questions. Team leader coaching may require also explaining why others' input is essential to effectiveness.

While coaching, team leaders can mitigate power imbalances through self-disclosure, noting awareness of their own fallibility (Gabarro, 1987) and emphasizing a need for teamwork rather than relying on hierarchical structures to direct action. They can also initiate off-site or off-line team sessions to practice or discuss work in a non-threatening setting. Mitigating power imbalances is a way to minimize concerns others may have about being humiliated or rejected.

Given the two barriers to speaking up in IATs identified above, I conceptualize team leader coaching in this context as any leader behaviours that explicitly invite and clarify the need for others' input or that seek to minimize power differences.

Proposition 3: Team leader coaching increases ease of speaking up in IATs.

Team leader coaching can also encourage members to talk to others in the organization who may be affected by, or able to help, the team's activities. Without support and encouragement from the leader, team members may find it difficult to take the interpersonal risks inherent in speaking up across team boundaries.

Proposition 4: Team leader coaching promotes boundary spanning in IATs.

The argument thus far, depicted in Figure 1, pertains to proximal factors influencing interpersonal behaviours within and outside of IATs, especially in the context of implementing new practices. The next section explores organizational factors that may influence these group-level processes.

Organizational Context

Most teams exist within organizational contexts – such as hospitals, airlines, or athletic associations (Hackman, 1987). A team's organizational context can provide resources and slack in its schedule to support practice, experimentation, and reflection on what works, all fostering learning and improvement. Team learning also may be enabled by information systems that simplify record keeping and access (Davenport and Prusak, 1998). Senior management can signal support for innovation and change through words and resources, making a change project visible and energizing others in the organization to provide assistance when needed. Finally, an organizational context characterized by a history of innovation may facilitate acceptance of new technology (Cohen and Levinthal, 1990; Iansiti and Clark, 1994). Disparate elements of the organizational context thus can facilitate team learning beliefs and behaviours, supporting successful implementation of new practices in a team, as shown in Figure 1.

Proposition 5: A supportive organizational context promotes team learning and successful implementation of new practices in IATs.

Another feature of the context that affects IATs relates to team membership stability (Moreland, 1999). Action teams in health care, high reliability organizations, or sports, necessarily face some degree of membership instability. Such teams tend to draw from a larger pool of members to put together a subset of members at a given point in time, due to the need for around the clock operations or the potential for exhaustion that action teams face. Research on transactive memory in teams suggests that members who work together longer develop an understanding of who knows what, enabling them to coordinate actions while learning a new task (Moreland, 1999). In a laboratory study of team adaptation, Okhuysen (2001) found that familiar groups (those consisting of members who know each other

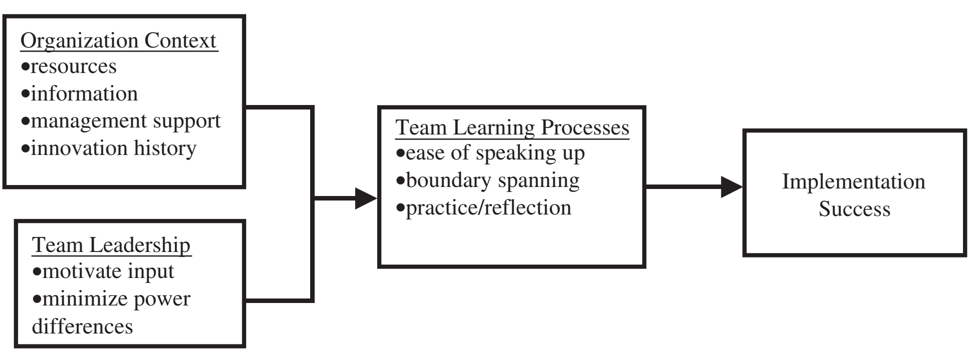

Figure 1. Proposed antecedents and outcomes of learning beliefs and behaviours in interdisciplinary action teams

well) were more able to initiate opportunities to reflect out loud on the task and change direction. Thus, if a stable subset of team members works closely together, this may enable rapid development of new coordination routines. At the same time, the broader goal of implementation success in an organization may suffer if an increasing pool of members is not being exposed to the new routines. Therefore, the net effect of team stability on implementation of new practices for IATs is likely to be mixed.

RESEARCH METHOD AND SETTING

IATs in Health Care

I explore the model presented in Figure 1 in the health care setting because of the prevalence and importance of IATs in this context. Interdisciplinary teams exist in the operating room, in intensive care units, in the emergency room, and in clinics that treat chronic diseases, which benefit from interdisciplinary team-based care (Horbar, 1999; Klein et al., 2002; Shortell et al., 1994). These teams face a series of unique patient situations (requiring effective event-based learning), coupled with more gradual changes in techniques and technologies supporting the work (requiring periodic learning of new approaches). Identifying factors associated with effective learning is of increasing importance for health care researchers and practitioners because of pressures to reduce cost and improve quality (Tucker and Edmondson, 2003).

To study team learning in this context, it was important to find multiple teams facing a learning challenge at the same time, where many other features of the context could be held relatively constant. A new cardiac surgery technology introduced in many US hospitals in the late 1990s met these criteria.

Operating Room Teams in Cardiac Surgery

Four disciplines come together in the cardiac surgery operating room. Cardiac surgeons, the team leaders, work with anaesthesiologists, nurses (scrub and assisting) and technicians called perfusionists who run the heart–lung bypass machine. Teamwork in this setting involves seamless coordination of many small tasks that together constitute the surgical procedure. The role of each team member in these procedures is clearly defined, and everyone is able to monitor the progress of the operation and to anticipate what actions are needed by simply looking at the heart and at what the surgeon is doing.

Minimally invasive cardiac surgery (MICS), an innovation developed and manufactured by a device company called Minimally Invasive Surgical Associates (MISA),[3] differed from the conventional approach to cardiac surgery in that the patient's breastbone was not split apart. This reduced the pain and recovery time for patients such that they were able to resume normal activities more quickly than after conventional cardiac surgery. Using special new equipment, the heart was accessed through small incisions between the ribs, and the patient was connected to the bypass machine through small incisions. A tiny deflated balloon, threaded into the aorta and then inflated to prevent blood from flowing backwards into the stopped heart, replaced the traditional clamp inserted directly into the chest cavity.

MICS increased the coordination challenge on the OR team dramatically, and all hospitals purchasing the technology were required to send a team to a three-day training programme run by MISA before using the technology on patients. During the surgical procedure the tiny balloon-clamp had to be constantly monitored by the team using fluoroscopy, a type of ultrasound technology. Team members had to coordinate their actions to guide the balloon into place and then monitor it for hours to make sure it stayed in place. Unlike conventional surgery in which surgeons relied on direct visual and tactile data, MICS called for team members to supply the surgeon with information displayed on monitors. The new technology thus changed individual team members' tasks, altered role definitions, and increased the need for speaking up to coordinate action that had previously been sufficiently routine to enable coordination without speaking.

Research Design

This study used a multiple case study design (Eisenhardt, 1989; Yin, 1989) to investigate learning in IATs. This design combined strengths of qualitative data for better understanding a process with the opportunity to learn from quantitative patterns of variance across cases. Multiple case comparisons encourage researchers to look beyond initial impressions from a single site and further inform theory building by suggesting how different constructs relate to each other (Eisenhardt, 1989). This design thus allowed qualitative study of team processes and quantitative correlations between constructs as preliminary tests of the research propositions.

Sample. The sample consisted of 16 cardiac surgery teams selected to ensure differences in geography and innovation history from the approximately 150 US hospitals that had purchased the technology. Each hospital had only one OR team learning MICS; the teams, all in well respected cardiac surgery departments, varied in size and were learning the new technology within the first year of its approval by the US Food and Drug Administration (FDA).

Data Collection

Preliminary fieldwork. To understand the technology and the surgical process, I attended MISA's three-day training programme with three colleagues, one of whom was a physician. We attended lectures, observed an OR team in hands-on laboratory sessions, and interviewed team members about the implementation challenge. We then developed an interview protocol to assess organizational and team characteristics related to MICS implementation. We spanned three disciplines and asked questions addressing a range of issues related to new technology in health care, creating a shared database for several sets of analyses.[4] This paper reports on data related to team process and outcomes.

Interviews. The primary data source is 165 interviews conducted at the 16 hospitals. Four interviewers participated in the first four site visits to promote consistency in asking questions and recording data; a team of two or three of us visited each remaining site. At each site, we interviewed members of the OR team and other hospital personnel who interacted with team members or were knowledgeable about the technology. Team members interviewed consisted of one to three people in each of four roles: surgeons, anesthesiologists, OR nurses and perfusionists. Others interviewed included cardiologists, intensive care unit (ICU) nurses, general care unit (or floor) nurses, and hospital senior management. Multiple informants at each site allowed cross checking of responses about factual issues and reduced the chances of obtaining unrepresentative responses from individuals. To minimize the effects knowledge of implementation success would have on our perceptions of sites, interviewers were blind to the outcome data throughout site visits.

Each interview began an open-ended question ('Can you tell us how MICS got started at this hospital and how it's going?') to obtain views about what mattered before limiting informants' responses with specific questions. The questions that followed addressed more specific team issues, such as how the team worked together, what they did to prepare (following training but before the first case), and who was involved at various stages of the learning process. Questions about the hospital as an organization included both broad and specific topics. Consistent with the aim of a multiple case study design, each new visit was used to check an emerging understanding of salient factors in the team learning process.

This iterative process clarified not only which aspects of the team learning process and organizational context varied but also the nature and range of variance. As a result, I developed a set of categories that corresponded to each of the consistently asked questions. For example, to assess ease of speaking up, informants were asked what they would do (or had done) if they noticed a marginally adverse indicator in one of the visual or numerical monitors – one that presented a situation in which the patient was in no immediate danger but could indicate a problematic trend. I coded responses into one of three basic options: the atmosphere and interaction in this team is characterized by (3) open reciprocal communication (very free and effortless), or (2) respectful but guarded communication (picking the right moment to speak, pronounced awareness of power differences), or (1) communication that is quite limited, with some members extremely hesitant to speak up.[5] This generated a database with numerical codes for each variable for each hospital. Interviewers also took extensive notes to justify the coding and to capture the additional detail and anecdotes provided in these responses.

Data Analyses

Data analysis for this paper occurred in four stages. First, I conducted preparatory analyses of the interview data to aggregate the coded questions into a set of meaningful independent variables. Second, a research assistant categorized and coded the free-form interview notes. Third, I analysed archival data to create a measure of implementation success (the outcome variable in this study), which assessed how effectively a team implemented the new technology into the hospital as an ongoing practice. Fourth, I examined qualitative and quantitative relationships between the independent and dependent variables and then further analysed the qualitative data to explore team leader behaviours associated with effective team learning. The strength of these data lie in their opportunity to provide qualitative insight; the derived (quantitative) measures were used as a check against researcher bias and as a way to leverage and extend intuition to learn more from the data than would otherwise be possible.

Stage 1. I analysed all coded interview data related to the team learning process and the organizational context to create composite variables. Following the logic of within-method triangulation (Jick, 1979), I examined correlations between coded responses to questions assessing the same construct (Campbell and Fiske, 1959). This provided measures of internal consistency reliability and discriminant validity for each composite variable, as shown in Table I; non-composite (or single-measure) variables are shown in Table II. My aim in these analyses, described in more detail in the Appendix, was to assess the similarity of responses to related questions. The result is a set of numerical ratings for five team constructs (team stability, team preparation, procedure innovation, boundary spanning, and psychological safety) and four organizational constructs (history of innovation, resource constraints, management support, and information infrastructure) for each hospital. These nine variables represent a set of factors that emerged as varying noticeably across hospitals.[6] Team leader coaching was assessed in the next stage of analysis, using free form qualitative data.

Stage 2. A research assistant who had not participated in site visits coded the transcribed verbatim responses using categories that corresponded closely to the interview protocol. Data that fit into more than one category were given multiple codes. The research assistant then developed subcategories by identifying recurring themes within each category, and finally coded each data unit (ranging from one

Table I. Construct definitions, internal consistency and discriminant validity of composite variables[a]

Variable name	*Definition*	*Interview questions*	*alpha*	*Average within-construct r*	*Average between-construct r*
Team preparation	The degree to which a team engaged in an inclusive and comprehensive practice session	1) Assessed who participated in a 'dry run': ranging from (0) no one, to (1) isolated disciplines, (2) pairs of disciplines, (3) most of the team (4) the entire multi-disciplinary team. 2) Assessed session content: from (0) no content (when there was no session), to (1) technical review of the equipment and procedure, and (2) technical review together with thorough discussion of communication issues such as how the team would talk and interact. These two variables were correlated (0.93) and added together to make a composite variable (ranging from 0–6).	0.85	0.93	0.31
Team stability	Degree to which membership of the team is consistent over time	1) Asked each participant how many operations were conducted by the original team, yielding a number between 0 and 15. 2) Asked about the strategy for team stability, coded by interviewers: (4) deliberately kept stable for at least 10–15 cases, (3) stable with staged inclusion during early cases, (2) immediate inclusion of new members, (1) immediate substitution of new members. The two variables were normalized and averaged.	0.79	0.65	0.03
Boundary spanning	Degree to which a team communicates with other organizational groups	1) Asked whether there was reciprocal communication between OR team and cardiology (coded as 1 or 0) 2) . . . OR team/ICU (1/0) 3) . . . OR team/floor (1/0). Composite variable is the sum of all three (0–3).	0.71	0.47	0.26
Procedure innovation	The degree to which a team made substantial changes in technical work procedures	1) Asked if patient eligibility criteria were changed as a result of reflection on past surgical results (coded as 1 or 0) 2) Asked if team introduced specific improvements or innovations in the procedure that constituted substantive changes to MICS (1/0) 3) Asked if team used MISA devices for procedures previously considered impossible without the new devices (1/0). Composite is sum of all 3 (0–3)	0.72	0.46	0.17
Information infrastructure	Extent of collection and use of data	1) Asked participants how data were used, counting the number of different uses of data mentioned (0–6). 2) Asked who used the data, and counted the number of administrative and clinical groups mentioned (0–9). Composite is sum of 2 variables (0–15).	0.64	0.50	0.05

[a] Composite variables are those for which more than one interview question and coded response addressed the same constructs. Chronbach's alpha is used to establish internal consistency reliability; showing that average within-construct correlation for each composite variable is substantially larger than average between-construct correlation demonstrates discriminant validity.

Table II. Single-measure variables created from interview data

Variable name (range)	*Description*
Ease of speaking up (interviewers' rating) (1–3)	Responses to a question asking what participants would do if balloon pressure were marginally high were coded on a single scale: (3) open reciprocal communication (very free and effortless), (2) respectful but guarded communication (picking the right moment to speak, pronounced awareness of power differences) and (1) communication that is quite limited, with some members extremely hesitant to speak up.
Resource constraints (0–3)	From responses to a question about factors limiting the number of MICS cases performed at a site, we identified three barriers: (1) capacity constraints (operating room and/or surgeon time – the long MICS procedures consume more of these resources than conventional surgery), (2) high cost of the MISA product, and (3) lack of referrals for MICS. Variable is the total number of barriers identified by informants at each site.
History of innovation (0–3)	Interviews asked about other cardiac surgery innovations adopted or clinically evaluated at the hospital, and responses were coded as (3) extensive (when all recent innovations in cardiac surgery had been tried at that hospital including heart transplants), (2) high (when all or almost all recent innovations were tried, (1) moderate (when 1 or 2 had been tried), (0) none (when no previous cardiac surgery innovations had been tried).
Management support (0–3)	Interviews asked about the role of hospital administration in MICS adoption, and responses were coded as either (3) initiated plan and promoted it actively, (2) supported MICS adoption, although it was initiated by surgeons, or (1) neutral or not involved, (0) opposed MICS.
Team leader coaching (1–3)	Two research assistants rated 613 quotes previously identified as related to team leader behaviour on a 3 point scale from high (creates an open environment, leads discussion, creates trust, advocates teamwork) to low (doesn't coach, doesn't listen to others, doesn't trust the team, disregards importance of teamwork).
Ease of speaking up (coders' rating) (1–3)	Two research assistants rated 168 quotes previously coded as relevant to ease of speaking up (by a research assistant) on a three-point scale from 3 (easy to speak up about anything on one's mind) to 1 (people appear to be very uncomfortable speaking up and only do it under extreme duress).

to several sentences) according to major and minor categories, speaker profession, and hospital. The coded data set allowed me to quickly compare particular features across hospitals by excerpting all data in the category of interest, sorted by hospital, facilitating identification of recurring themes and cross-case analyses.

To obtain a measure of leader coaching and to triangulate the measure of psychological safety described above, I used the free-form qualitative data to create measures of *ease of speaking up* and *team leader coaching*. Two research assistants rated all quotes identified as related to team leader behaviour on a three-point scale from high coaching (creates an open environment, leads discussion, advocates teamwork) to low coaching (doesn't coach, doesn't listen to others, disregards importance of teamwork). Quotations were scrambled so that raters did not confront a cluster of quotes from the same site, creating a bias for similarity of ratings within sites.[7] Using the same approach, they rated quotes previously coded as relevant to speaking up on a three-point scale from high (easy to speak up about anything on one's mind) to low (people appear to be very uncomfortable speaking up and only do it under duress). The two measures of ease of speaking up were correlated (Table III), triangulating interviewers' assessments of the construct.[8]

I subsequently combed through the 613 quotes coded as related to team leader behaviour to seek recurring themes and specific behaviours used by the team leaders, for insight into how leaders affect speaking up and learning outcomes.

Stage 3. Data on the annual number of cardiac surgery operations in each hospital and on the number of operations conducted in the first six months of using MICS were obtained from each hospital. I calculated implementation success – following Iansiti and Clark (1994) – as the sum of the ranks of three variables: (1) the number of MICS cases conducted in the first six months at each site, (2) the percentage of heart operations conducted using MICS in the same period, and (3) whether a site was increasing, decreasing, or remaining steady in its use of MICS. The measure considered absolute volume, penetration levels and trend, thereby giving credit to several dimensions of adoption success and not unduly penalizing small centres for carrying out fewer MICS operations. I planned this index of team learning outcomes in advance of analysis of the interview data.

Stage 4. Because of the small sample size and the nature of our rating systems, I utilized a non-parametric statistical test, Spearman's *rho*, to conduct tests of relationships between variables. Nonparametric statistics are inferential tests that do not require assumptions about the distribution of the population from which the samples were taken, and Spearman's *rho* is particularly well suited to small samples and to interval-scaled data for which the distribution is not necessarily normal (Saslow, 1982). Although Pearson's r can inflate the degree of association between

Table III. Spearman rank order correlations between variables

	HI	*MS*	*II*	*RC*	*TS*	*LC*	*TP*	*SU(i)*	*SU(c)*	*BS*	*PI*	*IS*
History of innovation	1.00											
Management support	–0.27	1.00										
Information infrastructure	–0.07	0.07	1.00									
Resource constraints	0.10	0.14	–0.34	1.00								
Team stability	–0.09	0.00	–0.19	–0.05	1.00							
Leader coaching	–0.24	0.02	–0.11	0.06	0.13	1.00						
Team preparation	–0.37	–0.30	–0.03	–0.27	0.26	0.74**	1.00					
Ease of speaking up (interview)	0.25	–0.10	–0.18	0.13	0.13	0.70**	0.48*	1.00				
Ease of speaking up (coders)	0.09	0.20	0.14	0.00	0.21	0.65**	0.37	0.62**	1.00			
Boundary spanning	–0.32	0.03	–0.03	–0.04	0.03	0.76**	0.71**	0.53*	0.42†	1.00		
Procedure innovation	0.04	0.17	0.03	0.10	–0.27	0.42†	0.39	0.39	0.33	0.60**	1.00	
Implementation success	–0.24	–0.03	–0.25	–0.20	0.18	0.65**	0.63**	0.55*	0.47*	0.66**	0.34	1.00

†$p < 0.10$.
*$p < 0.05$.
**$p < 0.01$.

two variables of this kind if there are a few extreme values, Spearman's *rho* solves this problem by correlating the rank order between two variables.[9] Given the small N and novel, emergent measures, these analyses can be considered tests of the plausibility of the research propositions – that provide insight into relationships and avenues for future research – rather than as conclusive tests of them. Table III displays all correlations.

FINDINGS

All teams studied found the MICS learning process challenging. Some were extremely discouraged by how difficult it was to re-learn how to work together. As one department head lamented, 'the first few [procedures] had poor results[10] and the cardiologists went after [the surgeon leading the team], which has affected his willingness to do [it]. Mistakes were made. I should have protected him . . .' In another hospital, a surgeon reported being frustrated that, 'after 50 cases . . . I'm not getting that much better at it'. In contrast, members of other teams seemed energized by the challenge. For example, one particularly successful site had frequent visits from others adopting the technology, and the team leader described this as a positive learning experience, 'At [this hospital] we have the luxury of having so many people come through here. It's amazing what you can learn from them if you listen. Even people who've just done a few cases have ideas. They say, "maybe you should try this" . . .'

Across all 16 teams, informants reported being amazed by the extent of change the technology required. The difficulty they encountered was more behavioural than technical. As one anaesthesiologist reported, 'There is nothing radically new in the technological components'; yet, as an anaesthesiologist in another hospital explained, the new process changed patterns of communication between different disciplines in the team:

> The name of the game is vigilance and flexibility. Often it's too late to get together to discuss changes, you just have to do it . . . it has to be like a reflex, you just have to work together . . . it's easy to discuss these things with the surgeons. They immediately just come to us and we discuss it . . . [but, we now have to discuss] with the nurses and perfusionists too. The role of the perfusionist is very important . . .

A perfusionist put this succinctly: 'In a routine case, you're in your own little world. In MICS it's much more communication-intensive. You have to know what others are doing, and others have to know what we're doing.' An anaesthesiologist from another hospital concurred, 'One thing we've noticed is that because of the nature of the cases people listen to other members of the team more than for standard CABG . . . people put more stock in what others are saying.'

Speaking Up as Essential for Implementation of New Practices

Proposition 1, that ease of speaking up promotes successful implementation of new practices in IATs, received abundant support from the qualitative data. First, as shown above, informants consistently explained that the change was especially challenging because it required speaking up in a new way; when people were hesitant to do this, it was difficult to improve proficiency with MICS. As one nurse said, '[people on this team] are not used to saying anything. They are afraid to speak out. But for this procedure you *have* to say stuff'. Similarly, an anaesthesiologist explained that if MICS implementation was going to be successful, he and others had to learn to speak up in the OR, despite never having dared to do so previously:

> For minimally invasive surgery you can't ever stop talking. For [MICS], I have to be able to tell the surgeon to stop. This is very new. I would never have dared to say anything like that before, nothing was that important.

He continued, emphasizing that this meant violating existing power-based communication norms,

> So you have to develop a way to deal with communication in advance, such as 'anaesthesia can be telling the surgeon what to do'. It has got to be legitimate. This is really important. Everyone has access to key information and so communication is essential. Anyone on the team can say something pertinent that will affect the operation.

In some teams, speaking up extended beyond the operating room itself. A perfusionist in the second most successful implementer described his new ability to speak up to surgeons with observations from the research literature,

> If an unusual case is coming up, I ask surgeons about it, look at the literature, and talk with them beforehand. The surgeons have become very open to me bugging them on that level. It used to be viewed sceptically, but they have grown to expect that interaction from me. This is true of other perfusionists, too. They learned the process of talking with the surgeons.

In contrast, in teams in which members reported feeling hesitant to speak up, the pace of implementation tended to suffer. In addition to extensive qualitative evidence providing insight into participants' views of how and why speaking up matters for success in learning MICS, both measures of ease of speaking up were correlated with implementation success (*rho* = 0.55, $p < 0.05$, for the interviewers' measure and 0.47, $p < 0.05$, for the raters' measure).

An early aspect of the team learning process – measured by the variable team preparation – emerged as an important influence on ease of speaking up. Team preparation refers to inclusiveness and thoroughness of a dry-run practice session (see Appendix for details of the measure) that helped launch a new way of relating to each other, experimenting with ideas and possibilities, and practicing alternative moves. Being able to speak up in a practice context made it easier to do so later, in the real operating room setting.

Altogether, data analysis identified a cluster of related team process variables, seen in the centre of Table III, that includes leader coaching, team preparation, ease of speaking up, and boundary spanning. This cluster points to the possibility of a multi-faceted, mutually-reinforcing team learning process that culminates in implementation success. Procedure innovation, a measure of whether teams used the technology in radically new ways or for patient conditions previously considered inoperable, was weakly associated with leader coaching but not with other process or outcome variables.

Boundary Spanning and Implementation Success

Team boundary spanning was strongly associated with implementation success (*rho* = 0.66, $p < 0.01$), consistent with Proposition 2. Although the cardiac surgery task itself is only loosely coupled with other hospital routines, when OR teams were implementing this major change, they benefited greatly from communication with other hospital groups. First, cardiologists refer patients to surgery. Thus, their cooperation was often needed to direct patients to MICS instead of the conventional approach. These medical specialists also had greater expertise in using the ultrasound technology upon which MICS relied and in some hospitals helped the OR teams by assisting with these imaging techniques during early operations using the new approach. Second, when OR team members communicated with members of the ICU, this enabled modification of post-operative care of MICS patients, helping hospitals to realize some of the advantages promised by the innovative technology. When the ICU had more knowledge about the technology, caregivers were able to provide early physical therapy and early discharge for MICS patients.

Some of the successful hospitals started on the implementation journey with extensive boundary spanning; others described explicit outreach efforts initiated for MICS. For example, the surgeon at one hospital invited cardiologists to a special presentation about the technology, and then organized a meeting with ICU and floor nursing staff to obtain input into designing postoperative care plans. As a result, ICU and floor nurses worked collaboratively with the OR team to modify existing care protocols to address specific needs of MICS patients. This boundary spanning involved all team members, not just the surgeons. A nurse reported,

> We studied the manual then took it back to the [floor and ICU] nursing units and gave talks. We introduced the concept and what we were trying to do and how it would change the nursing role [in the units]. We looked for input from them.

Good relationships between cardiology and anaesthesia – whether preexisting or newly established for MICS – eliminated conflict about the use of ultrasound ('echo') equipment in the OR. In contrast, in several hospitals, ownership of echo was tightly held by cardiology, creating problems in using or getting assistance for its use in the OR. When we asked surgeons at one such site early in our visit for suggestions of cardiologists we could interview, they struggled to name one. An OR nurse reported,

> There is a territorial war in this institution on who controls echo. There was a huge compromise in that we finally got them [cardiology] to come in at 6:45, but it was a huge fight to get them to cooperate.

Similarly, the ICU was uninformed about MICS. Another OR nurse complained,

> I had to take a patient to the SICU and [MICS] had never been heard of, so I had to diagram it out for them. Should this be my responsibility? No. But it happened more than once, so the information didn't get to them.

In sum, team boundary spanning – whether enabled by preexisting relationships or by deliberate effort to build relationships for MICS – appeared to be a critical dimension of the team learning process that led to successful implementation. Boundary spanning and both measures of ease of speaking up were correlated (*rho* = 0.53, $p < 0.05$; 0.42, $p < 0.10$), suggesting that teams with more internal (within team) communication were also likely to engage in more external (between-team) communication – both integral to the MICS learning process. One possibility is that engaging in one learning process facilitates another – as team members develop experience speaking up to each other and to outsiders. Another possibility is that team leader behaviour drives both processes.

Team Leader Behaviour

Team leader coaching was associated with ease of speaking up (*rho* = 0.70, $p < 0.01$ (interviewers' rating) and 0.65, $p < 0.01$ (coders' rating), supporting Proposition 3, and with boundary spanning (*rho* = 0.77), supporting Proposition 4. Because team leaders in this context had greater organizational power than other team members, they were better able to initiate contact with outsiders, such as cardiologists, who also had positional power in the organization. Further, leaders' attitude toward boundary spanning signalled to others whether it was desirable to be outgoing and in frequent contact with others or to be inward looking with plans held closely; others tended to follow these signals.

A significant relationship between team leader coaching and team preparation (*rho* = 0.74, $p < 0.01$) suggests that coaching oriented leaders were more likely to promote inclusive and thorough team practice sessions, giving teams an opportunity to practice speaking up without a patient's life at stake. Further analyses of qualitative data shed light on *how* team leaders enabled and motivated speaking up during the learning process.

I mined qualitative data to understand what leaders actually did to promote speaking up. Review of quotations previously coded as related to team leader coaching suggested two strategies that enabled speaking up and successful MICS implementation. One describes whether and how team leaders communicated a compelling rationale for change and for speaking up; the other describes how leaders helped others cope with differences in power that exist between cardiac surgeons and other team members. The first motivated the effort needed to overcome a history of not speaking up; the second mitigated the intimidating effects of power differences.

A motivating rationale. As one surgeon explained, successful implementation required a surgeon 'who *wants* to do it because it's a commitment of time, money and tremendous effort to make this work'. Although all surgeons had to let teams know about the technology and the need to attend training, some did little to clearly explain the new rules for engagement, nor to motivate participants to exert the extra effort or endure the hardship the change process might entail.

In contrast, about half of the team leaders studied explicitly communicated a compelling rationale for change. To do this, most emphasized patient benefits promised by MICS. To illustrate, at one successful implementer, the surgeon frequently noted technology's advantages for patients – such as going home from the hospital early, or lifting a grandchild within weeks rather than months following surgery. In turn, his team members focused on and described their own excitement in seeing the patients doing well following MICS surgery. In another successful site, the surgeon went out of his way to communicate about the innovation to the various disciplines in the OR team in advance. As reported by a team perfusionist, 'The surgeon came to talk to perfusion about [MICS]. He explained the advantages to me. He knew it was going to be a hard road.' Similarly, the perfusionist in another hospital reported that the extra effort and time required for learning MICS was worthwhile because, 'We all think our job is to help the patient.'

Other team leaders motivated effort by emphasizing that innovation and change were a way of life in cardiac surgery. At one successful implementer, the surgeon explained that the technology was not perfect, but that it was important to try to make it work, as it presented certain features that might later become commonplace in cardiac surgery. Nonetheless, he continued, all surgeons would *not* respond to this challenge the same way,

> Surgeons fall into three categories. One group looks and takes initiative [saying], 'The technology is awkward but it has potential. Even if the technology is preliminary, we will try it.' The second groups says 'it's interesting but it's not me who is going to be the pioneer.' The third group is critical and stands in the way, impugning negative motives to people who are actually going for it.

The importance of change had to be signalled by surgeons. As one perfusionist explained, MICS implementation 'starts at the top [meaning the team leader] and then rolls down. The surgeon's attitude affects the mood. His attitude was "let's go out and learn something new and try it . . ." They did their homework trying to make it work.' In striking contrast, in several teams the leader was reported by others as having done nothing to prepare or motivate the team for the change. In these hospitals, team members reported being sent to MICS training because they were on call when the training was scheduled and hearing little in the way of a compelling reason for extra effort. In these teams, when asked why they thought the hospital was adopting MICS, the response was typically that other nearby hospitals were doing it, and so 'keeping up with the Jones's' was necessary to prevent future loss of patients to these other centres. Similarly, many believed the team leader was not committed to the new technology; as one perfusionist said, 'If the surgeon didn't think of it then [he sees it as] a bad idea . . .'

Downplaying power differences. A second recurring theme in the data was how the team leader dealt with power. Some surgeons communicated that MICS was about teamwork and that implementation was a team project – an unusual frame in this context where most innovations involved surgeons learning new techniques without changes in team coordination. In contrast, other surgeons emphasized their own role in mastering the technology, or downplayed the extent of change, noting that the technology was not really all that new after all. For example, one surgeon explained, 'the technical aspects of MICS are not much different' from the standard surgical technology; as a result, he did not feel a need to practice with the team to develop new behaviours as a group.

Framing MICS as a team project explicitly downplayed power differences within the team. Team leaders could do this in several ways. First, some leaders made a point of taking action based on others' input. Second, some communicated that others' roles were as critical to success as the surgeons' role. In one hospital, this led to surgeons inviting nurses and perfusionists to seminars previously reserved for physicians. These behaviours elevate the status of the non-surgeon members. As the leader of the second most successful team explained,

> [MICS] is a paradigm shift in how we do surgery . . . the whole model of surgeons barking orders down from on high is gone. There is a whole new a wave of interaction . . . the ability of the surgeon to allow himself to become a partner not a dictator is critical. For example, you really have to change how you are doing something based on getting a suggestion from someone else on the team. This is a complete restructuring of the OR and how it works.

These leader actions led others to report that they felt respected for their particular abilities and contributions; one perfusionist said, '[the surgeon] respects us a lot . . . there's no doubt he values my input', while another said, 'I think we all respect each other to a great degree. We respect each other's contributions', and a third echoed, 'The surgeons just trust us. Very high trust. They don't have impossible personalities as [is] usual elsewhere'.

Third, team leaders encouraged speaking up by communicating a sense of humility, such as by noting his own fallibility or limits. One commented, 'The realization is that you cannot manipulate all the variables in the procedure yourself' (an observation that both conveys humility or limits and points to a clear need for others' input). In another team, the perfusionist reported, 'When the surgeon makes a mistake, he immediately writes a note to the entire group to explain how it happened.' These actions served to de-emphasize the surgeons' power, reducing this potential barrier to speaking up.

Finally, a surgeon could over- or under-react to others' errors; the latter went a long way toward mitigating power differences and creating psychological safety for speaking up. To illustrate, in one hospital, almost every team member we interviewed told a particular story about an incident in which a nurse made a terrible error of dropping a vein (just harvested from the patient's thigh for grafting onto the cardiac vessels as a bypass) on the floor. As told by the anaesthesiologist,

> Once an RN dropped a vein graft on the floor. She spoke up and [the surgeon] didn't say a word. He just made another incision. Maybe a millisecond was lost [before starting to harvest another vein]. No yelling or screaming. He didn't need to. She knew she'd made a mistake.[11]

He continued, 'This is a non-threatening environment. It facilitates the flow of information.' A nurse told the same story, which clearly had a profound impact on the team, starting, 'There was a screw up . . .'

In summary, team leaders affected team psychological safety through specific interpersonal moves. These actions served to motivate and emphasize the importance of others' input and to downplay power differences within the team. Table IV shows illustrative data for the two strategies.

Table IV. Two dimensions of team leadership that facilitate speaking up

Change strategy	Provide compelling rationale for new behaviour	Present as essential to success of teamwork
Barriers to speaking up	History of one-way communication, of others not being asked for or providing input	Differences in power and status
Leader behaviours	Communicate rationale for change, emphasize change and innovation as a way of life, explain need for others' input	Communicate others' importance through word/action, acknowledge own fallibility, under-react to others' error
Psychological mechanism	Motivation (team members understand need for and feel motivated to speak up)	Psychological safety (team members experience greater ease of speaking up)
Positive examples	'The surgeon talked to us about what MICS was about, how it would help patients . . .' (Nurse, H8) 'The surgeon's attitude is, let's go out and learn something new; let's try this.' (Perfusion, H13)	'The surgeon has to have the ability to allow himself to become a partner where he accepts input and [it] changes what you do . . . you really have to change how you are doing something based on a suggestion from someone else on the team.' (Surgeon, H10)
	'Surgeons fall into three categories. One group looks and takes initiative [saying], "The technology is awkward but it has potential. Even if the technology is preliminary, we will try it." The second groups says "it's interesting but it's not me who is going to be the pioneer." The third group is critical and stands in the way, impugning negative motives to people who are actually going for [it].' (Surgeon, H15)	'[the surgeon] definitely values what we say. He respects us.' (Perfusion, H14) 'The surgeons just trust us.' (Perfusion, H3) 'We speak up easily . . . No one is intimidated by the surgeon or the situation. I think the surgeon makes it so. He makes it easy to speak up. It's not a problem even for an RN to speak up.' (Nurse, H13) 'The surgeon communicates very well . . . In the OR, no one is talking down to you.' (Nurse, H4) 'He's a leader and lets you be a leader at what you do.' (Perfusion, H13) '. . . you cannot manipulate all of the variables yourself.' (Surgeon, H10) 'When he makes a mistake, he immediately writes a note to the whole group . . . ' (Perfusion, H3) 'Dr X was doing a case. A nurse dropped a vein graft on the floor and said I dropped a vein graft on the floor. He stopped. He said nothing. He just went to the thigh and took another vein out . . . It was understood there was a screw up, but he is not ruffled. If things are [bad], we just deal with it.' (Perfusion, H13)
Negative examples	'If the surgeon didn't think of it, then it's a bad idea.' (Anesthesia, H16) 'I was sent to MICS training because I was on call that weekend.' (Nurse, H7)	'It's very difficult because you see nothing. The surgeon has to tell you everything he is doing. It's a one-man show. We can't see what he's doing.' (Nurse, H1) 'You have to go through formal channels.' (Nurse, H5) '[The surgeon] doesn't invite that type of input. It's not an open forum.' (Perfusion, H5) 'Dr. X is really in command. For example, this poor nurse brought the film in on demand, and she just stands there and doesn't know if she can go back to work, and she's afraid to ask. Some other nurse asks if she can go back and he says, "well I guess what she's doing is more important than this." . . . It's his arena.' (Nurse, H2)

Organizational Context Support

These 16 teams were situated in organizational contexts in which much was held constant across hospitals by the nature of cardiac surgical practices. Nonetheless, they did face some differences in organizational context, in innovation history, management support, information infrastructure, and resource constraints (see Appendix for measures). None of these variables were associated with implementation success, as shown in Table III, constituting a lack of support for Proposition 5. Why this context may lend itself to a weak association between organizational support and team learning success is explored in the discussion.

Membership stability varied a great deal across sites. Some hospitals grew the pool of team members using MICS more quickly than others – introducing new team members into the MICS project soon after the training programme; others waited until the core team accumulated experience together, with five hospitals conducting 15 or more operations before bringing in new members. A larger team helped to spread the new technology's influence on the department but imposed challenges for developing smooth coordination routines as a team. As expected due to these competing influences, no association was found between membership stability and successful implementation of new practices.

DISCUSSION

A Learning Ensemble

The findings in this study support the proposition that team leaders facilitate speaking up and that ease of speaking up, in turn, enables successful implementation of new practices. This conclusion, however, is deceptively linear. More accurately, I identified a set of relationships among group-level variables that together were associated with successful implementation. Some of these variables have been characterized previously in the literature as inputs to team effectiveness, and others are generally considered elements of group process.

In this study, the line between inputs and processes was difficult to draw. To illustrate, availability of team leader coaching has been conceptualized previously as one of a set of input conditions that promote team effectiveness (Hackman, 1987; Wageman, 2001). This study suggests viewing team leader actions instead as both an integral part of an ongoing team learning process *and* an input condition. First, I found clear differences across team leaders in initial approach (and no evidence of change in approach during the project). Second, many of the episodes described vividly by informants – such as the dropping of the vein, or the discussions of research literature between surgeon and perfusionist – occurred after the project was underway.

The data thus presented team learning as an ensemble effort in which team leaders had an opportunity, early, to engage others in the project, to direct their attention to a meaningful rationale for investing effort and changing their behaviour, and, as part of this, to explicitly invite them to speak up. These leaders were integral to an ongoing team process that affected implementation. Boundary spanning, which showed the highest correlation with implementation success of all potential predictor variables, emerged as a critical element of this learning process. Given that MICS imposed additional interdependence between cardiac surgery and other clinical groups, communication with them appeared to pay off in implementation success; this finding, however, may not generalize to action teams in other contexts.

Self-sufficient Teams

Measures of organizational context support – management support, innovation history, information infrastructure, and resources – varied across sites in ways that were not related to implementation success, a finding that is inconsistent with previous work on technology implementation. Intuitively, it seemed that teams in hospitals with better information capture and retrieval would be better at learning, but in this case, successful implementation appears to be driven by speaking up and other interpersonal dimensions of teamwork in action; formal data gathering was less critical to success.

The lack of support for organization context overall in this study may be because cardiac surgery departments typically are highly self-sufficient operating units, such that senior management attention and other resources seem quite far removed from the front-line activities in the operating room. Moreover, cardiac surgeons uniformly had high levels of power in their organizations and could usually obtain the resources they wanted. So, despite some differences across hospitals in context support, these seemed not to influence how teams coped with the challenge of MICS. It is also possible that restriction of range in this highly homogenous industry limited the ability to detect relationships.

A New Conception of Team Leadership

Much past work on team leaders has emphasized managerial activities, such as directing members attention to the task, coordinating interdependent work, and ensuring that a supportive team design is in place (Hackman and Walton, 1986; Wageman, 2001); these models consider how to help leaders assess a team's stage and take action accordingly (Kozlowski et al., 1996). This paper emphasizes instead interpersonal and affective dimensions of team leadership to suggest that attention to social and emotional factors, especially related to interpersonal risk, may help explain variance in team outcomes not associated with differences in design or with managerial actions directed at design. In particular, this study shows that teams confronting major change in their work routines benefit greatly from non-threatening leadership. The goal of teamwork is better realized when leaders create psychological conditions of meaningfulness and safety (Kahn, 1990) that encourage and enable people to focus unselfconsciously on the task at hand.

The study also shed light on *how* team leaders facilitated learning. Those who took an active role in motivating the team – communicating a rationale for change and issuing a clear, direct invitation for others' input – and paid attention to mitigating the silencing effects of power discrepancies, made the challenge of learning new ways of working together more palatable. These two leadership strategies both related to helping people overcome hurdles to new, effortful, interpersonally-challenging behaviour: first, *motivating effort* through a compelling rationale, and second creating *psychological safety* by reducing power-based barriers to speaking up. Thus, effective team leaders emphasized helping patients or being on the leading edge of innovation to motivate the team and acted in ways that downplayed power difference, noting their own fallibility or elevating others' importance.

These categories present two dimensions upon which team leader behaviour can be measured, and although I did not see evidence of it in these data it is possible that a team leader might emphasize one and ignore the other. For example, a leader may work hard to ensure psychological safety for speaking up, but not provide much in the way of rationale and motivation for exerting the effort to relinquish currently comfortable behaviours.

Implications for Research

Research on teams. This paper joins Kozlowski (2002) in advocating the need for mid-range theory in the team literature. Mid-range theories recognize that teams vary greatly across types and contexts, such that theory building is appropriately grounded in specific contexts without being so arcane as to be of little value to other contexts. The context of cardiac surgery is on the one hand highly specific and idiosyncratic; on the other hand, these teams share important features with teams in other contexts. I introduce the term interdisciplinary action teams (IATs) to capture core dimensions of these similarities. Action teams face needs for coordination of member actions in uncertain situations; being interdisciplinary introduces differences in expertise and power that can threaten this coordination. Other teams in this category include many in health care delivery, as noted above, as well as change implementation teams including those installing new equipment in manufacturing contexts.

This study extends earlier work on teams as self-correcting units – catching errors before they have consequences (Edmondson, 1996; Hackman, 1990) – and on groups in high reliability organizations (Weick, 1993) by shedding light on *how* the ability to self-correct can be developed. Past work has found that high-reliability teams need to coordinate tacitly, quickly, and unselfconsciously, but has rarely examined how teams make the transition from old to new routines. Future research should examine the two dimensions of team leadership discussed here and whether they vary independently of one another and what their effects are on team outcomes.

The data suggested that proximal leader behaviour and interpersonal dynamics explain more variance than organizational context in learning in interdisciplinary action teams. In making this observation and in providing insight into *how* leaders promote learning, this paper contributes to a nascent literature providing useful guidance for leading teams (Kozlowski et al., 1996).

Research on speaking up and voice. This study adds to the literature on speaking up, in particular by advocating the importance of attention to speaking up in the context of doing one's job, especially while learning new tasks. Other work has emphasized that speaking up is integral to organizational citizenship behaviour (Van Dyne et al., 1994) and important for taking action to change employee conditions or to change some aspect of how the organization works (Morrison and Phelps, 1999). This study puts the emphasis on speaking up as an aspect of in-role behaviour, especially when roles are shifting or when doing one's job under conditions of task interdependence and uncertainty.

Limitations

A multiple case study design has both strengths and limitations. In this paper I have tried to leverage the former – in particular by using qualitative data to develop new insights about team leadership – and to minimize the latter. Nonetheless, methodological concerns remain. The sample was small for quantitative tests, and the reported correlations must be considered suggestive of theoretical relationships that require future testing. The interview measures, developed inductively by exploring what factors varied and how they varied during data collection, lack validation. At the same time, these measures capture a variety of issues relatively systematically across 16 sites and suggest new approaches for measuring a number of constructs in multiple case study research. Each measure at each site benefited from being discussed in team meetings in which the multidisciplinary backgrounds of the interviewers prevented us from oversimplifying what we saw in the field. Lastly, independent coding of some of the qualitative data was used to increase confidence in the measures.

Aspects of the cardiac surgery context predisposed the findings. Team leaders have far more power than other team members, increasing the others' interpersonal vulnerability to sanction. Without the surgeon signalling that speaking up is acceptable and desirable, OR team members struggled painfully with the risk of speaking up. Hence, team leadership may be especially important in this, but not all, settings. Equally important, speaking up was integral to effective use of the new technology and so affected implementation success in ways that may not turn out to be characteristic of the work of other action teams. More research is needed to develop the leadership dimensions and the quantitative measures introduced in this paper. Reflecting on the specialized context of this study, I speculate that these findings apply to other action teams settings with substantial power or status differences and multiple disciplines within the team.

CONCLUSION

This paper demonstrates the centrality of speaking up for individuals engaged in interdependent work in intense, unpredictable contexts – especially for teams facing substantial change in how members must work together in these contexts. The teams studied here faced both technical and interpersonal learning challenges; they had to learn to use new equipment and how to interact with each other in a profoundly new way – if they were to succeed in implementing a radical new technology for conducting cardiac surgery. They also had to grapple with boundaries created by differences in expertise, hierarchical level and organizational department while learning to use the technology. Past research has found that these boundaries inhibit communication and learning; this study shows some of the ways that teams can overcome them.

First, coaching by team leaders facilitated willingness to speak up openly in the team and to communicate with others in the organization about the changes; these behaviours together constituted a multifaceted team learning process that enabled successful implementation of the new technology. Teams lacking these practices did not succeed in their implementation efforts.

Second, two leadership strategies for enabling learning in teams emerged from analysis of qualitative data. First, some leaders articulated a motivating rationale for change and for speaking up, helping to make the effort and risk of speaking up worthwhile. Second, these leaders created psychological safety by acknowledging their own fallibility and by emphasizing teamwork – both of which served to downplay the power imbalance in the team. Those who engaged in these behaviours led teams in which members were more comfortable speaking up with observations, concerns and questions, helping them to change team routines as necessary. The former strategy created an explicit and compelling reason to speak up; the latter mitigated power imbalances that inhibit speaking up.

Other teams that face challenges similar to the interdisciplinary action teams studied here include steering teams leading organizational change initiatives, product development teams developing radical new products, and emergency room teams implementing new protocols. Each of these teams includes both disciplinary and power differences and each faces uncertainty and risk. Their members must take action without fully knowing the results. This study suggests that such teams can overcome this uncertainty to accomplish challenging goals, when they have leaders who facilitate interpersonal risk taking. In this way, leaders at the front lines of change implementation can help teams – and by extension, their organizations – learn by promoting speaking up.

NOTES

[1] In this paper team leader refers to an individual who is a member of a team but has special responsibility to help guide team activities, as opposed to an outsider who guides the team but is not involved in executing its work.
[2] Psychological safety and beliefs about how easy it is to speak up on the job are virtually synonymous; psychological safety encompasses a belief that it is easy it is to speak up; speaking up is a behavioural manifestation of that belief. Research measures are unlikely to distinguish between these.
[3] All company, product, hospital, and individual names are pseudonyms.
[4] Together we represented the fields of economics and operations management, medicine, quality improvement and statistics, and the author's field of organizational behaviour. The interview protocol is available from the author.
[5] In almost all cases, interviewers selected a common code for all constructs discussed in this paper. The few discrepancies were resolved by discussion, citing evidence from multiple interviews capturing responses to the same question.
[6] Other initially interesting variables were dropped as they either did not vary, or were not measurable because informants did not recognize them as salient.
[7] To assess within-site consistency, I used analysis of variance, with the numerical codes as the dependent variable and hospital identity and the independent variable; results verified within-site similarities and between-site differences for both variables (see Appendix for details).
[8] The research assistants were rating interviewers' notes and thus testing whether their ratings would replicate interviewers' ratings; however, raters did not know which hospital a given quote came from – preventing bias about the sites and precluding a cognitive tendency to impose within-site consistency. Further, the raters assessed additional data because they had all quotations related to speaking up, not just those in response to a specific question targeting this issue.
[9] Values of each variable are thus ranked from smallest to largest and Pearson correlations are computed on the ranks.
[10] In these cases, the team converted to the standard procedure, opening the patient's chest after having gone through the effort of setting up the balloon clamp. Poor results referred to the usefulness of the technology, not to patient outcomes, which were uniform across sites. A tendency to be conservative in their use of MICS resulted in fewer deaths (approximately 2 per cent) than the rate for conventional cardiac procedures (2.5 per cent).
[11] See Table IV for another team member's report of the same incident.

APPENDIX: QUANTITATIVE MEASURES DEVELOPED FROM INTERVIEW DATA

Group-level Variables Designed into the Interview Protocol

(1) The number of operations reported by informants as conducted by the team attending formal training was averaged across informants within a site. The espoused strategy for team stability was coded into one of four categories by interviewers: (4) deliberately kept the team stable for 10–15 cases, (3) kept the team stable with staged inclusion during early cases, (2) allowed immediate inclusion of new members, and (1) allowed immediate substitution of new

members. These two correlated variables (see Table I) were standardized and averaged to produce a measure of *team stability*.

(2) Two variables coded responses to questions about team preparation; one assessed who participated in a dry run of the new procedure, ranging from (0) no one, to (1) only one of the four OR team member disciplines, (2) two disciplines, (3) most of the team (4) the entire multi-disciplinary team (four disciplines); the other assessed session content from (0) no session/no content to (1) technical review of equipment and procedures, or (2) technical review together with thorough discussion of communication such as how the team would talk and interact. These two variables were correlated (0.93) and added together to make a composite variable measuring *team preparation*, ranging from 0 to 6.

(3) *Procedure innovation* – the extent to which a team used the technology in novel ways or for novel patient populations – was the sum of three dichotomous variables: (1) introducing innovations in the MICS procedure, (2) using MISA devices for procedures previously considered impossible, and (3) deliberately changing patient eligibility criteria.

(4) *Boundary spanning* was the sum of three dichotomous variables assessing reciprocal communication between adjacent groups in the care process for cardiac surgery patients (OR team/cardiology, OR team/ICU and OR team/floor).

(5) *Ease of speaking up (interviewers)* was assessed with a single variable. Informants were asked for stories about what they would do (or had done) if they noticed a marginally adverse indicator in one of the visual or numerical monitors – one that presented a situation in which the patient was in no immediate danger but might be a problematic trend. Responses were coded on a three-point scale: the atmosphere and interaction in this team is characterized by (3) open reciprocal communication (very free and effortless), (2) respectful but guarded communication (picking the right moment to speak, pronounced awareness of power differences) and (1) communication that is quite limited, with some members extremely hesitant to speak up.

Organization-level Variables Designed into the Interview Protocol

(1) To assess *history of innovation*, interviews asked about other cardiac surgery innovations adopted or clinically evaluated at the hospital. Responses were coded as (3) extensive (when all recent innovations in cardiac surgery had been tried at that hospital), (2) high (when all or almost all recent innovations were tried, (1) moderate (when 1 or 2 had been tried), (0) none (when no previous cardiac surgery innovations had been tried).

(2) Interviews assessed hospital *management support* during MICS adoption as (4) initiated plan and promoted it actively, (3) supported MICS adoption, although surgeons or (2) neutral initiated it or not involved, (1) opposed MICS.

(3) *Information infrastructure* measured the extent of data collection and use. Hospitals varied in the way data on cardiac surgery procedures were used and who used them. In some, data were used for research and academic publishing only; in others data were used for a range of applications including research, benchmarking and quality improvement. An interview variable ranging from 0 to 6 counted the number of different uses of data at each site. Another ranging from 0 to 9 counted the number of administrative and clinical groups using the data. The sum of these two variables created a measure of information infrastructure, ranging from 0 to 15.

(4) Responses to an interview question about factors limiting the number of MICS cases performed at a site suggested three organizational barriers to implementation: (1) capacity constraints (in operating room and/or surgeon time – the long MICS procedures consume more of these resources than conventional surgery), (2) high cost of the MISA product, and (3) lack of referrals for MICS. *Resource constraints* was the number of barriers (from 0 to 3) identified at each site.

Independent Ratings of Transcribed Qualitative Data to Create Two Additional Variables

Team leader coaching. Two research assistants rated 613 quotes previously identified as related to team leader behaviour on a three point scale from high (creates an open environment, leads discussion, creates trust, advocates teamwork) to low (doesn't coach, doesn't listen to others, doesn't trust the team, disregards importance of teamwork). I conducted a one-hour training session for the raters on how to assess both sets of quotes, using a written guideline specifying typical markers of each point in the two scales. Raters had the option of using a 9 to indicate that a quote was not relevant to coaching behaviour; 262 of the 613 quotes received a scaled rating and the others quotes were related to leader behaviour but not to coaching. Quotes were not identified by hospital and were scrambled. At the individual-quote level of analysis, interrater reliability was high for both measures: Spearman Brown up, R = 0.89 and 0.85, respectively (Rosenthal and Rosnow, 1991). One-way ANOVA showed that ratings of quotes were similar within and varied significantly between hospitals ($F(16,262) = 7.15$, $p < 0.001$), supporting aggregation to a group-level measure. The correlation between the two raters' scores at the quote level of analysis was 0.80 (n = 613) and at the group level was 0.94 (n = 16); the two raters' scores were averaged to produce one measure of coaching behaviour.

Ease of speaking up (raters). Additionally, two research assistants rated 168 quotes previously coded as relevant to 'ease of speaking up' on a three-point scale from high (easy to speak up about anything on one's mind) to low (people appear to be very uncomfortable speaking up and only do it under extreme duress). Raters used a 9 to indicate that a quote was not relevant to the construct only once. One-way ANOVA showed significant differences in ratings across hospitals ($F(16,168) = 7.66$, $p < 0.001$) but no difference across professions within hospitals ($F(4,168) = 0.29$, $p = 0.75$). The correlation between the two raters' scores at the quote level of analysis was 0.75 ($n = 168$) and at the group level was 0.94 ($N = 16$); the two raters' scores were averaged to produce one measure, then aggregated to produce a group-level measure – which was significantly correlated with psychological safety ($r = 0.62$, $p < 0.01$).

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