Disrupted Routines: Team Learning and New Technology Implementation in Hospitals

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This paper reports on a qualitative field study of 16 hospitals implementing an innovative technology for cardiac surgery. We examine how new routines are developed in organizations in which existing routines are reinforced by the technological and organizational context. All hospitals studied had top-tier cardiac surgery departments with excellent reputations and patient outcomes yet exhibited striking differences in the extent to which they were able to implement a new technology that required substantial changes in the operating-room-team work routine. Successful implementers underwent a qualitatively different team learning process than those who were unsuccessful. Analysis of qualitative data suggests that implementation involved four process steps: enrollment, preparation, trials, and reflection. Successful implementers used enrollment to motivate the team, designed preparatory practice sessions and early trials to create psychological safety and encourage new behaviors, and promoted shared meaning and process improvement through reflective practices. By illuminating the collective learning process among those directly responsible for technology implementation, we contribute to organizational research on routines and technology adoption.●

Adopting new technologies is essential to sustained competitiveness for many organizations. In both manufacturing and service industries, new technology can lead to product and process improvements that produce tangible market advantages—but these advantages can be elusive. Failure to adopt innovations, even those with demonstrable benefits, is commonplace (Kimberly and Evanisko, 1981; Tushman and Anderson, 1986; Henderson and Clark, 1990). Organizations have been depicted as blind to the existence or advantage of external innovations (March and Simon, 1958), trapped by current competencies (Levitt and March, 1988) or business models (Christensen, 1997), paralyzed by core rigidities (Leonard-Barton, 1992), and handicapped by a lack of relevant expertise (Cohen and Levinthal, 1990)—all leading to a failure to adopt external innovations. Further contributing to the challenge of new technology adoption, organizational routines, which characterize much of an organization's ongoing activity, reinforce the status quo (Nelson and Winter, 1982; Levitt and March, 1988). Organizations develop routines around the use of existing technologies, giving rise to a self-reinforcing cycle of stability (Orlikowski, 2000). Similarly, routines in task-performing groups tend to persist, even in the face of external stimuli that explicitly require a new course of action (Gersick and Hackman, 1990; McGrath, Kelly, and Machatka, 1984). Routines are thus thought to provide a source of resistance to organizational change, and the process through which organizations and managers alter routines remains underexplained in the technology and organization literatures.

Technology researchers point to both organizational and technological features that thwart adoption of innovations. The timing of adoption decisions thus tends to vary within an industry (Rogers, 1980; Baldridge and Burnham, 1975). An organization's history of innovation and the sophistication of its own research activities build absorptive capacity (Cohen

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and Levinthal, 1990) and the ability to recognize the significance of external innovations (Iansiti and Clark, 1994), leading to a greater proclivity to adopt new technologies. Organizational size and resources promote adoption of new technology (Kimberly and Evanisko, 1981), as does senior management support (Yin, 1977). Finally, certain technologies themselves present barriers to adoption; for example, architectural innovations—those with familiar components but new configurations—are often initially misunderstood (Henderson and Clark, 1990).

Following an organization's decision to adopt a technology, users' perceptions and managers' attitudes affect their willingness to use it, which affects implementation success (Leonard-Barton and Deschamps, 1988). Successful implementation has been defined as the incorporation or routine use of a technology on an ongoing basis in an organization (Yin, 1977; Szulanski, 2000). Many studies emphasize the need for organizations to adapt for a new technology to be effectively used (Barley, 1986; Attewell, 1992; Orlikowski, 1993, 2000; Szulanski, 2000). Leonard-Barton (1988) described a need for mutual adaptation by both organizations and technologies. For many technologies, new knowledge must be transferred to enable use—not just technical knowledge but social knowledge about who knows what (Attewell, 1992; Moreland, 1999). Also, technology adoption occurs in stages, presenting different hurdles to adoption over time (Szulanski, 2000). Evidence from a range of studies thus suggests that adopting new technologies in organizations is difficult. Less attention has been paid to understanding the process through which new behaviors and organizational routines are developed when technologies are implemented, a gap this study seeks to address by examining the collective learning process that takes place among interdependent users of a new technology during implementation.

We take the perspective that when a new technology disrupts existing work routines, the adopting organization must go through a learning process, making cognitive, interpersonal, and organizational adjustments that allow new routines to become ongoing practice. In contrast to previous research that emphasizes organizational characteristics, we focus on those directly responsible for implementation—the teams that initially use, communicate beliefs about, and transfer practices related to a new technology. A qualitative study of 16 hospitals that made the decision to adopt an innovative technology for cardiac surgery is used to explore the implementation process and to propose a process model for establishing new routines.

CHANGING ORGANIZATIONAL ROUTINES FOR NEW TECHNOLOGIES

Organizational routines refer to the repeated patterns of behavior bound by rules and customs that characterize much of an organization's ongoing activity (Cyert and March, 1963; Nelson and Winter, 1982). Gersick and Hackman (1990: 69) defined a habitual routine as "a functionally similar pattern of behavior [used] in a given stimulus situation without explicitly selecting it over alternative ways of behaving." The design of a technology often reinforces a habitual routine; for example, the design of a commercial aircraft's cockpit is conducive to certain standard operating procedures for takeoff and landing. The strength of this correspondence can lull teams into executing well-known routines even when external stimuli vary. For example, accustomed to uniformly warm weather, an Air Florida pilot automatically responded in the affirmative to his team member's routine question, "Anti-ice off?" despite the heavy snowfall at Washington, D.C.'s National Airport during the January 1982 takeoff. Tragically, this inappropriate adherence to routine led to the flight's crashing into a bridge over the Potomac River, killing all 74 crew members and passengers (Gersick and Hackman, 1990). The tendency to invoke familiar, routine sequences of behavior in situations in which they are no longer appropriate is well established in the psychology literature (Weick, 1979; Gersick and Hackman, 1990) and has been implicated as a cause of medical and other error (Reason, 1984).

Despite its emphasis on the stability of routines, the organizational literature acknowledges that routines can change. Classic models of organizational routines suggest that they change slowly, through evolutionary processes (Cyert and March, 1963; Nelson and Winter, 1982). According to organizational learning theory, experience with known routines inhibits active seeking of alternatives, but exceptional mismatches between current routines and environmental conditions can provoke change (Levitt and March, 1988). Recent research showed that routines can change when groups spend time reflecting on outcomes of previous iterations of the routines. In a detailed case study of a university housing office, Feldman (2000) found that an annually executed routine for allocating housing assignments was altered after a series of intensive meetings among stakeholders. Gersick and Hackman (1990) proposed several conditions under which habitual routines in task groups are likely to change, including encountering novelty and experiencing failure.

It is widely acknowledged that new technology is a trigger for changing organizational routines (e.g., Barley, 1986; Tyre and Orlikowski, 1994; von Hippel, 1994; Szulanski, 2000). Ethnographic studies provide rich descriptions of routines being disrupted during technology implementation, showing both cognitive and interpersonal changes. Orlikowski (1993) found that cognitive changes in "technological frames," which describe how people think about a technology, facilitated appropriate use of new information technology. Barley (1986) studied two hospitals implementing CT scanners and found that interpersonal "scripts" governing the interaction between physicians and technicians were altered in one but not in the other. In both studies, new technologies led to changes in established routines, but not without a struggle. In contrast to this micro lens on how technology disrupts existing ways of thinking and acting in organizations, stage models of technology transfer (Szulanski, 2000)—which recognize that organizational routines are disrupted by technologies—employ a macro lens that conceptualizes the technology adoption process broadly into encompassing temporal stages. Between these two approaches to studying technology implementation in organizations lies a third approach that investigates the disruption and subsequent learning process in groups.

Collective Learning in Collaborative Work

Technologies that threaten to disrupt organizational routines are those with interdependent users (Attewell, 1992; Orlikowski, 1993). Interdependence requires people to communicate and coordinate to create new routines, thereby participating in a collective learning process. This may involve learning about others' roles (Levine and Moreland, 1999), improvising (Orlikowski and Hofman, 1997), and making numerous small adjustments that facilitate technology implementation (Leonard-Barton and Deschamps, 1988). Research on teams suggests factors that promote coordination and learning in teams in general, including authority structures, psychological safety, and team stability.

Authority structures. Authority structures can promote or inhibit collective learning in several ways. First, those in positions of authority, such as project and team leaders, may influence the technology learning process by coordinating the activities in an implementation project. Second, people are highly aware of the behavior of those in positions of authority or power (Tyler and Lind, 1992) and dependent on them for recognition and preferred assignments (Emerson, 1962; Depret and Fiske, 1993). Thus, by conveying their thoughts about the implications of a new technology, those with power influence others' views, affecting how much effort is invested in implementing needed changes (Leonard-Barton and Deschamps, 1988). Similarly, if leaders hold a particular cognitive frame about a technology, this is likely to affect team members' perceptions of the meaning and implications of the project. Third, when project leaders select other participants, they can ensure an appropriate mix of skills for project execution (Hackman, 1987). By communicating a rationale for and confidence in the special abilities of those selected, leaders may enhance participants' motivation and effort. Finally, team leaders' actions influence psychological safety (Edmondson, 1996).

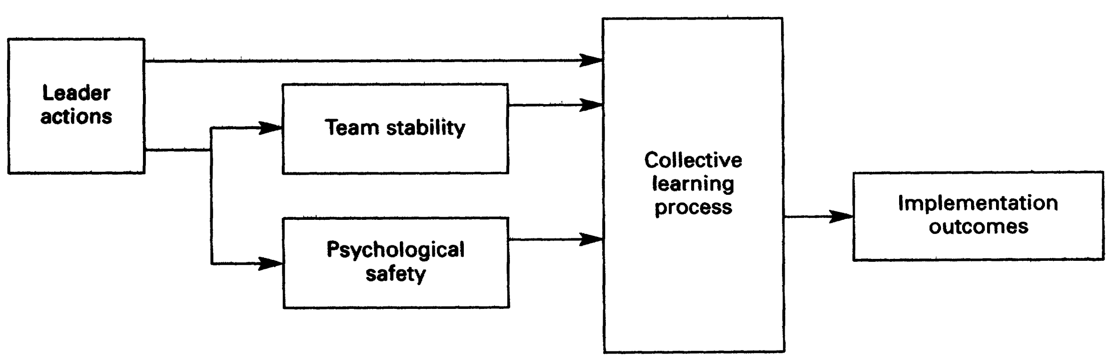
Psychological safety. An organization's interpersonal climate can affect collective learning in a new technology implementation effort. Psychological safety, which describes a shared belief that well-intentioned interpersonal risks will not be punished, has been shown to foster learning behavior in work teams (Edmondson, 1999). The activities involved in learning to use a new technology and in making the organizational changes required to support its use can pose interpersonal and career risks to individuals directly involved. For instance, technology implementation often requires experimentation, using trial and error to find solutions that work (Thomke, 1998), and help seeking (Lee et al., 1996), both of which involve interpersonal risk. Feeling comfortable asking questions and speaking up about concerns is likely to help people use a new technology, particularly one that requires learning alongside other interdependent users. Thus, psychological safety, by allowing interpersonal risks to be taken without fear of material or reputational harm, should facilitate collective learning during technology implementation.

Team stability. The stability of relationships among users can also affect the technology learning process. Initial users of a new technology in an organization may constitute an informal or formal implementation team. The relationship between team stability and team learning and performance is a matter of some debate in the literature. On the one hand, keeping the same team together facilitates coordination of interdependent work. Experimental research has shown that keeping team members together enables learning a new task, because teams develop transactive memory systems, in which members understand one another's capabilities and can more easily coordinate their actions (Moreland and Myaskovsky, 2000; Levine and Moreland, 1999). On the other hand, over time, stable teams may become slaves to routine and fail to respond to changing conditions. Katz (1982) identified a curvilinear relationship between membership stability and performance in product development teams, in which performance initially improved with membership stability but, over time, began to worsen. Given that technology implementation is a temporally bounded process, the risks of excessive stability in which the same team members are together for years are small, and we anticipate that team stability will facilitate collective learning and successful implementation.

Figure 1 depicts relationships among these constructs. Team leaders' actions influence the selection and stability of an implementation team and psychological safety. Team stability and psychological safety are likely to support collective learning and thereby facilitate technology implementation. The present study explores these relationships to develop a model of the collective learning process in implementing new routines.

Organizational factors. As discussed above, researchers have identified organizational size, resources, management support, and innovation history as antecedents of technology adoption. Although our focus is on how individuals and groups grapple with the challenges and disruption of a new technology, these organizational factors may facilitate implementation by reducing barriers that could hinder an effective

Figure 1. Relationships between constructs in the technology implementation process.



learning process, such as lack of resources, time, or experience with innovation.

To address the issues presented above, it was important to identify a new technology that called for changes in organizational routines. To ensure that these changes were challenging to make, we sought a context in which current technologies and organizational structures reinforced existing routines. We also sought an example of technology implementation in which features of the context were held relatively constant, such that efforts to understand differences in success would not be confounded by non-comparable contexts. A new cardiac surgery technology introduced in many U.S. hospitals in the late 1990s met these criteria.

Team Routines in Cardiac Surgery

Across hospitals of varying size, location, history, and academic status, the structure of cardiac surgery departments—especially as manifested in roles and relationships in the operating room (OR) team—are remarkably consistent. Performing a coronary artery bypass graft (CABG) or valve replacement surgery includes many small adjustments and minor differences across procedures due to patient variation and surgeons' preferences, but overall these procedures are highly routine, involving the repetition of a precise set of moves in operation after operation.

This team routine transcends institutions. Professional training in surgery follows widely accepted protocols and uses standard technology, both derived from the research literature with which physicians are expected to remain current. This promotes homogeneity across hospitals. Moreover, cardiac surgery places even more value on standardization than other surgical specialties; the only variation typically found involves specific surgical techniques and details of the operating room layout (O'Connor et al., 1996). Acting within prescribed roles, team members are able to act in perfect concert without discussion; conversation that does occur is typically about an unrelated subject, such as last night's baseball game. As an informant in our study explained, "In [CABG surgery], you look at the surgeon and you know the body language, and you act." The OR team in a typical cardiac surgery department is likely to perform one or two, and sometimes three, open-heart operations each day and, therefore, hundreds each year. All members of the surgical department are assumed to be equally capable of doing the work of their particular discipline, and team members within a discipline are readily substituted for each other. This consistency of practice reduced the likelihood of differences in preexisting routines across sites and thus made it an ideal context in which to investigate whether differences in the collective learning process occurred and whether this affected the implementation success of a new technology.

The cardiac surgery task. Conventional cardiac surgical procedures have three phases. First, the surgeon cuts open the chest, splits apart the breastbone (the "median sternotomy"), and stops the heart. The surgeon then directs the nurse and perfusionist to connect the patient's vessels to a heart-lung bypass machine that regulates oxygenation and blood pressure while the heart is stopped. In the second phase, a clamp is placed on the aorta to prevent blood from flowing backward into the heart while the surgeon repairs diseased components ("stitching"), and in the third, the surgeon restarts the heart, which then fills with blood, allowing the patient to be weaned from the bypass machine and the chest to be closed and stitched by the surgeon. The role of each team member in this routine is well established. Further, because everyone has direct visual access to the heart, each team member can monitor the progress of the operation and anticipate what actions will be needed. For instance, the clamping of the aorta is visually apparent to everyone in the operating room and is a signal to the scrub nurse that the surgeon will soon begin stitching.

A new technology. Minimally invasive cardiac surgery (MICS), an innovation developed and manufactured by a device company called Minimally Invasive Surgical Associates (MISA), differs from the conventional approach in that the patient's breastbone is not split apart.[1] This reduces the extent of pain and recovery time for patients, such that they are able to resume normal activities more quickly than after conventional cardiac surgery. Using special new equipment, the heart is accessed through small incisions between the ribs, and the patient is connected to the bypass machine through the artery and vein in the groin. A tiny deflated balloon, threaded into the aorta and then inflated to prevent blood from flowing backwards into the stopped heart, replaces the traditional clamp inserted directly into the chest (see Galloway et al., 1999, for details).

Balloon placement is the critical challenge the technology imposes on the OR team, requiring coordination among all team members. The balloon's path must be carefully monitored with specialized ultrasound technology, because there are no direct visual and tactile data to help guide the process. Tolerances on balloon location are excruciatingly low, and correct placement is critical. Team members must then continue to monitor the balloon to make sure it stays in place. Thus, unlike conventional surgery, in which surgeons rely on direct sensation, MICS calls for team members to supply the surgeon with vital information displayed on digital and visual monitors. The improvement for patients promised by the technology thus comes at a high learning cost for surgeons and OR teams. As one surgeon we interviewed joked, "[MICS] represents a transfer of pain—from the patient to the surgeon."

The new technology not only changes individual team members' tasks, it blurs role boundaries and increases team interdependence. Successfully enacting this change affects deeply engrained status relationships in the OR team, as the surgeon's role shifts from that of an order giver to a team member in the more interdependent process. As a nurse we interviewed explained,

> When you're on bypass for the standard CABG, there's no need for communication at all. In MICS there's a lot more. The pressures have to be monitored on the balloon constantly. For putting in the balloon and the primary line, the communication with perfusion is

1 All product, company, hospital, and individuals' names are pseudonyms.

critical. It is totally different. When I read the training manual, I couldn't believe it. It was so different from standard cases.

The technology and the organizational and interpersonal context in conventional cardiac surgery are mutually reinforcing, presenting a powerful barrier to the introduction of a technology requiring more team interdependence. We suspected, as Barley (1986) found, that this barrier would be more difficult to overcome in some hospitals than in others, but that collective learning processes, rather than a priori differences in status, would differentiate between hospitals that could overcome barriers to implementation and those that could not.

METHODS

Research Design

We used an embedded multiple case design (Eisenhardt, 1989; Yin, 1989) to investigate 16 hospitals implementing MICS; the design was embedded in that each case encompassed data on organizational factors, such as history of innovation, team factors such as psychological safety, and surgical events, including mortality and complication data.[2] These surgical data allowed a measure of implementation success (how extensively MICS was being used after six months). Throughout site visits and data analysis, we were blind to a hospital's identity in the outcome data set, to minimize its influence on our perceptions of sites. We coded interview data to assess the role of core constructs in each case study, as described below. We also mined qualitative interview data to develop a description of the implementation process.

Sample. At the time of data collection in 1998, 150 U.S. hospitals had purchased the technology. We studied 16 of these, following a theoretical sampling strategy in which we sought variance on organizational factors previously associated with technology adoption. We varied organization size, managed-care penetration, with its associated cost pressures, and type of hospital (academic versus community, as the former has more experience adopting innovations). The sample provided temporal comparability, because all hospitals had adopted the technology within its first year of Federal Drug Administration approval, minimizing differences in industry context or technology improvement that might affect ease of implementation. As the purpose of the study was to develop a theoretical model rather than to characterize responses to MICS across an industry, the sample was not selected to ensure representation of the population of all adopting hospitals but, rather, to include sufficient variation to explore factors affecting technology implementation. Despite participation being voluntary, the sample was not a self-selected group of high implementers; as shown below, we found substantial variance in this measure.

Participation in the study involved one to two days of interviews and allowing us access to clinical data on MICS procedures. MISA provided introductions to hospitals, and all approached agreed to participate. All sites were high-performing cardiac surgery departments, minimizing differences in technical competence that might confound our investigation of an implementation process. Hospitals varied in size, but all had only one OR team using MICS at the time of data

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The goal of the study was to explore factors influencing implementation success and not the clinical effectiveness of MICS. After site visits and data coding were complete, however, we conducted analyses to ensure consistency across sites in clinical outcomes: first, we checked complication rates and mortality rates and found no differences across sites. Second, the overall mortality rate in our sample (1.5 percent) was lower than the mortality rate for standard cardiac surgery (2–2.5 percent), which does not suggest that patients are better off with MICS but that surgeons were conservative in their use of MICS. Further speculation about clinical outcomes is beyond the scope of this study.

collection. Our sample of 16 was larger than needed to reach theoretical saturation (Glaser and Strauss, 1967; Eisenhardt, 1989), but this larger sample enabled detection of consistent patterns across successful implementers and increased our confidence in our understanding of the implementation process.

Data Collection

Phase 1. To familiarize ourselves with the technology and the surgical process, we conducted initial interviews at MISA with senior managers and sales representatives. Next, we attended MISA's three-day training program, accompanying an OR team from a hospital we planned to study throughout its implementation process.[3] During the training, we attended lectures, observed teams as they went through hands-on laboratory sessions, and interviewed team members about how they perceived the technology and the implementation challenge. We then developed a structured interview protocol to assess factors that affect implementation. This instrument, shown in Appendix A, had 41 questions, most of which corresponded to a set of structured responses (visible only to interviewers), with some open-ended questions.[4] To assess psychological safety, we devised ways to go beyond espoused views, as most informants responded "of course" to a question in early site visits asking whether they would speak up if they saw a problem. First, we probed for and obtained specific behavioral events (Flanagan, 1954). Second, we developed a hypothetical OR situation in which the patient was in no immediate danger but a problematic trend was possible and asked informants what they would do. This yielded strikingly varied responses, typically grounded in specific behavioral examples that captured what people actually did as well as how they perceived the team's interpersonal climate.

Phase 2. The three authors and a research assistant conducted 165 interviews at 16 hospitals over a five-month period. All of us participated in the first four site visits to promote consistency in using the protocol and recording data; a team of two to three of us visited each remaining site. Our different disciplines—organizational behavior, medicine, and economics—led us to focus on different phenomena, leading to a fuller understanding of the implementation process than any of us could have developed alone. At each site, we conducted an average of ten interviews, including one to three people in each of the four OR team roles: surgeons, anesthesiologists, OR nurses, and perfusionists. We also interviewed hospital personnel who interacted with team members or were knowledgeable about MICS, including hospital administrators, cardiologists, intensive care unit (ICU) nurses, and general care unit (floor) nurses. Interviews typically lasted an hour but ranged from 30 to 90 minutes. We started each interview with an open-ended question asking informants to describe how MICS was going, to obtain their perceptions of what mattered before influencing them with specific questions. Multiple informants at each site were used to obtain different perspectives across roles and to promote the validity of our data by cross checking responses about factual issues.

3
Ultimately, we were not able to study this team further, as it had not yet done a first MICS case a year later, but we recruited a second team at the training session, "Saints Hospital," to join the study.

4
We modified the protocol slightly after each of the first few site visits, adding questions to address issues that emerged as salient and dropping questions that informants could not answer or that showed no variance. To minimize missing data, we recontacted hospitals visited initially to ask questions added later.

Informants' responses were coded using scaled or categorical responses. Each interviewer selected a response and took supporting notes to capture details of informants' answers. We also took extensive notes on responses to open-ended questions, annotated these to clarify potential ambiguities within the same day, and later transcribed them to capture informants' verbatim responses as closely as possible. After each site visit, we held a debriefing meeting as a research team to review our coded responses. In almost all cases, interviewers had selected a common rating; a few discrepancies were resolved by discussion, citing data from different informants' responses to the same question. This generated a small data set with 16 cases, in which each hospital had a single rating for each question.

Data Analyses

We analyzed our data to support two aims: first, to examine the role of leader actions, psychological safety, and team stability, and, second, to describe the implementation process. After all site visits were completed, we analyzed interview data to assess our focal variables and later combed through these data to develop a model of the implementation process. Finally, we analyzed archival and clinical data to compute relative implementation success.

Interview data. A research assistant who had not participated in site visits coded the transcribed interview data, which consisted of informants' descriptions of their teams, organizations, and MICS. Using a software program for qualitative data analysis, the research assistant sorted the transcribed data into seven major categories based on core themes in the interview protocol, then developed subcategories by identifying recurring themes within each category, shown in Appendix B, and finally coded each data unit (ranging from one to several sentences) according to major and minor categories, speaker's profession, and hospital. The coded data set allowed us to compare particular features across hospitals quickly by excerpting all data in the category of interest, sorted by hospital, facilitating cross-case analyses in an otherwise unwieldy data set of 2,015 coded units. We examined variance across sites in leader actions, psychological safety, team stability, innovation history, organization resources, and management support. All of these constructs varied across hospitals, especially the first three. For each construct, we sorted hospitals into three groups (positive or high, negative or low, and neutral) based on evidence in the coded interview data. To illustrate the presence or positive version of a construct in the text and tables below, we selected quotes from hospitals with relatively higher ratings on structured questions. To illustrate the absence or negative version of a construct, we selected quotes from hospitals with lower scores on the construct.

Modeling the implementation process. We used an iterative process to develop an understanding of the implementation process and identify a recurring set of steps (Glaser and Strauss, 1967; Hargadon and Sutton, 1997). To do this, we combed through the qualitative data to follow up on inferences inspired by a remark in an interview or by one of us reflecting on a site visit, and then we would retain, refine, or abandon an inference or category. For example, after hearing informants describe a team's "dry run," we searched data from all sites and discerned a reasonably consistent pattern across more successful implementers. Similarly, informants' descriptions of how and why they were selected for the team surfaced as an aspect of implementation that was highly salient for them. Many inferences made along the way—such as how the organizational status of the adopting surgeon affected implementation outcomes—were abandoned due to insufficient support.

Archival clinical data. We obtained data documenting clinical detail on all 669 operations conducted in each hospital's first six months of using MICS. These data were provided to MISA by every hospital using the new technology; we were given the subset of this data covering the 16 sites in our sample.[5] The time frame in which these data were collected typically extended several months after our site visits were complete. From each hospital, we also collected data on the annual number of cardiac surgery operations. With these and the clinical data, we calculated an *implementation success* index, 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 implementation success and not unduly penalizing small centers for carrying out fewer MICS operations. It is a measure of relative implementation success within the study's time frame, not of ultimate implementation success. We formulated this index in advance of analyzing interview data and computed the results when qualitative analyses were complete.

Analysis of relationships across variables and data sources. We examined relationships between implementation success and team and organizational factors as follows. We ranked hospitals according to the implementation success measure and classified the seven highest as successful or high implementers and the seven lowest as unsuccessful or low implementers.[6] For the purpose of this classification, we ignored the two middle cases, both to reflect the location of step changes in the implementation success index and to avoid drawing an arbitrary distinction between two adjacent sites in the middle. We compared hospitals in the two groups, based on evidence of the focal variables. Table 1 summarizes the characteristics of the research sites, which are sorted by implementation success.

THE IMPLEMENTATION JOURNEY

We found considerable variance in implementation success. Some teams were able to establish new routines to support MICS as an ongoing practice in the hospital; others eventually abandoned the effort. For example, University Hospital expanded its use of MICS to encompass 95 percent of its cardiac valve operations, while, at the other extreme, Deco-

5 All hospitals agreed to give us this access, with patient identifiers removed from the data set.

6 Our sample ranged from hospitals that were among MISA's largest customers to hospitals that later stopped using the technology altogether. Hospitals scoring high on the measure of implementation success thus were considered successful implementers of the new technology, and those scoring low, unsuccessful.

Table 1

Characteristics of Research Sites*

Hospital	Annual number of cardiac bypass operations	Hospital type	Region	Status of adopting surgeon
University Hospital	1200	Academic	Mid-Atlantic	Dept. head
Mountain Medical Center	1200	Community	Southeast	Junior surgeon
Urban Hospital	560	Community	Midwest	Senior surgeon
Western Hospital	1636	Community	Midwest	Senior surgeon
Janus Medical Center	1100	Academic	Midwest	Dept. head
Southern Medical Center	1900	Academic	Southeast	Senior surgeon
Suburban Hospital	2507	Community	Mid-Atlantic	Senior surgeon
St. John's Hospital	1300	Community	Southwest	Senior surgeon
Saints Hospital	1000	Community	Southeast	Senior surgeon
Chelsea Hospital	378	Academic	Mid-Atlantic	Dept. head
State University Hospital	600	Academic	West	Senior surgeon
City Hospital	800	Academic	Northeast	Dept. head
Eastern Medical Center	1600	Academic	Northeast	Senior surgeon
Memorial Hospital	1444	Academic	Northeast	Senior surgeon
Regional Heart Center	3678	Academic	Midwest	Junior surgeon
Decorum Hospital	1330	Community	Mid-Atlantic	Dept. head

Hospital	Number of interviews conducted	Implementation success index	Implementation success group (high or low)
University Hospital	9	41	High
Mountain Medical Center	11	33	High
Urban Hospital	10	30	High
Western Hospital	7	30	High
Janus Medical Center	10	29	High
Southern Medical Center	10	27	High
Suburban Hospital	11	26	High
St. John's Hospital	8	24	—
Saints Hospital	7	23	—
Chelsea Hospital	9	15	Low
State University Hospital	11	15	Low
City Hospital	7	14	Low
Eastern Medical Center	11	12	Low
Memorial Hospital	7	10	Low
Regional Heart Center	8	9	Low
Decorum Hospital	12	6	Low

*Sorted by implementation success.

rum had conducted only a handful of procedures, and by the end of our data collection, its use of the new technology was limited.[7] Organizational differences in size, resources, academic status, innovation history, and senior management support were not associated with implementation success. For example, as shown in table 1, the two groups of hospitals (the seven most and seven least successful) included both small and large centers, with each group having an average size of 1,400 cardiac bypass operations per hospital per year. Both groups had a mix of academic and community hospitals, and, so, being a research institution was not associated with success. Instead, informants' stories drew our attention to the implementation journey traveled by each team and thus to temporal sequence. Data analysis suggested discrete steps through which new routines were implemented as

7
High and low implementer status does not indicate good or poor performance in either conventional or minimally invasive surgery. As noted above, our sample showed no differences in surgical outcomes across sites.

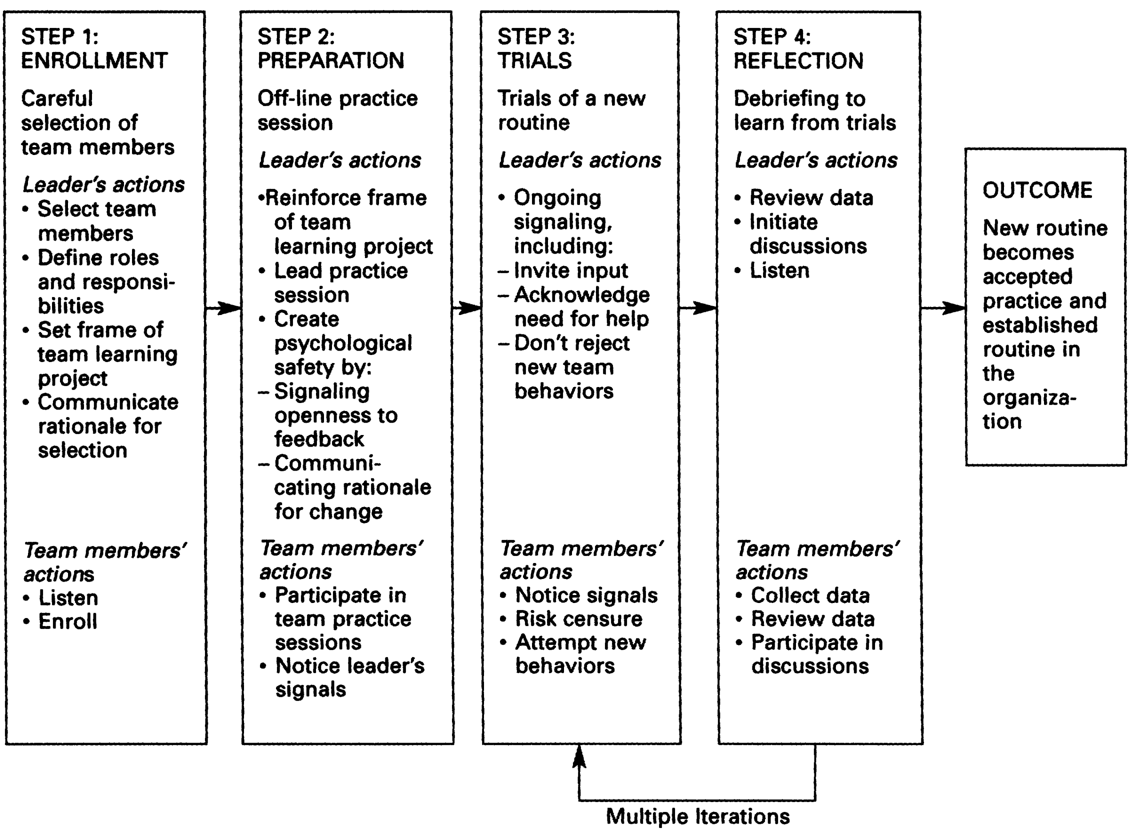
ongoing practice in a subset of the hospitals, which allowed us to develop a process model.

A Process Model for Implementation

These qualitative data suggested that technology implementation is a process, during which new beliefs, new skills, and new collaborative routines are simultaneously developed. Existing research has considered that the transfer of technology and knowledge is a process rather than a single act, but this process has been described as consisting of relatively encompassing temporal stages, such as initiation (which ends with the decision to implement), implementation, full ramp-up, and integration (Szulanski, 2000). In contrast, our data point to subdivisions in the implementation stage, in the form of four discrete steps: enrollment, preparation, trials, and reflection. Enrollment involves selecting and motivating participants for the implementation effort. Preparation describes activities such as practice sessions that simulate use of the technology off-line. Trials involve initial uses of the technology for actual work, and reflection involves discussion of trials among all or a subset of team members, planning changes for subsequent trials, and reviewing relevant data to learn from it for the purpose of informing ongoing practice.

The process model shown in figure 2 presents enrollment, preparation, trials, and reflection as discrete steps, because informants' descriptions conformed well to this delineation,

Figure 2. A process model for establishing new technological routines.



but the process was not always as well defined as the model implies. For example, certain ancillary team-learning activities extend across multiple steps, notably, coordination with other clinical groups in the hospital, or boundary spanning (Ancona, 1990), which took place during preparation and trials and occasionally during reflection and was noticeably higher in successful implementers. Also, while the first and second steps occurred only once during each site's implementation process, the third and fourth steps were repeated—trials followed by reflection, followed by more trials—giving rise to successive iterations that form a learning cycle (e.g., Schön, 1983; Kolb, 1984). Moreover, the process shown in figure 2 characterizes only a subset of the sample; hospitals tended to take one of two distinct paths through the implementation process. Figure 3 depicts the alternative path, which led to failure to implement the technology.

Step 1: Enrollment. Two factors characterized the first step of the implementation journey: (1) whether people were selected for the MICS project for a reason and (2) whether they were enrolled intellectually and emotionally in the project's goals and purposes. Both were determined largely by actions of the adopting surgeon, the team leader. In some hospitals, the leader was highly cognizant of a need to engage people in a team effort, such as by explaining how critical their skills and efforts were to success. For example, at Janus Medical Center, an urban teaching hospital, the surgeon's first step was to put together a special OR team for MICS. After selecting a second surgeon who would be partic-

Figure 3. Activities in sites where implementation failed.

STEP 1: ENROLLMENT	→	STEP 2: PREPARATION	→	STEP 3: TRIALS	→	STEP 4: REFLECTION	→	OUTCOME
Leader's actions • Ask people to participate without providing rationale, or use unrelated rule (e.g., availability) • Set frame of new "plug-in" technology		*Leader's actions* • Don't show up at practice session—view it as a team activity that does not contribute to skilled execution by surgeon of new routine		*Leader's actions* • Take laissez-faire approach to new trial opportunities • Ongoing signaling, including: – Discourage or remain neutral to others' input – Reject new moves made by team members		*Leader's actions* • Data analyzed late in process for academic publishing or department requirement, or not at all		New routine fails to take hold in the organization
Team members' actions • Show up for training		*Team members' actions* • Participate in team practice sessions without leader • Interpret leader's absence as message that team work is not critical • Or, don't hold practice session		*Team members' actions* • Notice signals • Reevaluate new behaviors • Hold back		*Team members' actions*		

ularly suited to "manage data collection," Dr. J deferred to leaders in each of the other three disciplines to select the remaining six team members.[8] Each group selected carefully. Betty, the head of cardiac surgical nursing, selected herself and another highly experienced nurse to participate, because of the challenge of the new procedure. The second nurse, Sophia, reported being selected for the team because "the surgeons recognize how important our knowledge is." Similarly, the head anesthesiologist explained, "the key to success [in MICS] is finding people who are good at what they do and limiting the technique to those people . . . the technique is so challenging that I felt it was best to keep in the hands of a couple of people."

The second facet of enrollment was building motivation, by communicating the importance of what the team was selected to do. The same surgeons who told team members that they were selected for specific skills also communicated that the team's efforts and ability to work as a team were critical for MICS. These team leaders were aware that the traditional hierarchy would make it difficult for others to speak up readily with their observations. As the team leader at Mountain Medical Center, a rural community hospital, explained,

> The ability of the surgeon to allow himself to become a partner, not a dictator, is critical. For example, you really do have to change what you're doing based on a suggestion from someone else on the team. This is a complete restructuring of the OR and how it works. You still need someone in charge, but it is so different.

This surgeon explained that his own behavior had to shift from "order giver to team member" and that he worked to empower and inspire other team members. His message was heard. As one of the perfusionists reported, "The surgeon empowered the team. That's why I'm so excited about MICS. It has been a model, not just for this hospital but for cardiac surgery. It is about what a group of people can do." He further explained that it works because "the surgeon said, 'Hey, you guys have got to make this thing work.' That's a great motivator."

In other hospitals, team leaders did not explicitly select a team. Teams were put together according to availability or seniority, without communicating a rationale. This was true at Decorum, another rural community hospital, and at Chelsea Hospital, an urban academic medical center like Janus, where hospital administrators sent a team to training that consisted of heads of anesthesiology, perfusion, and cardiac surgery nursing. The team leader, Dr. C, was nationally renowned and recently recruited to run and help revitalize the cardiac surgery department. He had significant prior experience with MICS, having performed 60 procedures at another hospital (not in our sample) and worked on the early design of the technology as a scientific advisor to MISA. He did not perceive a need to compose a special team for MICS, however, and did not play a role in its selection. In contrast to the sites described above, when we interviewed team members at Chelsea, no one described being selected for particular skills. Interestingly, the composition of the Chelsea team resembled the one at Janus in that both were characterized

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We use the first letter of the hospital pseudonym to assign names to the team leader. In this section, we draw repeatedly on evidence from a subset of the sample: two academic and two community hospitals. Focusing on a subset allows us to illustrate contrasts in a small number of sites that will become increasingly familiar to the reader, facilitating essential comparisons.

by seniority; however, perceptions of the selection process were strikingly different. When team selection was handled deliberately, it seemed to help "unfreeze" old habits and mindsets (Lewin, 1947). Five of the seven most successful implementers fit the pattern described above at Janus and Mountain, while five of the seven least successful implementers fit the pattern illustrated by Chelsea and Decorum. Table 2 provides evidence for differences in the process steps for the successful and unsuccessful implementers.

Table 2

Evidence Characterizing Process Steps of Successful versus Unsuccessful Implementers*

Step 1: Enrollment	Step 2: Preparation	Step 3: Trials	Step 4: Reflection
	Successful implementers (top 7 by implementation index)		
Deliberate selection of team members for implementation (strong evidence in 5 hospitals)	*Full team dry run, discussing technology and communication* (strong evidence in 6 hospitals)	*Implementing new forms of team communication in the OR* (strong evidence in 7 hospitals)	*Active team discussion of data on how MICS is going* (strong evidence in 5 hospitals)
[The lead anesthesiologist] was selected for his *echo* skills. Don from perfusion is the point man for any new technology. The nurses picked the most competent ones from nursing. . . . (Anesthesiologist, Mountain) [Everyone picked had the most experience.] That was the key: no program can be better than the weakest link. (Surgeon, Mountain) The people who were chosen to go were the best in each department. (Surgeon, Suburban) I was chosen and Libby was chosen because we'd be able to pull it off. We work well together, and we were both chosen for the ability to train others. (Nurse, Suburban) In picking the team, you know what clinical expertise you need. You also need to get people who can do the training of other people. . . . (Administrator, Urban) We had to talk to the [other] surgeons to free people up. The pre-training planning was extensive. . . . (Administrator, Janus)	[To prepare for our first case], we met informally . . . we discussed all of the possible bad outcomes and how we would deal with it. Then, we did a dry run and went through the scenarios that [other surgeon] and I had conjured up. We did a literature search and gleaned all the worst-case scenarios and then took this to the dry run. (Surgeon, Western) We had a couple of talks in advance and the night before we walked through the process step by step. Took two and half or three hours [and] communicated with each other as if it were happening, i.e., the balloon is going in, etc. [Then, Dr. S] gave us a talk about what MICS is about, the kind of communication he wanted in the OR, what results he expected, and [he] told us to immediately let him know if anything is out of place. (Perfusionist, Suburban) We went through the procedure real time, and at each step the surgeon would ask each person, "What's happening now? What are you doing?" He talked through exactly what to do. (Perfusionist, Urban)	[The communication pattern] used to be table [i.e., surgeon] to perfusionist, table to nurse, table to anesthesiologist. Now it is perfusion to anesthesia, nurse to surgery, anesthesia to surgery—all relationships. Everyone communicates. There is a lot of information. There are two or three sources of information—the monitors, the TEE, the *fluoro*—and we all discuss it. (Perfusion, Urban) We all have to share the knowledge. For example, in the last case, we needed to reinsert a guidewire and I grabbed the wrong wire and I didn't recognize it at first. And my circulating nurse said, "Sue, you grabbed the wrong wire." This shows how much the different roles don't matter. We all have to know about everything. You have to work as a team. (Nurse, Urban) We're more of a team in the OR. This is so much more interactive than I ever dreamed it could be. . . . It gave me a new lease on life. (Nurse, Suburban) The team [involves] everybody sharing. If you are wrong, you are told. There are no sacred cows. If somebody needs to be told something, then they are told—surgeon or orderly. (Perfusionist, Western)	We would sit down and discuss every case for the first 20. Before surgery and after. I would discuss them with the whole team. (Surgeon, Mountain) With [the two surgeons] I sit down in a quiet moment to rehash what has happened and how to improve. (Perfusionist, Mountain) Every Saturday morning we review past and upcoming cases. We look at films and say, "Maybe we should try such and such. . . ." (Surgeon, University) We meet constantly . . . we keep data on every patient, every complication . . . then we meet and discuss and decide what we need to do to improve. . . . 3 or 4 nurses are continually reviewing the data. . . . (Surgeon, University) After each case we debrief what could have been done better, what we could have changed. And then, that affects the next case. (Nurse, Urban) It's a morale booster when you get to see that patients did well. (Nurse, Suburban)

Table 2

(Continued)

Unsuccessful implementers (bottom 7 by implementation index)			
Team members selected randomly and/or not included in initial training (strong evidence in 5 hospitals)	*Partial-team dry run or no dry run* (strong evidence in 6 hospitals)	*Little or no change in OR team communication patterns* (strong evidence in 5 hospitals)	*Little or no team discussion of data or of MICS project* (strong evidence in 5 hospitals)
We [nurses] were not invited to go to training. We had hard feelings because of that. Everyone else got to go, but we have an integral role in the OR. (Nurse, Memorial) [*The surgeon had a team sent to training in advance of his arrival at the hospital. No particular criteria were established.*] (Chelsea)	[*Surgeon reported not participating in team dry run, because*] the technical aspects [of MICS] are not much, [so] it was not a matter of training myself, it was a matter of training the team. (Surgeon, Chelsea) [*When asked if he did anything to prepare, surgeon answered,*] Not really. Extensive background reading of course. I felt well prepared. A little trepidation but ready to go. (Surgeon, Decorum) [To prepare for our first case, we] kind of more or less looked at the room. (Nurse/P.A., Decorum) [To prepare for MICS], we had to adapt the setup and change the displays. Everyone was involved but the nurses. (Anesthesiologist, City)	I wouldn't speak up if I weren't confident that a mistake would lead to an adverse outcome. I'm not comfortable hypothesizing. (Anesthesiologist, City) We focus more on the clamp. They watch to see if it's slipping. Monitoring the clamp is a big issue. Otherwise it is not that different from conventional cases. We each focus on a job. We don't need to communicate with each other much. We are seasoned professionals. (Perfusionist, Memorial) [In MICS cases], there's more yelling. There's a greater need for communication between perfusion and anesthesiology. [But, the surgeon does not communicate] all that much. . . . (Nurse, Chelsea) If you saw something that was a problem, you're obligated to communicate, but you'd choose your time. (Nurse, Chelsea) The surgeon doesn't communicate much about what he's doing, but lately he has been wearing a camera. And that made a difference, at least for him. (Anesthesiologist, Regional)	The perfusionists might meet informally, but there are no formal meetings. (Perfusionist, Regional) We've never had a MICS related meeting. (Anesthesiologist, City) There is no evaluating before or after surgery. That's what was wrong with this [process]. (Anesthesiologist, Decorum) Every six months we review the [surgery] data. We separate out the MICS data [in the data set] but only use it if someone asks for it, and then we have it. (Surgeon, State) How is data used? To say, "Look, you're not doing enough cases." Otherwise, there's no use of data. (Surgeon, State)

*Summaries of evidence (in italics) of activity in the process steps in the top-seven versus bottom-seven implementers are followed by the number of hospitals in which there was strong evidence (of either positive or negative manifestations of each process step) and then by quotations from informants. Strong evidence is characterized by repeated mention (multiple informants at a site) and provision of clear, tangible examples, such as those provided in this table.

Step 2: Preparation. MISA encouraged all teams to undertake a dry run after formal training to practice the new procedure before operating on real patients. Whether and how teams actually did this varied. As illustrated in table 2, high implementers tended to engage in a full-team dry run, in which the surgeon directed a process of walking through a simulated operation, step by step. This practice session provided an opportunity for team leaders to reinforce the "technological frame" (Orlikowski, 1993) established in the team enrollment step of MICS as a team endeavor, in which every team member's role was crucial. These surgeons tended to repeat this novel message, aware, as Dr. M had put it, that it represented "a complete restructuring" and was "so different."

An OR nurse at Mountain described the team preparation step in detail, reporting that team members first wrote up "new protocol sheets for every group [of instruments]. . . . We talked about how the communication would be important, and everyone was involved in [this] conversation—nurses, surgeons, everyone. We developed special trays for MICS, more customized, more streamlined." The practice session then reinforced the message that teamwork was critical to success and that the surgeon would be playing a new, more interdependent role, with other members speaking up with ideas and observations. Similarly, at Suburban Hospital, a community hospital with a large cardiac surgical practice, a perfusionist reported,

> The night before [our first MICS case] we did everything. . . . We'd had a couple of talks in advance and the night before we walked through the process step by step. Took two and half or three hours. We communicated with each other as if it were happening—"the balloon is going in," and so on. . . . [And, Dr. S] gave us a talk about what MICS is about. The kind of communication he wanted in the OR, what results he expected, and told us to immediately let him know if anything is out of place.

In six of the seven high implementers, we heard similar stories. In each case, nurses, perfusionists, or anesthesiologists noted that the surgeon had explicitly told the team he needed to hear from them, that their role was critical. Many also said that this is when they really understood that the surgeon and the organization were serious about the changes. The use of practice sessions illustrates the concepts of learning before doing, as a way of improving later performance (Pisano, 1996), or learning by planning (Argote, 1999) and is similar to Senge's (1990) notion of management "practice fields," in which managers participate, in groups, in simulated experiences in which mistakes can be made and learned from without actual harm to the organization.

In contrast, other sites took minimal steps to prepare as a team prior to the first procedure. At Chelsea, nurses conducted a dry run of the procedure on their own; other members prepared by reading the manual, and the surgeon did not participate in any team practice. He explained that he did not see MICS as particularly challenging, having been experimenting with placing a balloon in the aorta since 1992, so "it was not a matter of training myself, it was a matter of training the team." This description reveals a different technological frame—held and implicitly communicated by the leader—in which MICS is seen as a plug-in technology (Orlikowski, 1993), such that associated activities can go on as usual while a new component technology is implemented. The team at Decorum Hospital also lacked a formal dry run. When asked if the team did anything to prepare for the first procedure, the team leader said, "Not really. Extensive background reading of course. I felt well prepared. A little trepidation but ready to go." His use of the first-person pronoun also suggests a plug-in frame. The lack of team-based practice was confirmed by a nurse: "We kind of more or less looked at the room." All seven low implementers reported a similar pattern in the preparation period.

Step 3: Trials. After learning before doing, teams shifted into learning by doing (Pisano, 1996) in trials of MICS with real patients. As in Steps 1 and 2, leaders' actions continued to provide a signaling function; remaining consistent with their emphasis on teamwork and not sanctioning the efforts of other team members was critical. As part of Step 3, team leaders actively coached the team. For example, at Janus, Betty reported, "[Dr. J] talks everyone through it. He says things like 'Can you see it?' and so on," helping them learn new technical skills. At the same time, he also encouraged new ways of communicating, and as a result, as reported by a perfusionist, "It is no longer surgeon outward; everyone has to talk to each other both ways. And so I have to say to the anesthesiologist, 'Don't do that until the balloon is up.'" Sophia echoed, "For [MICS] everyone is involved in the communication. . . . I always take the initiative [to look at vital pressures] because the surgeon is very busy [stitching vessels]." At Mountain, the team leader often wore a head camera, as a nurse explained, "so others can see what's going on and ask 'Why did you do this then?'"

Data from all seven high (and only one of seven low) implementers showed active team leader coaching. This was associated with psychological safety, assessed in analysis of interview data through evidence that lower-status team members were willing to speak up with observations without being asked directly by the surgeon. For example at Janus, Betty explained, "I am very comfortable speaking up. . . . You have to talk. I have no qualms about it. In a regular case, you can clam up, but in MICS it's too late. There is no chance for recovery." In equating no qualms about speaking up with no chance for recovery, she takes for granted a frame in which the potential value of an observation itself enables one to feel comfortable speaking up against status barriers and historical precedent, a frame that clearly was not shared across the entire sample. Team members at Mountain similarly noted that communication was "much more intensive" and that the "hierarchy [has] changed" so that "there's a free and open environment with input from everybody." An interesting illustration of shifts in hierarchical roles came from Urban Hospital, where a scrub nurse, a position senior to a circulating nurse, volunteered a story about her own error and how it was pointed out to her by the junior nurse:

> We all have to share the knowledge. For example, in the last case, we needed to reinsert a guidewire and I grabbed the wrong wire and I didn't recognize it at first. And my circulating nurse said, "Sue, you grabbed the wrong wire." This shows how much the different roles don't matter. We all have to know about everything. You have to work as a team.

The comment that "the different roles don't matter" depicts a profoundly different interpersonal context than in conventional surgery, in which the well-defined roles matter greatly.

In this story we see evidence that the OR team is learning a new kind of teamwork, strikingly different from the conventional surgical procedure, with its sharply delineated tasks.

In trials, some team leaders motivated the others to endure the hardship that learning MICS entailed by focusing on benefits to patients. For example, Dr. J frequently communicated his growing confidence in the technology, and Janus team members shared a belief that patients benefited enormously from the procedure. Sophia enthused, "Every time we are going to do a [MICS] procedure I feel like I've been enlightened. I can see these patients doing so well. . . . It is such a rewarding experience. I am so grateful I was picked." This enthusiasm—almost evangelical praise—cannot be attributed to ease or enjoyment in doing the procedure; Janus team members complained bitterly about the hours of wearing the heavy lead apron required for protection against the fluoroscopic radiation used in MICS.

Trials at Chelsea and Decorum and other low implementers were described in qualitatively different terms from those depicted above. At Chelsea, team members said that communication in the OR did not change for MICS, and as a result, according to Martha, "There is a painful process of finding out what didn't work, and saying 'We won't do that again.' We are reactive. The nurses have to run for stuff unexpectedly." Team members reported being uncomfortable speaking up about problems. Martha said, "If you observe something that might be a problem you are obligated to speak up, but you choose your time. I will work around [the surgeon]. I will go through his PA [physician's assistant] if there is a problem." Although Chelsea team members reported being aware that MICS imposed a need for new communication, they were less confident of their ability to put this into practice. Perhaps as a result, they displayed none of the enthusiasm for working more interdependently that we saw at Janus and Mountain. In contrast to Sophia's "gratitude" when an MICS case appeared on the Janus schedule, Martha expressed extreme frustration with the same experience, telling us, "If I see an MICS case on the list [for tomorrow] I think, 'Oh! Do we really have to do it! Just get me a fresh blade so I can slash my wrists right now.'" The team at Decorum similarly remained entrenched in old communication routines during trials. When asked to describe how communication had changed for MICS cases, one nurse responded, "There's no difference. . . . Only Dr. D and perfusion are talking." Another said, "In Dr. D's room, he doesn't want unnecessary chatter. Period." Jack, a perfusionist, offered an example of a time when he immediately spoke up about a potentially life-threatening problem in an early procedure:

> For example, once when we were having trouble with the venous return, and I mentioned it, the surgeon said, "Jack, is that you?" I said yes. He said, "Are you pumping [being the first rather than second, or assisting, perfusionist] this case?" I said, "No I'm assisting." "Well in the future, if you are not pumping the case, I don't want to hear from you." You see it's a very structured communication.[9]

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The culture of cardiac surgery is hierarchical, demanding, and direct. These data should not be interpreted as indicative of unreasonable behavior by a surgeon but, rather, as consistent with an industry culture that is highly functional in certain harrowing decision-making situations.

Similarly, a nurse told us that it was difficult to speak up openly when she suspected that something might be wrong, such as a possible migration of the balloon clamp (also life-threatening):

> I'd tell the adjunct. Or, I might whisper to the anesthesiologist, "Does it look like it migrated?" In fact I've seen that happen. It drives me crazy. They are talking about it—the adjunct is whispering to the anesthesiologist, "It looks like it moved" or "There is a leak in the ASD" or something, and I'm saying, "You've got to tell him! Why don't you tell him?" But they're not used to saying anything. They are afraid to speak out. But for this procedure you have to say stuff.

To understand this description fully, it is useful to visualize the constrained quarters of an operating room and realize that speaking up such that everyone hears you is virtually a default option. It requires effort to whisper to only one person, hoping to have the information passed along. This nurse's belief that team members "are afraid to speak out" epitomizes an absence of psychological safety. This absence was typical of sites in which the team leader did not explicitly signal a change by framing MICS as a team endeavor and encouraging others to speak up. Some surgeons were not prepared to make these kinds of changes. As a Decorum nurse explained, "[The surgeon] is a creature of habit." Another nurse described his leadership style as follows: "Dr. D is very regimented. Proper decorum in the room is his big thing." We were told in two different interviews that the surgeon was the "captain of the ship" and, in one, that "he's the chairman and that's how he runs the show." In all seven high (and only two low) implementers, trials were characterized by psychological safety and reports of profound changes in OR team communication.

Step 4: Reflection. After, between, and during trials, some teams engaged in reflective practices, including reviewing data, discussing past cases, planning next cases, and suggesting technical process changes. These practices informed subsequent trials. The reflection step was characterized by collective processing of the team experience—including full-team debrief sessions at two sites and partial-team informal but frequent conversations at other sites—grabbing whatever time was available rather than scheduling formal meetings. In all cases, reflection involved an explicit effort to learn from past cases. This characterized five of the seven high implementers and two of seven low implementers. Although some of the other low implementers did collect data and periodically analyze them for academic reports, they were not used as feedback to inform subsequent practice.

The reflection step provides a group-level analog to Schön's (1983) notion of the reflective practitioner, who engages in an ongoing private dialogue with his or her work. Group-level reflection, however, occurs publicly or out loud (Edmondson, 1999). Reflective teams explicitly asked themselves, through formal meeting, informal conversation, and shared review of relevant data, "What are we learning? What can we do better? What should we change?" In four sites—three successful and one not—these discussions led to process changes, including uses of the technology to carry out operations previously considered impossible, changes in patient eligibility criteria, and slight modifications of the equipment. Illustrating the latter at Janus, Betty reported, "[MISA] has been great at R&D. They take our suggestions and they come through with new changes. . . . [For instance, they] put markers on the balloon—that makes it easier. Within nursing we've shared ideas and we keep making changes." Likewise, a perfusionist at Mountain mentioned another process change, in which the team "developed a special perfusion pack for MISA's 3/8th-inch line. We had [another medical equipment supplier] manufacture it for us." Combined with Step 3, engaging in Step 4 created a meta-routine of learning from experience, within which the daily task routines sit. The implementation journey involved multiple iterations of Steps 3 and 4.

A team-learning process reinforced by a technological frame. These qualitative data support understanding MICS

Table 3

Illustrations of Contrasting Technology Frames in MICS Implementation

MICS as fundamental change for the OR team	MICS as a plug-in technology
The MICS procedure is a paradigm shift in how we do surgery. It is not just techniques, but the entire operating room dynamics. The whole model of surgeons barking orders down from on high is gone. There is a whole new wave of interaction. (Surgeon, Mountain)	MICS is routine, but there's a lot more equipment to be gathered. (Nurse, Regional)
When I read the training manual, I couldn't believe it. It was so different from standard cases. (Nurse, Mountain)	The only thing that's [really] different about MICS is the [particular component of the technology], and that doesn't work very well. (Perfusionist, Memorial)
To do MICS, it needs everybody to be working together. . . . (Anesthesiologist, University)	We focus more on the clamp. They watch to see if it is slipping. Monitoring the clamp is a big issue. Otherwise it is not that different from conventional cases. We each focus on a job. We don't need to communicate with each other much. We are seasoned professionals. (Perfusionist, Memorial)
It's changed the way we think about conventional cases. . . . (Anesthesiologist, University)	. . . the technical aspects of MICS are not much [so I didn't need to practice with the team]. (Surgeon, Chelsea).
I thought, this idea would change the shape of heart surgery and would be the wave of the future . . . and University should be involved from the beginning. (Surgeon, University)	We tried to do it our own way. We used our own perfusion apparatus for perfusion activity. But after six cases we did it their way. (Perfusionist, City)
The key to success [in MICS] is finding people who are good at what they do and limiting the technique to those people. . . the technique is so challenging . . . it was best to keep in the hands of a couple of people. (Anesthesiologist, Janus).	[*The surgeon continued to split open the patient's breastbone, using a smaller incision than usual. According to a perfusionist, this was seen as a more safe practice than the recommended approach, even though*] every time I go to a conference, it doesn't seem like we are doing it like MISA says—but having the stenotomy makes the access safer for [patients] so [we don't] take any risks. (Perfusionist, Decorum)
[MICS] allowed us to do cases [i.e., operate on patients] that would have been impossible otherwise. (Cardiologist, Southern Medical Center).	We do it because you want it on your brochure so you can say you offer it. (Perfusionist, Decorum)
[MICS] is not a dictatorship. . . . It's an interactive way to work. (Perfusionist, Western)	
In conventional surgery you look at the surgeon and you know the body language and you act. With MICS you can't do this. (Nurse, Suburban)	
[For MICS to work] you need to keep the team together. We all have to share knowledge. (Nurse, Urban)	
Hospitals in which evidence of each frame was found*	
University Medical Center (1), Mountain Medical Center (2), Western Hospital (3), Urban Hospital (4), Janus Medical Center (5), Southern Medical Center (6), Suburban Hospital (7)	Chelsea Hospital (10), City Hospital (12), Memorial Hospital (14), Regional Heart Center (15), Decorum Hospital (16)

* Implementation success rank (1–16) appears in parentheses.

implementation as a four-step process that centrally involves a team learning to work together to adjust to new constraints and challenges. A pattern emerged in which more successful implementers underwent a qualitatively different process than less successful implementers. For successful implementers, the consistency of a few core attitudes and actions within each of four steps suggest a model for how implementation teams can overcome structural barriers to new technologies. In these data, illustrated in table 3, how team leaders framed the technology and communicated with the team contributed to a particular kind of learning experience. When team leaders communicated that MICS was a team project rather than a plug-in technology around which "business as usual" was expected, teams were more likely to engage in a structured learning process, including team practice sessions, experimenting with new communication behaviors, and team reflection. These activities appeared to foster commitment to establishing a new, initially difficult, routine in the organization.

DISCUSSION

Prior organizational research has emphasized the stability of routines. The innovation literature has found new technology to be an inconsistent catalyst for change. Thus, the process by which new technologies successfully change organizational routines has not been well explained. The data from this study suggest a process theory in which *how* a collective learning process unfolds, after the decision to adopt a new technology, determines whether or not new routines take hold. Existing routines and status relationships in the context of cardiac surgery presented powerful barriers to implementing MICS. Some hospitals in this study were able to overcome these to develop new team routines, others were not. In contrast to previous research on technology adoption, we found that organizational-level differences did not influence this outcome. A possible explanation for this is restriction of range; this research context offered an unusual degree of homogeneity across sites, and our ability to examine effects of organizational factors may be limited. Nonetheless, we also found very suggestive data that show implementation success to be an outcome of differences in the collective learning process at the team level. Although an extensive body of research has identified predictors of technology implementation, few studies have focused on understanding how managers and teams at the front lines of technology implementation can make a difference in the effectiveness of these efforts. This paper thus contributes to theory by suggesting that how teams and team leaders work together to learn and implement new routines matters greatly when new technologies require collective effort by interdependent users.

Influences of Collective Learning on Implementation Success

The role of team leaders. In every site, informants volunteered descriptions of dramatic change, or lack thereof, in which the lead surgeon's behavior was causally implicated. These descriptions consistently suggested that the leaders had to convey permission for others to speak up if they were to change their behavior in the ways that supported the new technology. Non-surgeon team members seemed reliant on surgeons to take the first step toward forging new behaviors; none reported behaviors that suggested working around or trying to influence a surgeon's behavior. In addition to encouraging speaking up, some surgeons frequently communicated the benefits of MICS for patients, helping to instill in the team a sense of meaning in the drudgery of enduring long procedures using initially cumbersome equipment. Anticipating an MICS case on the following morning thus was met by Sophia at Janus with "gratitude" and by Martha at Chelsea with thoughts of "a fresh blade" to slash her wrists rather than going through the procedure again. The technology was, of course, identical at both hospitals. The framing and social construction of the technology was vastly different. Two distinct technological frames emerged: MICS as a plug-in component and MICS as a team innovation project. These frames were held by leaders and communicated to others in subtle ways and seemed to matter greatly in how team members construed the technology and, more importantly, their role in making it work for patients and for the organization.

On the one hand, the finding that team leader behavior influences project success is not surprising. On the other hand, deeply engrained institutional structures and cultural norms in cardiac surgery do not foster the surgeon behavior we observed in many of the successful implementers. The teamwork that members of the cardiac surgery community understand well is one in which every member's job is important to the outcome, albeit some less important than others, while roles that dictate speaking patterns are sharply delineated. Consistent with Barley's (1986) findings, our data do not suggest that surgeons at successful hospitals had to yield their expertise-based authority; instead, they simply adjusted to the absence of visual and tactile data by allowing themselves to be dependent on others for verbal data. A possible psychological explanation for the differences we found in surgeon behavior across hospitals was that surgeons at unsuccessful hospitals could not separate reliance on others for data from loss of expertise-based authority.

Team psychological safety. Although the MISA training program emphasized the need for everyone in the team to speak up with observations, concerns, and questions during an MICS operation, team members' perceptions of the safety of the interpersonal climate in their own team for this kind of behavior varied widely across sites. Our analysis of informants' stories and responses to a hypothetical problematic trend in the OR created a measure of psychological safety that provided rich insight into how team members perceived their situation. When they lacked psychological safety, lower-status team members were unwilling to risk censure by experienced surgeons who might view their comment as useless or disruptive. In this necessarily hierarchical context, psychological safety seemed particularly important for enabling the behavioral change MICS required, echoing early research on organizational change (Schein and Bennis, 1965; Schein, 1993).

Team membership stability. We anticipated but did not find that team membership stability would promote implementation success. It is possible that membership stability creates a tension in which stability enables transactive memory and thus ease of coordination, which could facilitate implementation, but at the same time, increases the identification of a special small team with the technology, which can lead others to reject it. For example, when new work-practice innovations are not diffused quickly in a system, resentment of the attention received by those selected for the effort can generate pressure from others to destroy its success (Walton, 1975). Similarly, if an MICS team is seen as exclusive, this may threaten the technology's acceptability in the broader organization. Thus, for successful implementation over time, the core team necessarily must expand, yet excessive rotation of new members early on may diminish success. This suggests there may be a point at which the project—after gaining some momentum through a focused, stable team—may have to shift to be more inclusive if implementation is ultimately to succeed in the broader organization.

A Process for Establishing New Routines

Technology implementation provided a good context in which to investigate how organizational routines can be changed. First, routines surrounding the use of a particular technology are generally well defined and can be easily identified by informants and researchers. Second, technology-use routines have been shown to be difficult to change (Orlikowski, 2000). Third, the implementation of a new technology creates a specific opportunity and clear starting point for investigating change in routines. Although past research has acknowledged that the decision to adopt a new technology does not guarantee its successful implementation (e.g., Leonard-Barton, 1988; Szulanski, 2000), there has been little work on how to manage the group and interpersonal process to make implementation happen.

Our analysis of new technology implementation in 16 hospitals advances ideas about organizational and group routines. Literature on routines has emphasized stability and the gradual nature of change and described mechanisms, such as selection, through which routines change naturally. In contrast, this paper proposes preliminary normative ideas about how organizations and managers can facilitate establishing new routines, especially when struggling against constraints imposed by historical precedent. Qualitative analyses revealed a four-step process for establishing new routines that both replace and coexist with existing habitual routines. In contrast to Feldman (2000), who found that a group, meeting over many months, changed an organizational routine that took place once a year, we studied a work routine executed by interdisciplinary teams several times each day. Gersick and Hackman (1990) suggested that changing frequently executed routines would be particularly difficult, and our data are consistent with that prediction. These authors also suggested that encountering novelty would provoke new routines. We found, instead, that encountering a new technology led to new routines in some sites but not in others. By the end of data collection, a few hospitals were effectively establishing the new routine as an integral part of the organization's work activities; these hospitals had teams and team leaders that underwent a consistent implementation process that was qualitatively distinct from the process that took place at other hospitals.

In developing a process model for how to implement new technological routines, we have emphasized the role of implementation leaders and built on the observation that technological frames shape the way technology is used (Orlikowski, 1993). Our data shed light on the process through which such frames arise and are communicated in an organization through the efforts of implementation teams. We found that team leaders play a critical role in communicating and reinforcing a particular technological frame, which affects how others think about a new technology and the nature of the challenge it presents. This in turn may give rise to self-reinforcing processes in which use of the same technology process is alternatively seen as drudgery and pain or as opportunity and privilege.

The process model that emerged from these data is, on the one hand, mundane: (1) carefully select a team, (2) practice and communicate, (3) work to encourage communication while experimenting with new behaviors in trials, and (4) take time to reflect collectively on how trials are going so that appropriate changes can be made. This process has much in common with long-standing descriptions of the learning process (e.g., Kolb, 1984) and the quality improvement process (e.g., Hackman and Wageman, 1995). On the other hand, although individual learners have been shown to follow such iterative practices instinctively (Schön, 1983), teams are less likely to do so. Organizational and group factors often conspire to preclude interpersonal learning (Argyris, 1982) and team learning (Edmondson, 1999), especially when teams are multidisciplinary (Dougherty, 1992). Moreover, these simple practices were seen as radical in the context in which we found them. Encouraging low-status OR team members to speak up and challenge high-status surgeons went against the grain of the cultural and structural context of cardiac surgery. This context and its traditions are neither arbitrary nor irresponsibly harsh but, instead, reflect a well-established process that functions effectively. Surgeons have years of specialized training, are medically and legally responsible for patients' care, and conventional surgical technology allows them the highest quality, most direct access to data on a patient's well-being in the OR. The kind of top-down, one-way communication that was problematic in learning MICS can be essential to saving lives in critical moments during conventional cardiac surgery.

Our process model attempts to explain how new routines were implemented in this particular context, and it suggests steps for designing an implementation effort. A range of theories of organizational learning describe adaptive processes that occur naturally, generally not in optimal ways, such as trial and error, selection and retention, and diminishing openness to alternatives (Levitt and March, 1988). In contrast, we propose an iterative learning cycle that must be actively managed by local leaders; in that sense, it is a teleological process model, in which the implementation team acts in ways that are purposeful and adaptive (Van de Ven, 1992). Our findings thus plant the seeds of theory that is as much normative as descriptive (Argyris, 1996).

Limitations

Given the limitations of a case study approach, the ideas in this paper remain speculative. Future research is required to explore our process model in other implementation contexts. Features of this particular context are likely to predispose support for our theoretical emphasis on team learning. First, the technology itself required a team for its use, such that team learning was necessarily involved for mastering technical skills. Second, the homogeneity of the organizational context meant that team process was the primary source of variance across hospitals. Nonetheless, we still faced two important hurdles. We might have found that team characteristics were similarly homogenous across sites—corresponding to the homogeneity of the conventional OR-team routine—or team-level differences may have existed but not affected implementation success.

Our sample was too small for quantitative tests and too large for in-depth observational research at all sites, but the cross-sectional interview design offers several strengths. The data capture a variety of issues relatively systematically across sites, with interview measures that benefited from being discussed in team meetings in which our multidisciplinary backgrounds prevented us from oversimplifying what we saw in the field. Independent coding of qualitative data was used to increase confidence in our coding schemes. Concerns about biases inherent in retrospective accounts were diminished somewhat by interviewing people in the middle of the implementation process, while MICS was still new and uncertain. Our measures did not allow the precision of a large sample survey study in measuring psychological safety and other constructs, but they did provide insight into how people viewed the team leader, the new technology, and the challenges they faced when both came together.

Lastly, given the specialized context of this study, concerns about the generalizability of our propositions must be considered. First, unlike some technologies, MICS was not being implemented in these organizations to fully replace an existing technology in accomplishing the organization's tasks. The nature of variation in cardiac patients precluded MICS ever being used exclusively. This may have increased the challenge for participants, who had to learn to shift back and forth from conventional to minimally invasive technology and yet still not fall prey to the trap of habitual, routine responses when doing the latter (Gersick and Hackman, 1990). It also may reduce the generalizability of our findings to those situations in which new and old technologies must coexist. Second, it is not entirely clear to what extent the propositions discussed here apply outside of the cardiac surgical context. For new technologies that challenge behavioral norms and organizational routines, the models presented here may have considerable applicability. In particular, for technologies in which a multidisciplinary team is involved in implementation, team learning is likely to matter, and differences in the collective learning process are likely to affect implementation success. MICS is a technology for which mastery by one person, even the critical person, separately from a team appeared to be ineffective in ensuring organizational acceptability, as the experience at Chelsea illustrated vividly. For other technologies presenting similar challenges, such as enterprise resource planning (ERP) systems in manufacturing or interactive software tools for team and project management, collective learning processes may be a fruitful area for future research to explain differences in implementation success.

CONCLUSION

The findings in this study suggest that understanding collective learning processes contributes to knowledge about technology adoption and organizational innovation, an area of research that has been conducted almost exclusively using an organization-level lens. Our study suggests an important role for a group-level lens, with attention to how interdependent team members view a technology and the nature of the challenge it presents. How a technology is framed can make the challenge of learning compelling and exciting rather than threatening and painful. This study also calls attention to the role of team leaders rather than the role of senior management in leading change. The high status of these team leaders relative to other team members was both a blessing and a curse. It made others afraid to take risks unless explicitly encouraged to do so, but it contributed to building excitement and courage when others heard the invitation for change as a genuine one.

In an industry context in which individual heroism and skill are assumed to be the critical determinants of important outcomes, this study produced evidence that empowering a team and managing a learning process matter greatly for an organization's ability to learn in response to external innovation. The data in this study did not tell a story of greater skill, superior organizational resources, top management support, or more past experience as drivers of innovation. Instead, they suggested that face-to-face leadership and teamwork can allow organizations to adapt successfully when confronted with new technology that threatens existing routines. These findings suggest the potential to impose an additional challenge on surgeons—and other team and project leaders, who already carry the weight of many burdens. Adding to their need to be skilled individual contributors maintaining sophisticated technical expertise, they may also need to be skilled team leaders who can manage a project and create an environment in which team learning can occur. Similarly, engineers are asked to be leaders in technical firms, which increasingly rely on teams to carry out strategically important projects, including adopting external innovations and developing new technologies internally. As teams become even more widely used to promote innovation in organizations, the need for the team leadership skills and team learning processes explored in this paper may become even more acute.

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APPENDIX A: Interview Questions

1. Can you tell us a little about how MICS got started at this hospital, and how it's going?
2. How were you selected to attend the training at MISA? What issues were considered in staffing the MICS team?
3. To what extent was the group that went to MISA working together as an intact team before training?
4. How many cases did the original team that attended training do together before new people started?
5. Did you do a dry run before the first case? Who was involved? What did you discuss?
6. Is there anything else that you have done to prepare for MICS cases?
7. When you first started doing the procedure, what were the eligibility criteria for selecting MICS patients? What are the criteria now?
8. When you started doing the MISA procedure, how many (surgeons, nurses, perfusionists, anesthesiologists) typically worked on a case? And now?
9. We would like to know if you have made any changes in the procedure, and if so, what, and what was the source and impetus for the change?
10. Have you used MICS components for procedures other than coronary artery bypass graft, mitral valve replacement, or atrial septal defect?
11. Does the team meet to discuss MICS cases?
12. Do surgeons meet on a regular basis to discuss MICS cases?
13. Do other functions meet on a regular basis to discuss MICS cases?
14. During an MICS case, if you thought, for example, that the endoaortic balloon pressure might be [a number that is only slightly high], would you tell the surgeon?
15. Do you know what the surgeon's opinion is on why the department started using MICS technology?
16. When the surgeon makes decisions, does he do so independently or with input from others?
17. How much coaching does the surgeon do with members of the OR team?
18. How comfortable are you speaking up about a problem or mistake with him?
19. Is the adopting surgeon the chief of the department?
20. Can you tell us a little about the adopting surgeon's management style?
21. Do you have planned meetings that include people from other clinical areas? How often? Who attends?
22. When you go on rounds, who typically accompanies you?
23. Can you describe the process by which patients are referred from cardiology to cardiac surgery?
24. Describe the interaction between cardiac surgery and cardiology.
25. Describe your interaction with the ICU . . . with the floor. . . .
26. Who has primary responsibility over patients' post-ICU care? Is there a care-path for MICS patients?
27. Have you ever converted a patient intended for MICS to a median sternotomy? What was the reason?
28. For how many days per year do you attend conferences or professional continuing education programs? What is the nature of this hospital's support for education and development?
29. How many colleagues at other hospitals do you speak with on a regular basis?
30. Why did the hospital start doing MICS procedures?
31. What was the role of the hospital administration in the decision to start doing MICS procedures?
32. Since then, has the administration been active in evaluating or promoting the MICS program? In what way?
33. Who is responsible for the MICS program?
34. What are the most important factors limiting the number of MICS cases thus far?
35. Does the number of cases surgeons do influence their compensation?
36. Five to ten years from now, what percentage of cardiac surgeries do you think will be minimally invasive, not just MICS?
37. Over the past 10 years, how many other major cardiac surgery innovations has this institution adopted or clinically evaluated?
38. Does this hospital do heart transplants?
39. Can everyone see the monitors?
40. Does the surgeon wear a head camera?
41. What is different about working in this hospital, compared with other hospitals in which you've worked?

APPENDIX B: Categories used in Coding Qualitative Data

Major category	Minor categories
Boundary spanning	Cardiology relationship Care paths Echo (ownership of echo technology) Interdisciplinary communication ICU/floor relationships Referral patterns
OR team	Ease of speaking up Culture of cardiac surgery group Communication behaviors during MICS Dry run Debriefing meetings for MICS Planning for MICS communication Selection of team members Team stability
Hospital culture and history	Responses to adverse events This hospital is different because . . . (unique traits) Satisfaction with hospital/job Hospital support for training/continuing education Role of hospital administration Formal processes for technology adoption/ assessment History of/attitude about technology adoption
Team leader	Attitude/behavior of adopting surgeon Attitude/behavior of department head Deliberate choice of team leader Status of adopting surgeon
Data use	Data collection for MICS Data collection/use (in general) Reviewing reports, aggregate data
Views of MICS and MISA	Attitude toward MICS project MISA people/company MICS technology Future of minimally invasive techniques Outcomes/benefits of MICS Reasons for adoption Technical aspects of MICS