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Enabling Software Development Team Performance During Requirements Definition: A Behavioral Versus Technical Approach

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As software development projects continue to be over budget and behind schedule, researchers continue to look for ways to improve the likelihood of project success. In this research we juxtapose two different views of what influences software development team performance during the requirements development phase. In an examination of 66 teams from 15 companies we found that team skill, managerial involvement, and little variance in team experience enable more effective team processes than do software development tools and methods. Further, we found that development teams exhibit both positive and negative boundary-spanning behaviors. Team members promote and champion their projects to the outside environment, which is considered valuable by project stakeholders. They also, however, guard themselves from their environments; keeping important information a secret from stakeholders negatively predicts performance.
(*Information Systems Development*; *Team Processes*; *Case Tools*; *Software Development*; *Managerial Effectiveness*)

1. Introduction

As business increasingly relies on more powerful computer systems and as software becomes embedded in more industrial and consumer products, the need to effectively manage larger and more critical software development projects is acute. In spite of over 40 years of effort, the ability to do so continues to elude us.

The information systems field has numerous examples of highly visible software development failures. For example, the opening of Denver's new international airport was delayed for more than a year, at a cost of more than $1 million per day, due to a software problem in the automated baggage-handling system. The Confirm travel reservation system was recently canceled, with sunk costs exceeding $125 million. And the Federal Aviation Administration is currently five years behind schedule and more than $1 billion over budget in its development of a new air traffic control system (Gibbs 1994).

These costly and conspicuous failures of software development projects point to a serious challenge for IS researchers. We must carefully examine the software development process to understand how to develop

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better systems. A first step is to focus on the requirements phase. Getting the requirements right may be the single most important and difficult part of the software development process (Guinan 1986, Salaway 1984, Holtzblatt and Beyer 1995).

However, the research literature is replete with examples of users' inability to accurately specify their requirements (Edstrom 1977, Boland 1978, Scott and Simmons 1974), and developers are frequently criticized for being both unable to elicit requirements from users (Salaway 1984, Davis 1982) and unwilling to work with these requirements because they seem to think they know what is best for the user (Bostrom and Kaiser 1982, Cronan and Means 1984). If the requirements are incomplete or inaccurate, the final system will not meet the needs of the client population (Salaway 1984, Holtzblatt and Beyer 1995), and a system that does not meet user needs is a failure by definition. In addition to being critical, the requirements determination phase of system development is extremely complex (Davis 1982, Curtis et al. 1988). Given its complexity, requirement determination is typically conducted by teams and thus current theories of group behavior provide a viable lens through which to study the problem (Hackman and Oldham 1980, Gladstein 1984, Ancona and Caldwell 1992, Goodman et al. 1987). Creating common goals and visions for the project, managing team progress and failures, and maintaining a positive group atmosphere are all significant behaviors that take place during the requirement determination phase.

In this research, we study 66 software design teams in 15 companies in order to identify the full range of team dynamics that take place during the requirement determination phase. We direct the study by focusing on the following two questions: (1) what are the group processes exhibited by high-performing software development teams, and (2) what factors enable these processes? To answer these questions, we contrast two views of group process enablers based on the literature—one focused on behavioral factors and the other on technical factors—and empirically test the contributions of each group of factors to the performance of software development teams during requirements definition.

2. Research Model

The first research question addressed by the study is: what are the group processes exhibited by high-performing software development teams? There have been a number of different approaches to examining the processes that underlie effective design and development activities. Drawing on a number of different theoretical rationales such as conflict management (Elam et al. 1991, Robey et al. 1989), problem solving (Vitalari 1981), organizational learning (Salaway 1984), and control theories (Henderson and Lee 1992), it becomes obvious that a valuable way to understand system development is to understand the processes that team members exhibit while working with users and other team members. What other studies typically have not addressed, however, are the broad range of team group processes inherent in requirements determination and the factors that influence them (for an exception, see Robey et al. 1989).

In this study we incorporate a number of theoretical perspectives, focusing on group process theories. The basic premise of these theories is that performance is a result of the interactions and dynamics among team members (McGrath 1991, Hackman 1990, Gladstein 1984). We apply this premise to IS teams by focusing on the group processes the teams exhibit during requirements determination.

The second research question this study addresses is: What factors enable the group processes exhibited by high-performing teams? There are at least two distinct perspectives on these issues. Some researchers have argued that tools and methods will enhance or impede group processes (Dennis et al. 1988, Henderson and Cooprider 1990, Sambamurthy and Poole 1992). For example, researchers have focused on specific techniques and methodologies to direct the team in carrying out requirements determination (Davis 1982, Card et al. 1987, Topper et al. 1994). Although results of empirical tests of the impact of methods on development team performance have been mixed (Zmud 1983), it is still generally believed that methods such as Joint Application Development, business enterprise modeling, and structured analysis positively affect the quality of the final requirements (Yourdon 1989, Martin and McClure 1988).

Alternatively, traditional group researchers argue that the behaviors and capabilities of the team members are the major influence on group processes (Hackman et al. 1976, Hackman and Morris 1975, Hackman 1983, Gladstein 1984, McGrath 1984). Research that has focused on the group processes that developers exhibit during requirements determination has found, for example, that communication behaviors are related to stakeholder-rated performance (Guinan 1988).

These two distinct perspectives drive our examination of what influences group processes in the requirements determination phase of the systems development life-cycle. The technologist argues that tools and techniques make the critical difference (Topper 1994, Card et al. 1987), whereas the behaviorists maintain that people, skills, and team characteristics most determine success (Hackman and Oldham 1980, McGrath 1984, Ancona and Caldwell 1992). While no one would argue that either world view is complete by itself, it is our intention to juxtapose the two views in a single study in order to better understand the relative contributions of each. Figure 1 illustrates our guiding research model, presenting the major constructs and relationships. The following section describes each component of this model in detail.

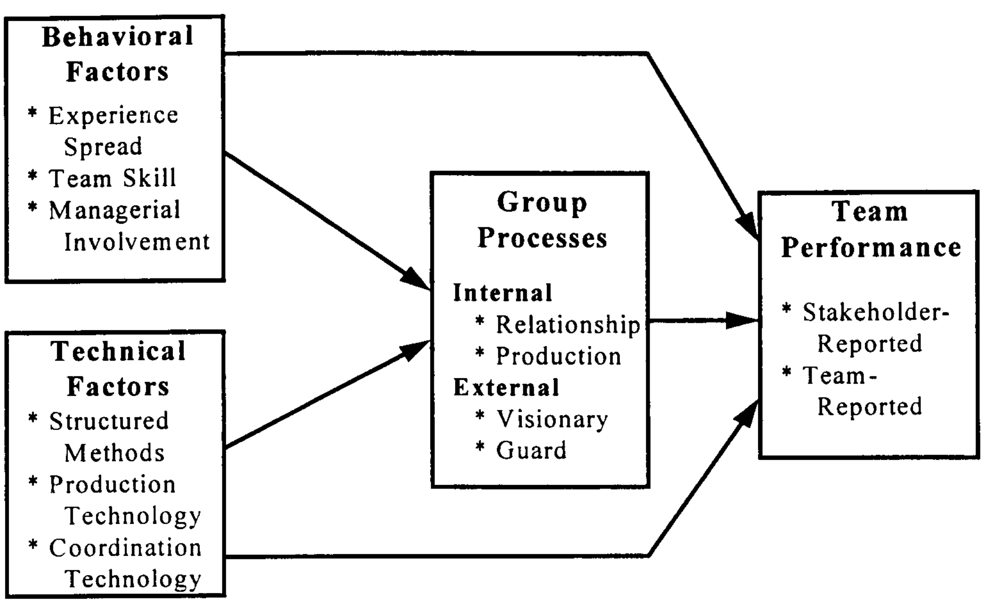
Group Processes and Performance

We begin with a discussion of the group processes that contribute to the successful performance of a group. We divide these processes conceptually into two separate classes: internal and external.

Internal Group Processes. The group process literature has traditionally divided the types of interactions among individuals inside a group (i.e., the internal group processes) into two distinct categories: those that affect the emotional well-being of the team (relationship processes), and those that directly influence the task to be addressed (production processes). Relationship-oriented processes "build, strengthen and regulate group life" (Bales 1958), while production processes enable the group to "solve the objective problems to which the group is committed" (Philip and Dunphy 1959).

Relationship Processes. Relationship processes regulate and strengthen internal group interactions. Such relationship-oriented activities aim to create an environment in which team members share positive, friendly feelings toward each other as well as a sense of loyalty and responsibility toward each other and a common goal (Festinger 1950). Value is placed on open communication, supportiveness, commitment to the

Figure 1 Conceptual Model



team, and positive interpersonal relations (Collins and Guetzkov 1964, Argyris 1966, Dyer 1977, Kiesler 1978, 0'Reilly and Pondy 1979).

The relationship between relationship processes and performance has been more assumed than theoretically derived or empirically documented (Goodman et al. 1987, Levine and Moreland 1990). However, development projects frequently last considerable lengths of time and require extensive coordination among members (Kraut and Streeter 1994) and considerable commitment by individuals to behave like a team (Henderson 1987, 1988). Thus, relationship processes may prove a particularly important contributor to the cause of building better systems.

Hypothesis 1a. *Relationship processes are positively related to team performance.*

Production Processes. Decision theorists have identified specific types of production activities critical to improving team performance (Pounds 1969, Van de Ven 1974, Hackman et al. 1976, Hoffman 1979). They include maintaining the team's schedule, providing effective plans for coordination, and exploring the best ways to ensure the effective flow of work between team members (Hackman et al. 1976, Hoffman 1979, Van de Ven 1974). Locke et al. (1987) and Buller (1986) found that production-related processes such as identifying problems and implementing action plans are important determinants of team success.

In an information technology context, researchers interested in studying the production activities of developers have typically focused on the problem-solving and decision-making abilities of individual system developers (Vitalari 1981)—the team has not been the level of analysis. In a study of software team performance, Henderson and Lee (1992) found that production processes affect performance. This is one of the few studies that has looked at production capabilities from a team perspective. We argue that production processes are important determinants of success.

Hypothesis 1b. *Production processes are positively related to team performance.*

External Group Processes. Teams that manage their external dependencies and are able to obtain critical resources are predicted to perform better than those that only manage their internal dynamics (Allen 1969, 1970, 1977; Pfeffer 1972, 1986; Pfeffer and Salancik 1978). In research and development laboratories, for example, communication across boundaries is critical for team success (Allen 1984; Katz and Tushman 1981; Tushman 1977, 1979). Successful new product design teams manage their lateral communication with individuals who are not formal team members to complete their work (Gladstein 1984, Ancona and Caldwell 1990).

Communication across organizational (e.g., departmental) boundaries is both inefficient and prone to bias and distortion (Dearborn and Simon 1958, March and Simon 1958, Wilensky 1967). One way to deal with the difficulties in communicating across organizational boundaries is to develop special boundary-spanning roles (March and Simon 1958, Thompson 1967, Aldrich and Herker 1977). While significant attention has been paid to the importance of boundary spanning, little research has attempted to discuss and operationalize the specific activities that individuals perform when exhibiting these roles (Tushman 1977). Ancona and Caldwell (1988) describe the activities related to boundary spanning in new product development teams. They found that high-performing teams generally engage in more externally oriented activities than do low-performing teams.

Although IT researchers discuss the importance of managing external boundaries (Markus 1983, Zmud 1983, Bostrom 1982), little research has examined the external activities that development teams exhibit in order to be effective (for an exception, see Zmud 1983). Two types of external activities that are important to understanding the requirements determination task are visionary processes (which help to promote and coordinate the team with outsiders) and guard processes (Ancona and Caldwell's 1988 term for activities designed to keep information inside the team until the team desires to release the information).

Visionary Processes. Visionary activities are aimed at interpreting and influencing the team's environment. They are a combination of the activities Ancona and Caldwell (1990b) label ambassador and scout. Referring back to the familiar role of the gatekeeper in R & D research (Tushman 1977), these activities include attending to external constituents while maintaining or improving the political legitimacy of the group (Aldrich and Herker 1976).

In an IT context, project managers frequently perform visionary activities, but visionary activities are perhaps most closely associated with the role of project champion (Lockett 1987, Reich and Benbasat 1990, Runge 1988, Vitale and Ives 1988). A champion is often a manager who actively promotes IS solutions. Champions normally have the organizational clout and political savvy to overcome resistance to the drastic organizational change brought on by new information systems (Beath 1991).

Hypothesis 2a. *Visionary processes are positively related to team performance.*

Guard Processes. Guard activities (Ancona and Caldwell 1990b) monitor and restrict the teams' external influences. Specifically, guards evaluate requests for information or resources by outsiders and help to determine what information the group will release in response to those demands.

When designing software, these activities may be important to team survival but may operate differently depending upon the project's stage in the life cycle. At requirements determination, guard activities may not be appropriate since involvement and input from all interested parties are required and an open exchange of information is critical to success (Whitten et al. 1989).

Hypothesis 2b. *Guard processes are negatively related to team performance.*

Performance

Historically, the performance of IS design teams has been measured in many different ways. A variety of measurement methods have been proposed and used. Unfortunately, most of these methods have significant measurement problems (Kemerer 1989, DeLone and McLean 1992). For example, due to differences in environments and how costs are allocated, it is notoriously difficult to find objective (e.g., accounting) measures that are consistent across firms, especially in the software development area. We address these problems by using two perspectives of performance: stakeholder-reported team performance and team-reported team performance. First, we view IS development in general—and requirements determination specifically—as an activity intended to produce a product that will affect one or more stakeholders. Stakeholders are individuals who are not team members but influence design activities and/or are affected by the resulting IS. These stakeholders assess performance based on their knowledge of the organizational needs, experience with previous and ongoing system design projects, and their expectation of quality work. For example, Bourgeois (1980) used a panel of managers as judges of a group's performance. Venkatraman and Ramanujam (1987) suggest that perceptual assessments of performance provided by knowledgeable managers (i.e., stakeholders) have a high level of convergence with other objective measures of performance. In addition, using stakeholders helps to eliminate self-report bias of performance ratings provided by team members themselves.

Performance assessments often vary across constituent groups because as constituent groups have different interests and different data (Tsui 1984). For example, several studies of group performance have found differences between stakeholder performance ratings and ratings by team members (Ancona 1990, Gladstein 1984, Ancona and Caldwell 1992). It may be, for example, that team members are more interested in creating a more productive, task-oriented environment, while stakeholders are more interested in the specific outputs generated by the team. In addition, team members have a constant stream of information about team interaction and can use that to evaluate performance. Stakeholders are more distant and frequently rely on specific quantitative data such as meeting budget and schedule commitments. We therefore conceptualize performance in two different ways: the team members' ratings of their own performance and the stakeholders' evaluation of it.

Antecedents of Group Processes: Two World Views. We have outlined the importance of a broad set of group processes—both internal and external—that we believe influence software development team performance. We next contrast two different classes of variables which we believe will influence these group processes during requirement determination: behavioral and technical.

A Behavioral Perspective. The behavioral perspective argues that the capabilities and characteristics of team members are the major influence on group proceses. In presenting this perspective, we focus on three primary determinants: experience spread, team skill, and managerial involvement. Each is discussed in turn.

Experience Spread. Design team composition is an important antecedent to team effectiveness in software design (Brooks 1987, Boehm 1981 and 1987). Aspects of team composition that may be related to team effectiveness include previous experience with the task, which implies the background and organizational awareness/competence to accomplish the task as well as the skills/expertise that the team brings to bear on the project. Previous research in small group behavior emphasizes the impact of experience and team expertise on team effectiveness (Schutz 1966, Shaw 1971, Sutton and Rousseau 1979, Hackman and Oldham 1980).

In this study we examine the experience spread of the team members, rather than experience itself. The demography literature suggests that demographic diversity increases conflict, reduces cohesion, complicates internal communications, and hurts coordination within the team (Dougherty 1987, Kiesler 1987, Pfeffer and O'Reilly 1987). The group literature reminds us of the difficulties incurred when attempting to unify different cognitive attitudes and values (Bettenhausen and Murnighan 1985, Shaw 1971) such as those found on teams with members who have different levels of experience. According to Ancona and Caldwell (1992), "if not managed effectively, this diversity can create internal processes that slow decision making and keep members from concentrating on the task" (p. 323). Although not studied extensively, a few studies have found that demographic variables such as experience spread may act indirectly through processes such as social integration (O'Reilly et al. 1989). To date, previous work in IT has not examined the impact of experience spread on team performance. We argue that experience spread will influence internal and external processes. For example, O'Reilly et al. (1989) found that teams with similar degrees of experience on the job are more socially integrated—they create and experience shared models of the world. It is reasonable to assume then that these teams are more likely to be more cohesive; more likely to engage in relationship-type behaviors. With similar logic, a production-oriented team with similar levels of experience on the job shares the same view of the task and how to accomplish the task enabling a smoother approach to solving design and development problems.

In regard to external processes, experience spread may influence them differently. Specifically we argue that teams that are homogeneous—i.e., have a small degree of experience spread—are less likely to exhibit visionary processes because they are not aware of the need to look beyond their immediate boundaries for help in their problem-solving processes. Based on the work of Allen (1984) teams with little diversity tend to exhibit the "not invented here" syndrome which may translate into their unwillingness to exhibit boundary-spanning processes. Furthermore, a more homogeneous team is more likely to erect walls and turn inward and is then more likely to exhibit guard processes.

Hypothesis 3a. *Experience spread is negatively related to relationship processes.*

Hypothesis 3b. *Experience spread is negatively related to production processes.*

Hypothesis 3c. *Experience spread is negatively related to visionary processes.*

Hypothesis 3d. *Experience spread is negatively related to guard processes.*

Team Skill. Goodman (1986a) points out that when studying work teams, skill is an important ingredient in team effectiveness, yet "no one really knows what skill means or how it relates to other variables" (p. 109). In IS development teams, skill (defined as the breadth of abilities team members provide a group) has been directly related to increased team performance (Curtis et al. 1988, Rash and Tosi 1992, White and Leifer 1986). Brooks (1987) stresses the importance of people factors in addressing the essence of the software development problem. In his view, effective software development requires the use of developers with superior abilities. Boehm (1981, 1987) similarly focuses on the significance of team staffing in relation to IS productivity improvement. He stresses the importance of selecting the most highly skilled people to work on a particular project. Because the productivity difference between exceptional performers and average performers is believed to be so significant in software development, the use of highly skilled team members plays a crucial role in overall project success (Brooks 1987, Boehm 1987).

While this research suggests that skill directly impacts performance, research on problem-solving teams in laboratory settings has found that team skill influences internal processes which in turn influence performance. Specifically, it is established in the group literature that highly skilled team members exhibit both production and relationship oriented processes (Schutz 1996, Shaw 1971, Sutton and Rousseau 1979, Hackman and Oldham 1980).

Gladstein found that more highly skilled team members exhibit more boundary-management activities, but she did not break them down into particular types of processes. We empirically test for different types of boundary-management processes. For example, it may be that highly skilled team members carry out visionary processes but not guard processes during requirements determination. Previous literature does not indicate these differences; hence, based on related work from the networking literature that posits a relationship between gate-keepers and their expertise (Allen 1984, Katz and Tushman 1981), we posit the following hypotheses:

Hypothesis 3e. *Team skill is positively related to relationship processes.*

Hypothesis 3f. *Team skill is positively related to production processes.*

Hypothesis 3g. *Team skill is positively related to visionary processes.*

Hypothesis 3h. *Team skill is positively related to guard processes.*

Managerial Involvement. One of the crucial functions of a manager is to increase the performance of subordinates (Howell 1986). Managerial involvement is believed to influence work team effectiveness (Yukl 1989, Hackman 1984, Hunt et al. 1984). The extent to which and the circumstances under which involvement makes a difference is unclear. Managerial style—formal or informal, participative or autocratic, or the now popular transformational, charismatic leader—has long been the focus of work in small-group effectiveness research (Hoffman 1979, Vroom and Jago 1988, Hackman 1983, McGrath 1984). These authors suggest that the behavior of the project manager within a team is directly related to increased performance. While this may be the case, the prevalent view is that such behavior may be better understood through indirect means. Intervening variables offer a richer, more complete and in some instances unique view of the phenomenon (Howell et al. 1986, Yukl 1989 and 1990, Weed and Mitchell 1980). Similarly, much IT research has not focused on the complex nature of the processes of the project manager in relationship to team performance (for an exception, see Henderson and Lee 1992).

Managerial involvement by the project manager is defined as the relative importance of the formal leadership role of the project manager. Leadership behavior of this kind is based on the theoretical argument that the project manager is perceived by the group as a leader—an individual who by his or her stature on the team has more influence than other members of the team and so carries out particular leader functions that cannot necessarily be shared (Yukl 1989). Thus, managerial involvement is a social process in which the project manager demonstrates a higher level of influence. He or she is more "directive," "hands-on," and "involved" in the day-to-day workings of the team. The approach is a behavioral approach to leadership that emphasizes what managers actually do on the job and the subsequent relationship to processes and effectiveness.

In the context of software development, we posit that the project manager's degree of involvement influences both internal and external processes. We argue that because of the complexity inherent in software development (Kraut and Streeter 1994), the lack of structure in problem-solving (Vitalari 1981), and the role ambiguity experienced by developers (Baroudi 1985), a strong project manager orientation is required (Henderson and Lee 1992). Research conducted by organizational theorists has tested whether such managerial involvement has a stronger direct influence on team effectiveness or a stronger indirect effect through internal and external processes (Hackman and Oldham 1980). Following Vroom's original work, we test this relationship and argue that the type of managerial involovement that is required of project managers in this context will influence both internal and external team processes.

It is reasonable to assume that the more involved the manager, the more likely he or she is to influence production-type processes because he or she is just that much more aware of the day-to-day operations of the team. Along this line, Lee (1989) found that an involved manager exhibited task clarification and work assignment processes similar to our notion of production. Based on the work of Yukl (1989), an involved manager is more a "part" of the team, more drawn into the norms of the team and hence more likely to influence processes.

Previous work has not focused on the relationship between boundary management processes and managerial involvement. Borrowing from the IT literature however, we maintain that the personality type referred to as the "champion" exhibits the type of behaviors associated with these processes, and that the champion is often the project manager. What remains to be seen is whether or not members of the team exhibit these behaviors as well. In regard to visionary processes, because the manager is more involved in the project he or she has a clearer understanding of the team vision for the project and may therefore be better able to "evangelize" it to the larger organizational institution. Likewise, managers may become such a part of the team (Bostrom and Kaiser 1982) that they are unable to distance themselves from the problems associated with keeping secrets from the organization and are likely to engage in guard processes.

Hypothesis 3i. *Managerial involvement is positively related to relationship processes.*

Hypothesis 3j. *Managerial involvement is positively related to production processes.*

Hypothesis 3k. *Managerial involvement is positively related to visionary processes.*

Hypothesis 3l. *Managerial involvement is positively related to guard processes.*

A Technology Perspective

An important issue in the current conceptualizations of team performance is the need to gain a better understanding of the context in which teams operate, focusing on the importance of the technology being used (Goodman 1986a, McGrath 1991, Hackman 1987). By technology, Goodman refers to the equipment—tools, machinery, computers—and the software, methods, and programs directly involved in and or changing an object from one state to another (Goodman 1986a). A recurring question in our field is how and to what extent technology influences the performance of individuals, groups, and organizations.

Clearly, software development teams use a number of "technologies" when performing their tasks. As an example of a leading characterization of the types of tasks performed in software design and development, the impact of structured methods on team performance has been an interesting research question. Although heralded in the practitioner literature as one of the most critical solutions to the software crisis (Yourdon 1975, Martin and McClure 1988, Chapin 1979, Topper et al. 1994), empirical research suggests that the impact of using these techniques is disappointing (Zmud 1983). However, the development community remains steadfast in its belief that the use of structured methods makes a critical difference when developing software (Yourdon 1989).

Structured Methods. Structured methods refers to a philosophy of software development that emphasizes an adherence to a set of consistent rules or methods throughout a project (Yourdon 1975, 1989). Such methodologies are often used by software development teams to manage the inherent complexity of the software development (Pressman 1982). These methods often include broad programs such as systems development life-cycles and information engineering, as well as individualized techniques such as data flow diagramming, data modeling, structured programming, and object-oriented methods. By giving development team members a relatively clear objective and set of procedures for accomplishing their work, these methods can improve both the group's production processes and their ability to work together as a team: their relationship processes (Hackman and Oldham

1980). Further, the use of structured methods encourages stronger communication links with individuals outside the team—particularly users (Yourdon 1989). For example, JAD, business enterprise modeling, and rapid prototyping are designed specifically to help engage the team in the user's point of view (Cooprider and Henderson 1992) and to engage the user more fully in development processes. Because of this, it is expected that teams using structured methods are better able to maintain task commitments and bridge external boundaries—increasing visionary processes and reducing guard processes.

Hypothesis 4a. *Structured methods usage is positively related to relationship processes.*

Hypothesis 4b. *Structured methods usage is positively related to production processes.*

Hypothesis 4c. *Structured methods usage is positively related to visionary processes.*

Hypothesis 4d. *Structured methods usage is negatively related to guard processes.*

Production Technology. Henderson and Cooprider (1990) proposed an empirically derived functional model of CASE technology. Their model presents two dimensions of CASE technology: production and coordination.[1] The view of CASE as an underlying production technology emphasizes the ability of the technology to transform inputs into outputs (Kottemann and Konsynski 1984, Perrow 1967). Although production and coordination technologies are designed to support the entire life-cycle, they are supposed to affect the requirements determination phase of system development in particular (Bustard and Winstanley 1994). Production technology is defined as "functionality that directly impacts the capacity of an individual(s) to generate planning or design decisions and subsequent artifacts or products" (Henderson and Cooprider 1990, p. 232), thus directly affecting the production processes of the development team. In addition to these "first-level" effects on production processes, however, these technologies are also expected to have "second-level" effects that profoundly affect the social contact and attention of the development team members (Sproull and Kiesler 1991). These second-level social effects impact the way developers think and work together. Examples of such social impacts from the use of CASE technology have already been documented in the literature (Orlikowski, 1990). In addition to these inter-team impacts, many development teams are using these CASE production technologies to build system models and diagrams for communicating design issues and decisions with users and others outside the team. Such examples of using productions technology (specifically, representation or modeling technology) to aid communications between developers and nonteam members lead us to expect that production technology enhances the links between team members and users and other stakeholders outside the team—increasing visionary processes and decreasing guard processes. We therefore make the following hypotheses.

Hypothesis 4e. *Production technology usage is positively related to relationship processes.*

Hypothesis 4f. *Production technology usage is positively related to production processes.*

Hypothesis 4g. *Production technology usage is positively related to visionary processes.*

Hypothesis 4h. *Production technology usage is negatively related to guard processes.*

Coordination Technology. Viewing CASE as a coordination technology focuses on the enabling and supporting capabilities of the technology (Malone 1988, Winograd and Flores 1987, Holt et al. 1983). A major role of computer technology is to better support the coordination needs of the organization (Malone 1988). Coordination technology is defined as "functionality that enables or supports the interactions of multiple agents in the execution of a planning or design task" (Henderson and Cooprider 1990, p. 233). Coordination technology is expected to have its most obvious impact

[1]Henderson and Cooprider (1990) actually include a third dimension in their final model: organizational technology. However, they found that this dimension could not be isolated empirically because it affects tool use through its impact on production and coordination. We therefore concentrated our effort on the two empirically validated dimensions of CASE tool functionality.

on team-related work (Cooprider and Henderson 1991, Vessey and Sravanapudi 1995), using messaging and other tools to improve communication between and among team members and relevant outsiders.

The research on group decision support systems (GDSS) provides a specific example of how such technology provides support for the production processes of group work (DeSanctis and Gallupe 1987, Dennis et al. 1988, Kraemer and King 1988). Newer research in the area posits that the technology affects not only production processes but the relationship processes of the team as well (Zigurs et al. 1988, Poole et al. 1991, Sambamurthy and Poole 1992). Thus, as with production technology, coordination technology has both first-level (production/efficiency) and second-level (social/relationship) effects (Sproull and Kiesler 1991). In addition to aiding internal team communication, modern coordination technology enables linkages with critical individuals outside of the team. Such links are particularly important during requirements determination (Cooprider and Henderson 1991). By providing team members with the ability to communicate and share information with critical users and important stakeholders, coordination technology is expected to increase the amount of visionary processes that the team uses, while correspondingly reducing the amount of guard processes. We therefore make the following hypotheses.

Hypothesis 4i. *Coordination technology usage is positively related to relationship processes.*

Hypothesis 4j. *Coordination technology usage is positively related to production processes.*

Hypothesis 4k. *Coordination technology usage is positively related to visionary processes.*

Hypothesis 4l. *Coordination technology usage is negatively related to guard processes.*

Direct Performance Impacts of Behavioral and Technology Enablers

In specifying the role of internal and external group processes as mechanisms that mediate the relationship between enablers and performance, we have drawn upon group, leadership, and coordination theories. Here we have argued that two different world views' a behavioral view and a technology view—identify important factors that affect the processes of the development team, which in turn influence team performance while generating information requirements. However, there is previous research to suggest that what we have labeled enablers directly influence team performance. For example, Boehm (1978) and Curtis et al. (1988) all argue that team skill and experience directly affect performance. Furthermore, what has been called the technology imperative suggests that technology itself will directly influence performance. For example, a number of researchers claim that CASE technology will directly impact the quality and productivity of the development team (Norman and Nunamaker 1989, Chen and Norman 1992, Banker and Kauffman 1991).

Given these different points of emphasis, we now raise two important questions for investigation. First, which view of enablers (behavioral or technological) provides a better explanation for team performance when taking into account their influence on group processes? Second, do any of these enablers directly influence team performance? The following section describes the methodology of our study to address these questions and test the above hypotheses.

3. Methodology

Research Design

The model described in the previous section was tested using a cross-sectional field study of 66 teams performing requirements analysis in 15 organizations. The unit of analysis is the team, since the intent is to understand the behavior of a team as a whole rather than that of the individual team members. The targeted development projects were "mid-sized," with each project expected to take from 12 to 15 months to complete. All projects had business application software as their design domain. Each participating team was surveyed at the end of the systems requirements phase of software development. Thus, all teams worked on a similar class of problems, were studied at the same development phase, and had comparable team size and project duration.

Data were collected directly from members of each team studied. Where possible, all team members were surveyed. In the few cases where reaching all team members was not possible, teams were requested to provide a representative sample of key informants from the team. Using key informant techniques for data collection has been found to be effective for survey research in organizations (Phillips and Bagozzi 1981; Silk and Kilwani 1982).

The 16 organizations participating in the study represent a range of industries, including insurance, financial services, high technology, and both heavy and light manufacturing. For each team, two sets of questionnaires were distributed. First, as requirements definition was completed, project team members were given a survey asking about specific resources used (e.g., technology), work flows, and team-building processes. At the same time, a second survey was sent to senior managers drawn from both the user and IS organizations. These managers had intimate knowledge of the project and a direct stake in its outcome. For each project, one to three project stakeholders answered a brief questionnaire asking for their ratings of IS development team performance during requirements definition.

Out of a total possible 91 yproject teams contacted by the researchers, 66 teams returned both the team member responses and a stakeholder rating, providing a response rate of 72 percent. A total of 369 team members and 110 stakeholders are included in our analysis. Average age of the respondents is 35.2 years; 38 percent of the respondents are female. The average length of the respondents' job tenure at their current organization is 5.3 years, while professional tenure (years in the IS field) is 8.1 years. The mean team size is 5.6 members. Table 1 summarizes the characteristics of the sample.

Table 1 Description of Study Sample

Industry	Number of Companies	Number of Teams	Number of Stakeholder Respondents	Number of Team Member Respondents
Insurance	3	11	14	57
Transportation	2	16	28	95
High Technology	1	8	16	50
Financial Services	4	19	31	89
Oil and Gas	2	4	8	34
Steel	1	3	6	31
Education	1	4	5	11
Pharmaceutical	1	1	2	2
Total:	15	66	110	369

Measures and Procedures

Both newly created and previously validated indicators were used to measure the constructs contained in the research model. All of the indicators used are listed in Appendix 1. Questions were randomized in the actual measurement instrument to counter possible order effects in the responses. Indicators for the two internal group process constructs (production and relationship) were drawn from Hackman (1983). Indicators for the two boundary management process constructs (guard and visionary) were drawn from Ancona and Caldwell (1988, 1990c). For the factors derived from the behavioral perspective, the indicators for two of the group process enablers (skill and managerial involvement) were drawn from Hackman (1983). The experience spread coefficient represents the relative diversity of the team's work experience (number of years of experience in the IS field). The coefficient for each team is calculated by dividing the standard deviation of the team members' work experience by the mean. This coefficient provides a superior and scale-invariant measure of dispersion compared to traditional measures such as the group mean or variance. Pfeffer and O'Reilly (1987) and Ancona and Caldwell (1992) use similar measures to assess the distribution of team members on interval data such as age or job tenure. For the technology perspective, the use of structured methods was measured using three indicators asking respondents to simply characterize the extent to which they were used (see Appendix 1 for details). These indicators were normalized before aggregation to insure consistent scales. The indicators of production technology and coordination technology were drawn from Henderson and Cooprider (1990) and Lee (1989).

This study uses both stakeholder-reported and team-reported performance evaluations taken at the end of the requirements determination phase, using a four-item scale based on Henderson and Lee (1992). Stakeholders were selected from both the IS organization and from the user (client) organization in order

Table 2 Descriptive Statistics and Zero-Order Correlations (*N* = 66)

Variables	Scale Items	Mean	S. D.	1	2	3	4	5	6	7	8	9	10	11	12
1. Team Performance	5	5.25	0.71	(0.73)											
2. Self-Rated Performance	5	5.22	0.60	0.40	(0.86)										
3. Production	4	5.44	0.60	0.40	0.76	(0.79)									
4. Guard	3	1.86	0.96	−0.13	0.13	0.09	(0.73)								
5. Visionary	4	3.83	0.99	0.33	0.19	0.18	0.33	(0.83)							
6. Relationship	4	5.50	0.78	0.15	0.41	0.47	0.01	−0.07	(0.87)						
7. Team Skill	4	4.71	0.73	0.31	0.54	0.60	−0.04	−0.03	0.63	(0.77)					
8. Managerial Involvement	4	4.92	0.66	0.17	0.47	0.53	0.28	0.19	0.61	0.38	(0.75)				
9. Experience Spread	1	0.60	0.29	−0.35	−0.11	−0.08	−0.05	−0.28	−0.01	−0.30	0.09	NA			
10. Structured Methods Use	3	0.13	0.91	0.18	0.05	0.18	0.03	0.11	−0.04	0.14	−0.03	−0.08	(0.84)		
11. Coordination Technology	4	1.28	0.92	−0.01	−0.11	−0.07	−0.03	0.05	−0.13	−0.04	−0.11	0.06	0.22	(0.71)	
12. Production Technology	4	1.39	1.01	0.08	−0.28	−0.16	0.15	0.24	−0.30	−0.06	−0.21	−0.09	0.23	0.57	(0.87)

*Reliability (Cronbach's Alpha) is on the diagonal ($N = 369$). Correlation coefficients greater than 0.27 are statistically significant at $p < 0.05$.

to minimize organizational bias. For each design team, from one to three stakeholders filled out a performance questionnaire. The majority of responses consisted of the rating of two stakeholders, one from the user organization and one from the IS organization. Data analysis (split-sample) undertaken to study the differences between IS organization respondents and user organization respondents showed no significant differences. Thus responses from multiple stakeholders were averaged to obtain a single rating of group effectiveness for the design team as a whole. The team members' ratings are based on the same questions used for the stakeholder ratings, to increase the comparability of the two perspectives.

The measurement properties of the indicators for each construct are shown in Appendix 1. The value assigned to each indicator at the team level is the mean value of all responses to that question by members of the team. This process is justified in two ways. First, for the vast majority of the teams we obtained responses from all team members. This high rate of team coverage provides confidence in the overall representativeness of the responses for the behavior of the team as a whole. Second, other methods of aggregating (such as using the maximum response for the team) were tested and the factor patterns and results remained stable and consistent.

In order to justify aggregation of data from the individual to the group level, a one-way analysis of variance was undertaken on each of the constructs. Results indicated that the differences within groups were significantly less than the differences between groups for each construct. A Bartlet-Box F test was also run in order to test the data's homogeneity of variance. No significant differences were found for any of the constructs. Therefore, all variables were aggregated to group means. Finally, we ran the same homogeneity tests on the group-level data to determine whether there were any organizational effects, but found that there was no significant difference in the patterns of responses among the participating organizations.

Data Analysis

The measurement characteristics of the constructs used in this study were assessed by calculating Cronbach's alpha and performing principal component factor analysis. Appendix 1 provides a list of indicators used in this study and Cronbach's alpha for each of the constructs. They fall between 0.71 and 0.87, all within an acceptable range (Nunnally 1967). In Appendix 2, Tables 2A, 2B, and 2C provide statistical evidence of the convergent and discriminant validity of the constructs in the study. Table 2A presents the results of a principal component factor analysis with varimax rotation on the behavioral perspective factors, Table 2B presents the corresponding results for the indicators of the technology perspective factors, and Table 2C shows the same information for the group process indicators. All indicators loaded onto their proposed factor, thus providing evidence of convergent and discriminant validity for the measures. These results provide evidence that the proposed dimensions are relatively stable and justified. Table 2 presents the zero-order correlations between constructs as well as means and standard deviations.

The hypotheses presented earlier are tested empirically using path analysis. Path analysis was chosen as the analytic technique for this study because of its ability to assess causal relationships (Pedhazur 1982, Loehlin 1987) and decompose effects into direct and indirect components (Alwin and Hauser 1975). The model being tested posits causal relationships from: (1) the enabling factors (behavioral or technology) to performance; (2) group process to performance; and (3) enablers to group process. The required analysis involves three steps. First, the derivation of the path coefficients is based on a series of ordinary least squares (OLS) regressions where normalized path coefficients are used to test the strength of individual hypothesized relationships. Second, we calculate the indirect effects as a multiplicative measure of the standardized beta coefficients of the relevant paths. The third step involves computing the correlation between the enabling factors and the performance variables to determine the total association between each combination, and decomposing these correlations into indirect and direct effects.[2]

[2]We tested the model variables for univariate and multivariate threats to normality. No variable exhibited significant departure from normality. A simple method to identify multicollinearity is to compare the correlation coefficients between variables. All of our variables are well below the 0.8 value that is commonly acknowledged to be indicative of problematical high correlation (Kennedy 1985, p. 150). Because this simple test does not allow the detection of cases where groups of more than two independent variables are multicollinear, we tested for the presence of multicollinearity by means of Variance Influence Factors (VFI) (Neter et al. 1985). This method detects variables that are highly intercorrelated with other variables through a series of multiple regressions between the independent variables. The VFI of our variables were well below the suggested cutoff value of 10 and ranged between 1.1 and 2.7 (Netter et al. 1985, Norusis 1988).

In order to test the hypotheses, we tested the path models shown in Figures 2 and 3 (with dependent measures of stakeholder-reported and team-reported performance, respectively). In these figures, the hypotheses correspond to the various paths illustrating the relationships among the constructs. Specifically, we ran a series of regressions to investigate the strength of the relationships between the behavioral (experience spread, skill, and management involvement) and technical (use of structured methods, production technology, and coordination technology) enabling factors and group processes, and between the performance constructs and the group processes and enablers. These models illustrate that the group process and the proposed enablers explain a significant amount of the variance in both stakeholder reports (adjusted $R = 0.28$, $p < 0.01$) and team reports ($R = 0.58$, $p < 0.01$) of performance.[3]

Table 3 shows the results of these analyses. The path coefficients provide the data for testing our hypotheses, which are discussed below.

Internal and External Processes

Relationship Behaviors and Performance:

> "One of the reasons why we are so successful is because we like each other . . . . we genuinely get along with each other." "We are a cohesive bunch. . . . We believe in the team concept and what it stands for."

Production Behaviors and Performance:

> "The most important thing is to get the job done. With the time pressures we are under project management is extremely difficult."

> "It is all in the task. It is a five phase process, when you finish one phase you go on to the next. . . . We have specific objectives, requirements and deadlines."

> "I want to know what the deliverable was, the major milestone, if you made it or not, if not, why not and what are you going to do about it."

[3]A power analysis undertaken to assess the adequacy of our sample size. We used the commonly specified power level of 0.8 and an alpha of 0.05. We specified an effect size of 0.35 that has been shown to be typical in sociology and economics (Cohen 1988). Even for our larger model (10 independent variables) our sample size exceeded the required minimum of 54 (Cohen 1992).

Figure 2 Path Model 1—Stakeholder-Rated Performance

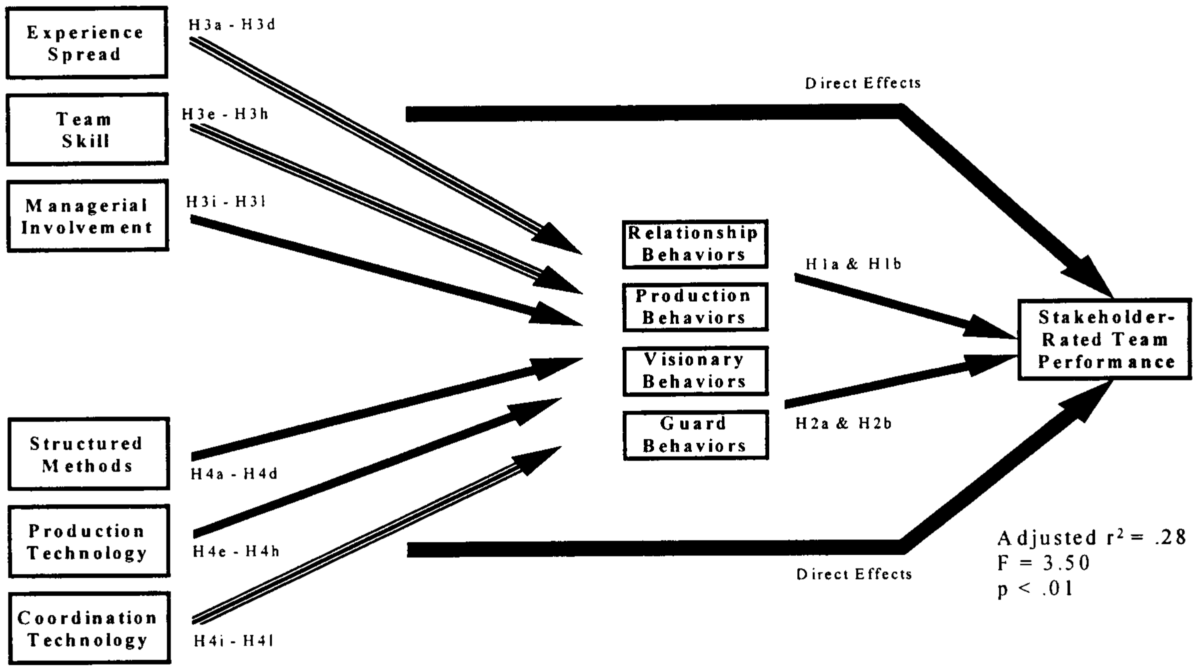


Figure 3 Path Model 2—Team-Rated Performance

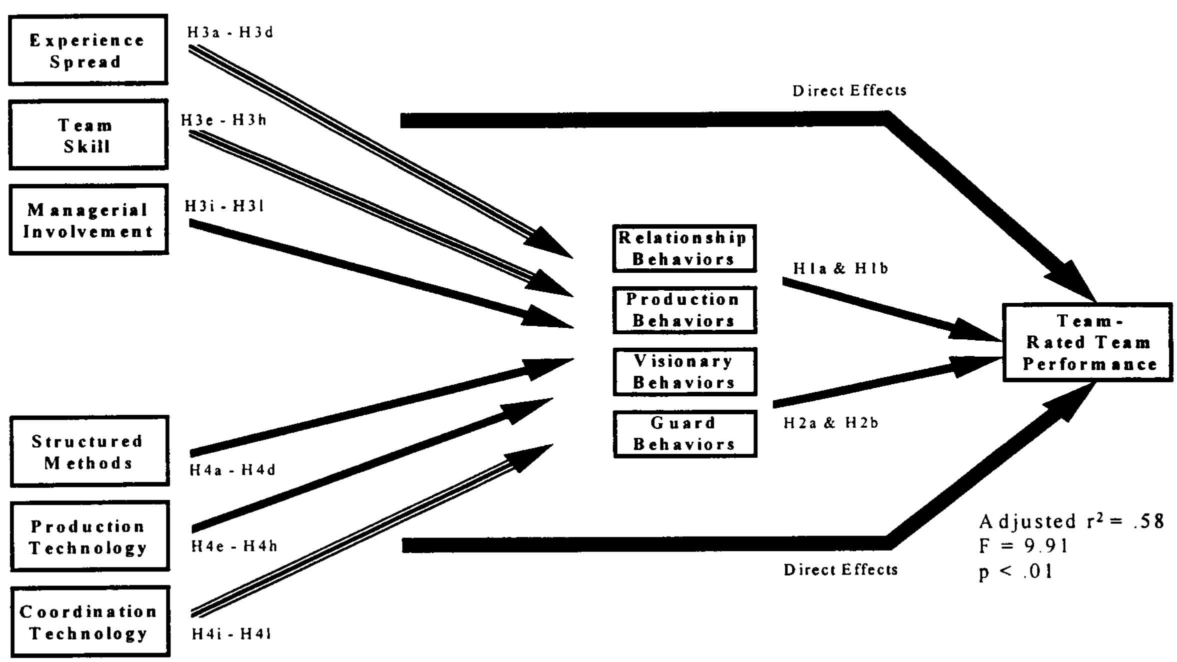


Table 3 Hypotheses Tests from Path Models

Hypothesis	Path	Hypothesized Relationship	Path Coefficient (Standardized Beta)	Hypothesis Supported?
1a	Relationship Behaviors → SH-rated Performance	+	0.01	No
1a	Relationship Behaviors → Team-rated Performance	+	−0.09	No
1b	Production Behaviors → SH-rated Performance	+	0.32*	Yes
1b	Production Behaviors → Team-rated Performance	+	0.56*	Yes
2a	Visionary Behaviors → SH-rated Performance	+	0.25*	Yes
2a	Visionary Behaviors → Team-rated Performance	+	0.13	No
2b	Guard Behaviors → SH-rated Performance	−	−0.29*	Yes
2b	Guard Behaviors → Team-rated Performance	−	0.09	No
3a	Experience Spread → Relationship Behaviors	−	0.09	No
3b	Experience Spread → Production Behaviors	−	0.02	No
3c	Experience Spread → Visionary Behaviors	−	−0.35*	Yes
3d	Experience Spread → Guard Behaviors	−	−0.12	No
3e	Team Skill → Relationship Behaviors	+	0.52*	Yes
3f	Team Skill → Production Behaviors	+	0.44*	Yes
3g	Team Skill → Visionary Behaviors	+	−0.27*	No
3h	Team Skill → Guard Behaviors	+	−0.23	No
3i	Mgt. Involvement → Relationship Behaviors	+	0.37*	Yes
3j	Mgt. Involvement → Production Behaviors	+	0.35*	Yes
3k	Mgt. Involvement → Visionary Behaviors	+	0.38*	Yes
3l	Mgt. Involvement → Guard Behaviors	+	0.43*	Yes
4a	Structured Methods → Relationship Behaviors	+	−0.06	No
4b	Structured Methods → Production Behaviors	+	0.15	No
4c	Structured Methods → Visionary Behaviors	+	0.08	No
4d	Structured Methods → Guard Behaviors	−	0.03	No
4e	Production Technology → Relationship Behaviors	+	−0.20*	No
4f	Production Technology → Production Behaviors	+	−0.09	No
4g	Production Technology → Visionary Behaviors	+	0.31*	Yes
4h	Production Technology → Guard Behaviors	−	0.30*	No
4i	Coordination Technology → Relationship Behaviors	+	0.05	No
4j	Coordination Technology → Production Behaviors	+	0.01	No
4k	Coordination Technology → Visionary Behaviors	+	−0.10	No
4l	Coordination Technology → Guard Behaviors	−	−0.16	No

$*p \Leftarrow 0.05$.

Hypotheses 1a and 1b posit that internal group processes are positively related to performance. Hypothesis 1a states that relationship behaviors are positively related to performance. As seen in Table 3, this hypothesis is not supported. Relationship behaviors are related to neither stakeholder-rated performance ($p = 0.96$) nor team-rated performance ($p = 0.51$). However, as proposed in Hypothesis 1b, production behavior is found to be significantly related to performance ($p = 0.04$ for stakeholder-rated, and $p < 0.01$ for team-rated performance). Thus, we find production behaviors to be related to team performance during requirements determination, but also find relationship behaviors to be unrelated to performance.

Boundary Management and Performance:

"The biggest problem we have here are interactions of the team, getting people to work together, crossing the bounds of what may be defined as their jobs . . . . talking to people that they don't normally talk to . . . . members don't always know that this is part of the job."

"No organization is an island. With launch systems today and the way we have these huge cost centers, with so many things interacting . . . . it takes people from outside of your group to get things done. . . . . Today we have outside reviews on everything. It is very rare today that we put a system in that is not connected somewhere else or requires exchanges from other parts of the business."

Hypotheses 2a and 2b focus on the relationship between boundary management processes and performance. Hypothesis 2a states that visionary processes should be positively related to performance. As seen in Table 3, visionary processes is related to stakeholder-rated performance ($p = 0.05$), but not team-rated ($p = 0.19$).

Hypothesis 2b links guard processes with performance, proposing a negative relationship between the two. Once again, this proposition is supported for stakeholder-rated performance ($p = 0.02$), but not for team-rated ($p = 0.31$).

Behavioral Enablers and Group Processes:

"That's our biggest weakness here . . . . with the drive to be excellent we don't always take the time to understand what we are doing so that we can improve."

"I am not sure we ever learn from our mistakes. We just do them all over again . . . ."

"Teach the inexperienced folks . . . . who has the time?"

Hypotheses 3a–31 explore the relationship between the group process constructs and the behavioral enablers of experience spread, team skill, and managerial involvement. We examine each group of hypotheses in turn.

Hypotheses 3a–3c focus on the relationship between experience spread and relationship, production and visionary process, positing negative relationships. Hypothesis 3d states the relationship between experience spread and guard processes is positive. Experience spread is found to not be related to relationship ($p = 0.33$), production ($p = 0.84$), or guard processes ($p = 0.36$). However, it is found to be significantly negatively related to visionary behavior ($p < 0.01$), which supports Hypothesis 3c.

Hypotheses 3e–3h link team skill with group processes. Skill is found to be significantly related to relationship ($p < .01$) and production processes ($p < 0.01$), so hypotheses 3e and 3f are supported. Interestingly, skill is found to be negatively related to visionary processes ($p = 0.04$). Hypotheses 3g and 3h cannot be supported.

Hypotheses 3i–3l explore the linkage between managerial involvement and group processes. All four of these hypotheses are supported. Managerial involvement is found to be related to relationship ($p < 0.01$), production ($p < 0.01$), visionary ($p < 0.01$), and defender behaviors ($p < 0.01$).

Technology Enablers and Group Processes:

"I know that tools are important, a lot of things are, but it's the people that are key . . . any successful manager will tell you to surround yourself with successful people and you will be successful."

Similarly, Hypotheses 4a–4l explore the relationships between the group process constructs and the proposed enablers from the technology perspective.

Hypotheses 4a–4d link the use of structured methods with group processes. None of these four hypotheses is supported by our data. Structured methods are not significantly related to relationship ($p = 0.49$), production ($p = 0.12$), visionary ($p = 0.49$), or guard behaviors ($p = 0.79$).

Hypotheses 4e–4h focus on the relationship between the use of production technology and group processes. There is some mixed support for these hypotheses. The use of production technology is found to be positively related to external group processes. Specifically, production technology use is positively related to both visionary processes ($p = 0.03$) and guard processes ($p = 0.05$). Thus, Hypothesis 4g is supported, but 4h—which posited a negative relationship between production technology and guard processes—is not. Production technology is found to be unrelated to production processes ($p = 0.43$), and negatively related to relationship processes ($p = 0.05$). Thus, Hypotheses 4e and 4f are not supported.

Hypotheses 4i–4l examine the use of coordination technology and its relationship with group processes. Surprisingly, no relationships were found between the two. That is, the use of coordination technology is not found to be significantly related to relationship ($p = 0.61$), production ($p = 0.98$), visionary ($p = 0.49$), or guard processes ($p = 0.28$), and thus Hypotheses 4i–4l are not supported.

Finally, we explore the nature of the impacts of our behavioral and technology factors by contrasting their direct and indirect (through group process) impacts on performance. Table 4 breaks down the covariance between performance and each of the behavioral and technology enablers into direct, indirect, and spurious effects. Looking first at stakeholder-rated performance, the direct effect of experience spread on stakeholder-reported performance is found to be much larger than its indirect effects through group process (a direct/indirect ratio of 6.19). The other behavioral factors (managerial involvement and skill) both affect performance indirectly through group process, with the indirect impact of skill being particularly strong in relative terms (with a ratio of −0.09). The technology enablers have ratios relatively close to 1, so it is difficult to claim a great difference between the direct and indirect effect though it is interesting to note that production technology had a slightly positive direct effect and a negative indirect impact—primarily through its relationship with guard processes on stakeholder performance.

In examining the corresponding direct/indirect effects on team-reported performance, there are a few results that stand out. First, the direct (and negative) impact of production technology dwarfs any indirect effect of its use through its impact on group processes (direct/indirect ratio of −8.94). Similarly, coordination technology's direct effects are much greater than its indirect effect—but neither is particularly strong. However, managerial involvement's indirect effects are much greater than its direct effect (direct/indirect ratio of 0.08), particularly acting through production processes. Finally, the direct impact of team skill on team-reported performance is about twice the indirect impact through skill's influence on group processes.

4. Discussion

The goal of this study was to examine the requirements determination process of the system development lifecycle in order to better understand how to develop successful systems. We were interested in answering the following two questions: (1) What are the group processes associated with high-performing software development teams? and (2) What factors enable these processes? We implemented the research using two different dependent measures—a self-reported team

Table 4 Analysis of Direct Versus Indirect Relationships

Antecedent Factor	Experience Spread	Managerial Involvement	Team Skill	Structured Methods	Production Technology	Coordination Technology
Total association with stakeholder-rated performance (A)	−0.38	0.17	0.31	0.17	0.06	0.05
Direct effect on team performance (B)	−0.30	0.08	−0.01	0.05	0.05	0.04
Indirect effect through relationship (C)	0.00	0.00	0.00	0.00	0.00	0.00
Indirect effect through production (D)	0.01	0.11	0.14	0.05	−0.03	0.00
Indirect effect through visionary (E)	−0.09	0.10	−0.07	0.02	0.08	−0.02
Indirect effect through guard (F)	0.03	−0.13	0.07	−0.01	−0.09	0.05
Total indirect effects (C + D + E + F)	−0.05	0.08	0.14	0.06	0.04	0.02
Unanalyzed effects (A − (B + C + D + E + F))	−0.03	0.01	0.18	0.06	0.05	−0.01
Ratio of direct to indirect effects (B/(C + D + E + F))	6.19	0.89	−0.09	0.87	−1.32	1.65
Total association with team-rated performance (A)	−0.09	0.48	0.54	0.04	−0.30	−0.13
Direct effect on team-rated performance (B)	0.04	0.02	0.28	−0.06	−0.29	0.08
Indirect effect through relationship (C)	−0.01	−0.03	−0.05	0.01	0.02	0.00
Indirect effect through production (D)	0.01	0.20	0.24	0.08	−0.05	0.00
Indirect effect through visionary (E)	−0.05	0.05	−0.04	0.01	0.04	−0.01
Indirect effect through guard (F)	−0.01	0.04	−0.02	0.00	0.03	−0.01
Total indirect effects (C + D + E + F)	−0.05	0.25	0.14	0.10	0.03	−0.03
Unanalyzed effects (A − (B + C + D + E + F))	−0.08	0.21	0.12	0.00	−0.04	−0.18
Ratio of direct to indirect effects (B/(C + D + E + F))	−0.80	0.08	1.93	−0.62	−8.94	−2.70

measure as well as a stakeholder-reported measure of team performance. In the following section we discuss the answers to these questions along with the implications for theory and practice.

Internal and External Behaviors That Predict Performance

Grounded in the theories of small-group behavior, we found that the internal team-building processes of high-performing software development teams share one type of process—what has often been labeled production activities. Two types of external processes were also found to impact performance: visionary activities are positively related to performance and a guard activities are negatively related performance. Previous studies have often focused on internal processes rather than both internal and external processes (for an exception see Ancona 1988, 1989, 1990, 1992). Production processes—activities that are directly related to completing the software development task—account for performance as reported by both the project stakeholder and the team. Our results confirm theory that points to the importance of setting clear goals and milestones. For practice, the message is clear although not terribly surprising. When performing a task as complex as software development, team members must stay on track and achieve specific intermediate goals in order to increase their team's performance. The implication for management is clear: effective plans and procedures are critical. It is interesting to note that the production process is the only group process that is significantly related to team performance in all four of our models that reinforces the importance of the construct in this context.

The positive link between the external visionary activity confirms previous IT and organizational behavior studies reinforcing the importance of maintaining good relations upward in the organization and managing team progress to a higher organizational levels (Ancona 1989, 1990). This is an important message to our field. Although previous work has indicated the "power" and political dimensions of software development (Markus 1983), few studies have actually operationalized the construct based on theoretical work (for an exception, see Zmud 1983), and none to our knowledge has looked at the team's ability as well as that of the project manager to exhibit behaviors associated with visionary processes. When we contrast the two different measures of team performance, however, we note that visionary activities are only related to the stakeholders' perception of performance and are not present in the team-reported models. This may mean that the team members themselves do not value or understand the importance of managing outward, although the data suggest that they should.

A second external process, guard processes, is negatively related to stakeholder-reported team performance. This result contradicts Ancona's (1989, 1990) research on new product development teams. This difference may be due to the particular task and type of team. Specifically, requirements determination requires open communication. Any nondisclosure, even to keep the team on track, may be perceived as inappropriate by the user community. It would be interesting to determine the value of guard activities at other points in the life-cycle when the team may need to keep the organization at bay to buffer it from external influences. The message to software developers is meaningful: team members exhibit negative behaviors that they are probably not aware of that influence the performance of their team. Like visionary activities, guard activities are only negatively related to performance when the stakeholder is evaluating the team.

Behavioral Enablers of Team Performance

In addressing the second research question, we juxtaposed two different sets of enablers of group process: behavioral and technology. A significant conclusion of this study is that the behavioral model influences these processes more than the technology model does. The specific implications for theory and practice are discussed below.

Team skill influences both internal group processes—production and relationship—but is not related to external group processes. In other words, the more skilled the team as a whole, the more likely it will exhibit relationship and production processes; but team skill does not influence its ability to exhibit visionary or guard processes. We were surprised by this finding since it contradicts earlier research that found that more highly skilled teams are better able to promote themselves to the outside (Gladstein 1984). It may be that highly skilled developers are unaware of the need to exhibit boundary-management activities (both positive and negative). An alternate explanation is that the more expert developer is convinced that he or she knows what is best for the user—a phenomenon that is well documented in the R&D literature as the "not invented here" syndrome (Allen 1970). These results point to the need for more research to better determine the relationship between team skill and external group processes. It might be that the task influenced this result or it may be a problem with taking the idea from the new product development environment to software development.

Managerial involvement is the most powerful behavioral enabler and influences all four of the group processes. This result confirms previous leadership research that promotes mediation models of leadership in organizational settings. From a practical point of view, one of the most important conclusions of the study is that a highly involved manager influences the types of group processes associated with high-performing teams with the exception of the guard processes. The lesson here is that there is a downside to extensive managerial involvement—perhaps because the more involved managers are, the more likely they are to behave like team members and less like management (Bostrom and Kaiser 1982). They may be protecting their team at a time when user involvement is critical. We assume that managers are unaware of this defensive phenomenon that their degree of involvement may produce.

Technology Enablers of Team Performance

To what extent does technology influence group processes during requirements determination? As is evident from the path models, compared to behavioral enablers, technology enablers, account for significantly less of the variance of the group process constructs. In addition, counter to previous research on small groups (Goodman 1986a), the type of technology that we studied played a relatively small role in predicting team performance. This result may be due to the inherent difficulty in determining the role that technology plays in team performance. For example, structured methods use was positively but not significantly related to production activities, and not related to any of the other group processes. Previous research has been equivocal as to the impact of these methods. Similarly, coordination technology was not related to any of the group processes or to performance. This may be due to the lack of coordination functionality inherent in many traditional CASE tools (Henderson and Cooprider 1990, Vessey and Sravanapudi 1995)

Surprisingly, production technology was found to be unrelated to production processes, and negatively related to relationship processes. This result deserves further discussion. It may be that team members using production technology find that the effort to establish a strong working relationship among team members hurts their production efficiency. Again, this may reflect the common perception among developers that getting the task done on time is the paramount issue.

The positive influence of production technology on visionary processes supports the CASE vendors' claims that these types of tools will enable teams to share their models and views of the desired system with end users (Chikofsky 1991). It appears that these tools can aid developers in carrying their message beyond the team.

When the development team reported their own performance, we found similar results in regard to coordination technology and structured methods, but an even stronger message about the use of production technologies. One of the most interesting conclusions of the study is that the use of production technology actually interferes with the successful performance requirements determination of the task as represented by team members themselves. This may be a result of the backlash against CASE (Orr 1994). The developers might be responding to the realization that CASE is not a silver bullet and that, in fact, its use can even create performance penalties (from the learning curve and other effects). Or it may be that we simply still do not fully understand how these development tools actually affect the process and performance of development projects.

Conclusion

A summary of our findings suggests that group processes are important predictors of team performance in requirement determination. Behavioral factors have a major influence on group processes and team performance, whereas technology factors have a more limited but still important impact. Despite these findings, our study, like most other field studies, has limitations that must be noted. First, because we specifically focused on the requirement determination phase of system development the results cannot necessarily be generalized to the entire development life-cycle. For example, it might be that guard processes are appropriate and necessary during code and implementation in order to keep the team on schedule. Similarly, it might be that different aspects of technology use become more or less important as the system unfolds. Second, there are a number of weaknesses inherent in a cross-sectional study like ours. A longitudinal approach to examining these phenomena would obviously provide a richer, more accurate picture of the causal factors of team performance. Finally, subjective measures of team performance must always be viewed with caution. Although we took steps to improve the reliability of the measures by using a multiple-informant approach, admittedly using both objective and subjective measures would be useful.

These limitations notwithstanding, we believe that the results of this study provide important insights for both researchers and practitioners. We are still left with a number of interesting research questions which should be addressed in the future. One of the most obvious and interesting questions that we have previously alluded to is: How does the team's behavior change over the life of a development project? This is most critical because we could easily find that a strategy that is effective in the beginning of the project is detrimental at the end. Like Gertzick's (1988, 1989) work on marking time in group work, we might find that the passage of time makes all the difference. Similarly, the way that technology usage patterns change over time could also be an important question to explore. The results of this study indicate a mixed and limited relationship between technology and group processes during requirements determination, but other researchers (Cooprider and Henderson 1990, Vessey and Sravanapudi 1995) suggest that the technology utilized during other phases of the life-cycle (design, code, and maintenance) might be very different and have different effects on team performance. In addition, it is possible that new classes of tools (e.g., Lotus Notes and other groupware or GDSS tools) will affect different processes differently than the traditional CASE tools that we studied.

In conclusion, we believe that our approach of examining both behavioral and technical factors when studying software team performance has proved valuable. We hope the insights of our study are helpful to both researchers and practitioners, and that others will be able to build on our results.[4]

Appendix 1 Measurement Details

1. Behavioral Perspective Factors

Response Scale:

"Please indicate how accurate or inaccurate each statement is in describing how your team is functioning"

Seven-point scale, with 1 = very inaccurate, 4 = uncertain, and 7 = very accurate.

Managerial Involvement (Cronbach's Alpha = 0.75):

1. The project manager is clear and explicit about how he or she wants our design team to operate.
2. The project manager keeps a watchful eye on how each project is progressing, and alerts the team when he or she notices things that could be done to improve the team performance.
3. The project manager goes out of his or her way to consult with other team members and to seek their ideas and advice.
4. The project manager's behavior shows that he or she cares a great deal about our being a good design team.

Team Skill (Cronbach's Alpha = 0.77):

1. Members of our design team have example expertise for doing the work.
2. Some people in our design team do not have enough knowledge or skill to do their part of the team's task well.
3. Behavior in our design team is very orderly—it is clear what members are expected to do, and they do it.
4. Our design team has the right mix of people needed to do its work well.

2. Technology Perspective Factors

Structured Methods (Cronbach's Alpha = 0.84)

1. Extent of use of structured development methods (seven-point scale: 0 = never perform, 4 = perform daily, and 7 = perform extensively).
2. Number of hours of *daily* use of structured development methods.

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3. Number of hours of *weekly* use of structured development methods.

Response Scale:
"For each function, please circle the frequency with which you perform that activity using CASE tools during the course of a normal work week while working on the project."
Seven-point scale: 0 = never perform, 4 = perform daily, and 7 = perform extensively.

Production Technology (Cronbach's Alpha = 0.87)

1. Represent a design in terms of the business.
2. Construct data flow diagrams.
3. Detect data definition inconsistencies with a data dictionary.
4. Search the design for redundancies using an entity list.

Coordination Technology (Cronbach's Alpha = 0.71)

1. Send messages to other users.
2. Access a database, dictionary, diagram, etc. at the same time as another user.
3. Automatically maintain a record of the changes made in a design.
4. Instruct the tools to freeze a portion of the design to protect it from changes.

3. Internal Group Process Variables

Response Scale:
"Please indicate to what degree you feel the following statements describe your project team."
Seven-point scale: 1 = very strongly disagree, 4 = no opinion, and 7 = very strongly agree.

Relationship (Cronbach's Alpha = 0.87):

1. The people on this team get on my nerves.
2. There is a lot of unpleasantness among people on our team.
3. Dealing with the members of this team often leaves me feeling irritated and frustrated.
4. Often I am disappointed with the other members of this design team.

Production (Cronbach's Alpha = 0.79):

1. This team has done a good job in figuring out how work will flow among team members.
2. Team members have developed effective plans and procedures to coordinate work.
3. This team has taken sufficient effort to ensure that the project being developed meets the user's needs.
4. This team does a good job of trying to ensure that the product being developed meets company demands.

4. External Group Process Variables
Response Scale:

"Please indicate the extent to which you currently see it as your responsibility to engage in the following activities with individuals outside your team."
Seven-point scale: 0 = not at all, 1 = a very small extent, 4 = to some extent, and 7 = a very great extent.

Guard (Cronbach's Alpha. = 0.73):

1. Avoid releasing information to others in the company to protect the team's image and the product it is working on.
2. Control the release of information from the team in an effort to present the profile we want to show.
3. Keep news about the team secret from others in the company until the appropriate time.

Visionary (Cronbach's Alpha = 0.83):

1. Persuade others to support the team's decisions.
2. Review project design with outsiders.
3. Report the team's progress to a higher organizational level.
4. Scan the environment inside the organization for threats to the project team.

5. Team Performance
Team-Rated Performance (Cronbach's alpha = 0.85)

Response Scale:
"In relation to other project design teams you have been a member of or have observed, how does your design team rate on each of the following?"
Seven-point scale: 1 = deeply disappointing, 4 = no opinion, and 7 = exceeds my expectations.

1. Number of innovations or new ideas introduced by the design team.
2. Our ability to coordinate with one another.
3. Our reputation for work excellence.
4. Our ability to meet the goals of the project.

Stakeholder-rated Performance (Cronbach's Alpha = 0.67):

Response Scale:
"In relation to other project design teams you have observed, how would you rate this design team on each of the following?"
Seven-point scale: 0 = extremely poor, 4 = neutral, and 7 = outstanding.

1. Number of innovations or new ideas introduced by the design team.
2. Ability to communicate with one another during requirements definition.
3. Reputation for work excellence during requirements definition.
4. Ability to meet the goals of the project during requirements definition.

Appendix 2 Factor Analyses of Principal Components

Table A-1 Factor Analysis of Group Process Input Indicators (Principal Components, Varimax Rotation)

	Team Skill	Managerial Involvement
Team-Skill 1	0.80	0.13
Team-Skill 2	0.77	0.06
Team-Skill 3	0.77	0.20
Team-Skill 4	0.66	0.22
Managerial-Involvement 1	0.15	0.81
Managerial-Involvement 2	0.12	0.79
Managerial-Involvement 3	0.33	0.72
Managerial-Involvement 4	0.06	0.62
Eigenvalue	3.28	1.41

Table A-2 Factor Analysis of Technology Perspective Indicators (Principal Components, Varimax Rotation)

	Production Technology	Structured Methods	Coordination Technology
Production-Technology 1	0.88	0.07	0.13
Production-Technology 2	0.80	0.02	0.26
Production-Technology 3	0.80	0.08	0.19
Production-Technology 4	0.77	0.14	0.13
Structured-Methods 1	0.08	0.93	−0.01
Structured-Methods 2	0.01	0.90	−0.06
Structured-Methods 3	0.17	0.78	0.19
Coordination Technology 1	0.22	0.06	0.79
Coordination Technology 2	−0.03	−0.07	0.78
Coordination Technology 3	0.32	0.11	0.67
Coordination Technology 4	0.40	0.06	0.61
Eigenvalue	4.06	2.17	1.32

Table A-3 Factor Analysis of Group Process Indicators (Principal Components, Varimax Rotation)

	Relationship	Visionary	Production	−0.00
Relationship 1	0.88	0.03	0.10	−0.01
Relationship 2	0.83	−0.05	0.29	−0.05
Relationship 3	0.80	−0.04	0.21	−0.02
Relationship 4	0.77	0.12	0.27	−0.02
Visionary 1	0.04	0.87	0.03	0.07
Visionary 2	−0.02	0.79		
Visionary 3	0.01	0.79	0.10	0.21
Visionary 4	0.02	0.75	0.11	0.21
Production 1	0.22	0.16	0.78	−0.07
Production 2	0.12	0.15	0.78	−0.06
Production 3	0.28	0.05	0.74	0.08
Production 4	0.23	−0.02	0.69	0.19
Guard 1	−0.08	0.08	0.14	0.83
Guard 2	−0.04	0.07	−0.06	0.83
Guard 3	0.05	0.47	0.01	0.66
Eigenvalue	4.26	3.16	1.53	1.30

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