INVOLVEMENT AS A PREDICTOR OF PERFORMANCE IN I/S PLANNING AND DESIGN

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INVOLVEMENT AS A PREDICTOR OF PERFORMANCE IN I/S PLANNING AND DESIGN

Abstract

The critical role of computer-based information systems in a firm's competitive strategy increases the need to effectively manage I/S planning and design processes. This research examines how the involvement of two key organizational roles, i.e., users and I/S professionals, affects the performance of I/S planning and design teams. Involvement is conceptualized as the level of influence of a role for a planning and design task. A problem-solving model is used as a general model of task. Results indicate that a three-component problem-solving model (problem formulation, decomposition/distribution and solution/synthesis) provides a valid basis to discriminate between levels of influence among roles for actual I/S planning and design teams. Analysis of the relationship between the measure of involvement and the performance of the teams supports existing theory that user involvement increases performance of design teams. An exploratory analysis of patterns of influence among roles across problem-solving components (termed involvement strategies) indicates that interactive strategies where designers and users are highly involved in every aspect of problem solving correlate with high performance.

1. Introduction

The importance of computer-based Information Systems (I/S) to the competitive capability of the firm appears to be increasing (Bakos and Treacy 1986; Huber, MS 1984; Rockart and Scott Morton 1984). To the extent that this is true, the capability to effectively plan, design and implement such systems is a critical task facing most organizations. Not surprisingly, there is a significant emphasis in the I/S research literature reflecting a range of perspectives on how to effectively accomplish this task (Kottemann and Konsynski 1984, Martin 1982, Zachman 1986). Central to many of these research efforts is the premise that increased involvement of key organizational roles in these tasks will increase the likelihood of achieving the proclaimed benefits of an I/S investment.

Such claims are based on a variety of theoretical and empirical work. For example, Zachman (1986) draws an analogy between I/S planning and design and the field of architecture to support a model of design that involves five distinct roles. He argues that successful I/S planning and design processes require these roles to effectively coordinate their activities. From a different perspective, Mumford (1981), Kling (1977) and others argue for incorporating key constituencies in the planning and design process. They claim that involving a variety of roles improves the likelihood of successful implementation by affecting issues such as perceived ownership, commitment and the ability to reflect a wide range of beliefs and values.

This research investigates the premise that increased involvement of key roles (specifically the user and designer roles) improves the performance of I/S planning and design teams. Section 2 examines the concept of involvement and discusses the use of influence of a role for a task as one means to conceptualize and operationalize involvement. Section 3 empirically evaluates the validity of using a problem-solving model of task for measuring the influence level of the user and designer roles. Section 4 then examines the validity of using this perspective of involvement for predicting the performance of an I/S planning or design team. The patterns of influence across components of a problem-solving model are examined and used to characterize alternative involvement strategies and predict planning and design team performance. Finally, Section 5 discusses both the limitations of this research and the implications for future research.

2.0 The Concept of Involvement

2.1 Overview

A fundamental premise underlying many approaches to the I/S planning and design process is the need to involve a range of stakeholders. In this context, a stakeholder is an individual or organizational unit that will be affected by or can affect the performance of the planning and design team (Henderson 1987, Mason and Mitroff 1973). Therefore, planning and design is viewed as a purposeful activity intended to produce a product or artifact that will affect the behavior of one or more stakeholders (Churchman 1971, Henderson 1987, McGrath 1984). Design team performance is assessed in terms of its members' ability to execute design tasks as well as the impact of their efforts on the organization and their stakeholders.

The manner by which stakeholders interact in the planning and design process is often discussed in general terms of participation or involvement. For example, the need to *involve* users in the I/S planning and design process appears to be a premise held by most I/S designers (Boland 1978, De Brabander and Thiers 1984, Edstrom 1977, Ginzberg 1981, King and Rodriguez 1981, Markus 1983, Zmud 1981).

However, the way in which the concept of involvement is operationalized and measured is less clear. For example, Ives and Olson (1984) review a wide range of empirical research on the impact of user involvement in I/S design. They find that results are mixed and trace this confusion to an inadequate definition of the concept of involvement.

This work proposes that an adequate definition of involvement must reflect at least two dimensions: (1) the definition and selection of role representation and (2) a model of task. The notion of role representation is inherent in the concept of involvement. That is, involvement requires that the I/S planning and design process interact with individuals representing various values, experiences and skills. A role definition is one mechanism to generalize process models from one setting to another. In this work, the notion of role is a representation of the perspectives and skills embodied in key participants of the design process. A role is defined as the set of knowledge, processes and implied values that are expected from a given individual(s) filling a role. In this sense a role is a part played and can be defined by expectations, capabilities and policies (Van Maanen and Schein 1979). Similarly, Simon (1976) has argued that a role is a representation of a set of premises held by individual(s) filling that role. Such a view highlights the importance of the values carried by individuals filling roles.

Henderson (1987), Nutt (1975), Zachman (1986) and others have identified a range of roles that could be studied in the context of I/S planning and design. A common model used to study I/S planning and design has focused on two key roles: the user and the designer (Beath 1986, Churchman 1971, Henderson 1987, Ives and Olson 1984). This research will also focus on these two roles. As will be discussed in Section 3, the managerial role is also included as an informant type and used to develop the influence measurement model. The potential for explicitly incorporating the managerial role as an element of an involvement strategy is discussed as a key direction for future research.

The term "role representation" is used to emphasize that an actual planning and design team seldom interacts with every individual that could fill a given role. For example, the user role is represented in a planning or design process by those individuals identified as users and involved in some way in the planning or design process. The manner by which such involvement occurs is often unspecified (Ives and Olson 1984). At a general level, an important distinction is whether or not the role is represented as a formal member of the planning or design team. A team may well reach beyond these boundaries to interview or interact with non-team members that represent a given role. Gladstein (1984) has argued that this boundary activity will significantly effect the performance of a group. In this research, teams that explicitly represent the user role as a member of the team are the focus of study. The extent to which the team interacts with non-team members (i.e., manage their boundaries) is not formally addressed, although such activity is clearly a major part of the team's activities.

The second dimension of involvement is a general model of task. Involvement connotes a state or relationship that results from a set of actions or behaviors. For example, Ives and Olson define user involvement as "... participation in the systems development process by representatives of the target user group" (1984, p. 587). Boland (1978) explores user involvement by comparing two radically different processes of interaction between a system designer and user. He differentiates this process in terms of the responsibility of each role across the phase design task model. King and Cleland (1975) suggest that combining role and task models is an effective basis for definition of planning and design methods. Their use of techniques such as Linear Responsibility Charts (King and Cleland 1975) to define design strategies for

Decision Support Systems represents an approach that explicitly partitions responsibility of a variety of roles across a task model. Similarly, McGrath (1984) uses task as a basic dimension in developing a taxonomy of the study of groups. In essence, these researchers and others (Ancona and Caldwell 1987, Hackman 1968, Rowe 1987) suggest that understanding involvement requires knowledge of how a set of roles affects each other across a model of task. Less clear is what constitutes an *appropriate* model of task for the study of I/S planning and design.

Finally, a key issue in the development of a model of involvement centers on the specific variables used to operationalize this involvement and the implications of these definitions for measurement. The variables most often used are participation and influence (Edstrom 1977, Ginzberg 1981, Henderson 1987, Ives and Olson 1984, King and Rodriguez 1981, Locke and Schweiger 1979, Robey and Farrow 1982). The use of participation is grounded in an extensive history of participatory decision making and problem solving (Ives and Olson 1984, Locke and Schweiger 1979, Mumford 1981). The use of an influence variable is justified based on both a notion of participation and the need to reflect power relationships (Pfeffer 1981). For example, Robey and Farrow (1982) suggest that participation by itself may not be sufficient to reflect the process of resolving goal conflicts that often occurs in I/S planning and design.

While some research has suggested that participation and influence are related to performance (Edstrom 1977, Ives and Olson 1984, King and Rodriguez 1981, Olson and Ives 1981, Robey and Farrow 1982), evidence of the quality of the measures used in studying this relationship is seldom assessed. And yet, the existence of method bias as well as poor reliability in the measurement of influence for a buyer decision process model is noted by Silk and Kalwani (1982). Similarly, Bagozzi (1980), Huber and Power (1985) and others have pointed out the sensitivity to method in obtaining assessments of influence for complex organizational processes. However, attempts to systematically address these threats to validity are lacking in I/S design research. As a consequence, it is not clear whether the mixed results found by Ives and Olson (1984) are due to poor measures or inadequate theory. This issue will be explored in depth in Section 3.

This research will operationalize the concept of involvement as the level of influence exerted by a role using a problem-solving model of task. Specifically, we will examine the involvement of individuals filling an I/S planning and design role and those filling an organizational user role. A managerial role is reflected in the measurement model but a detailed assessment of the impact of this role on the performance of the team is beyond the scope of this paper. In the following section, the rationale for using a problem-solving model for task in the context of I/S planning and design is discussed and the particular problem-solving model used in this study is described.

2.2 A Measurement Model of Involvement: A Problem-Solving Perspective

As indicated in Section 2.1, this research will examine how the involvement of the user and designer roles affects the performance of an I/S planning or design team. A key issue is the model of task used to operationalize the involvement concept. One approach has been to examine the involvement across a life cycle model of design. Edstrom (1977), for example, assesses the level of influence of the user at different points in the systems design life cycle. His findings suggest that increased user influence, particularly at early stages in the life cycle, positively affects performance of a team. Similarly, a consistent theme in research on information requirement analysis is the need to effectively involve key users in this stage of the system design life cycle (Davis 1982, Martin 1982).

The research presented here uses a problem-solving model, rather than the systems design life cycle, as the model of task. Simon (1981) describes the design process as a problem-solving or decision-making process. He views design as a general task domain in which the designer must generate alternatives and choose the "best" design solution. This view of design provides a general foundation to apply methodologies and concepts from management science to the problems of design. It emphasizes the search and choice processes found in design and provides a linkage between the research on design and the research on human problem solving and decision making. While it does not reflect the entire range of issues or perspectives found in I S planning and design, the centrality of this perspective to the I S field justifies its selection as a focal point for research on I S planning and design.

A variety of researchers have pursued this decision-making perspective of design. Mostow (1985), Thomas and Carroll (1984), Adelson and Soloway (1985), Gross and Fleisher (1984) and others have proposed decision-making models of design and have conducted empirical studies of designers to support this perspective. Empirical and theoretical work ranges from micro-analysis of individual designers using protocol and observation techniques (Adelson and Soloway 1985, Mostow 1985) to formal modeling of the design process (Gross and Fleisher 1984, Tong 1984). While these approaches represent a wide range in reference disciplines used to study design, they have a common theme of design as a problem-solving or decision-making process.

Often, however, the decision-making or problem-solving model used implicitly or explicitly to study I S planning and design is individual-based. Mostow (1985), for example, uses single individuals as subjects in developing a descriptive model of design behavior. Similarly Adelson and Soloway (1985), Thomas and Carroll (1984) and Lawson (1984) also base their empirical work on observations or experiments of individual planners or designers. While these perspectives have yielded insight into the process of I/S design, such models have two significant limitations: (1) lack of communication-intensive constructs and (2) limited emphasis on formulation processes that emphasize cooperative processes. A group process model must explicitly recognize interaction among members of the group. McGrath (1984) and Witte (1972), for example, argue that communication should be a key element of models used to study group behavior. While the research on I/S planning and design discussed above recognizes the relevance of communication activities, the models of problem solving do not readily provide constructs to explicitly account for them.

Secondly, in the I/S design environment, the design team can seldom work only collectively, even though success depends upon collective action. Rather, the team often comes together, disperses to execute tasks, and then integrates their results. This practice coupled with the centrality of decomposition in problem-solving behavior of designers (Adelson and Soloway 1985, Gane and Sarson 1979, Kottemann and Konsynski 1984, Martin 1982) suggests the need to highlight how design teams decompose problems and manage the assignment of work among members of the team. Further, the opportunity to exploit parallel processing in the design cycle requires attention to the decomposition stage. In such circumstances, a problem must be decomposed not only to provide conceptual or resource bounds, but to maximize the ability to effectively distribute subproblems to dispersed solvers.

These aspects are reflected in a problem-solving model proposed by Davis and Smith (1983) as a basis to study the interaction between multiple agents or knowledge bases. The Davis and Smith decision-making model is defined as having five components: (1) problem formulation, (2) decomposition, (3) distribution, (4) solution and (5) synthesis. The problem formulation component focuses on need identification and specification of relevant environmental contingencies. Although Davis and Smith do not explicitly address these activities in their research, the importance of problem formulation in planning and design has been discussed by Simon (1981), Churchman (1971) and others. Similarly the concept of a generation activity has been used to characterize the problem-solving processes of groups (Hackman 1968, McGrath 1984).

Decomposition focuses on dividing the large problem into manageable chunks. It is an activity recognized as a critical component of I/S planning and design. Studies of individual design emphasize the use of decomposition in problem solving (Adelson and Soloway 1985, Carroll, Thomas and Miller 1978, Gross and Fleisher 1984, Lawson 1984, Mostow 1985). General I/S planning and design methodologies emphasize the importance of the decomposition task. To the extent that performance goals encourage the use of parallel work strategies among team members, decomposition may be a critical task for the I/S planning and design process.

Distribution focuses on work assignment. This activity is the focus of the Davis and Smith (1983) research. They investigate the knowledge and protocols necessary to effectively match a problem solver with a problem requirement. As suggested above, distribution is quite analogous to the task of work assignment that has been studied extensively in research on group behavior (Eils and John 1980, Hackman 1968). This activity is a key allocation process and reflects a communication-intensive aspect of group problem solving that is often left implicit in individual-oriented problem-solving models.

The problem solution component centers on the activities associated with producing a solution to a defined subproblem. The Davis and Smith (1983) model is a distributed problem-solving model in that it is possible, if not assumed, that the problem-solving behavior for particular subproblems occurs independently. Of course, such a requirement is not necessary if the team works as though it is a single unit. However, the settings studied in this research involve independent work on problem solution by individuals or subgroups within the team. The notion of solution-centered activities, particularly those involving choice behaviors, is often highlighted in models of group problem solving (Hackman 1968, Laughlin 1980, McGrath 1984).

Finally, synthesis focuses on the need to combine the solutions for each subproblem. Again, this activity may be a minor issue if the team works as a single unit. However, in cases where subproblems are worked on independently, the solution process may in fact produce conflicts. In such a case, synthesis becomes a critical task for a design team. This activity is emphasized in many I/S design methods. For example, the benefits of using a rigorous syntax in requirements specification are often justified on the basis of an improved ability to combine or synthesize the work on independent design processes (Gane and Sarson 1979, Martin 1982).

Figure 1 shows the five-component problem-solving model. A pilot test of this problem-solving model with project members from six design teams[1] indicated that each activity level is a *distinct component* of work. However, the highly interactive nature of the problem-solving process made it difficult in their minds to specify a single *sequence* of these activities that represented the team work process. Therefore, the model does not imply a sequence of activities. Rather, the problem-

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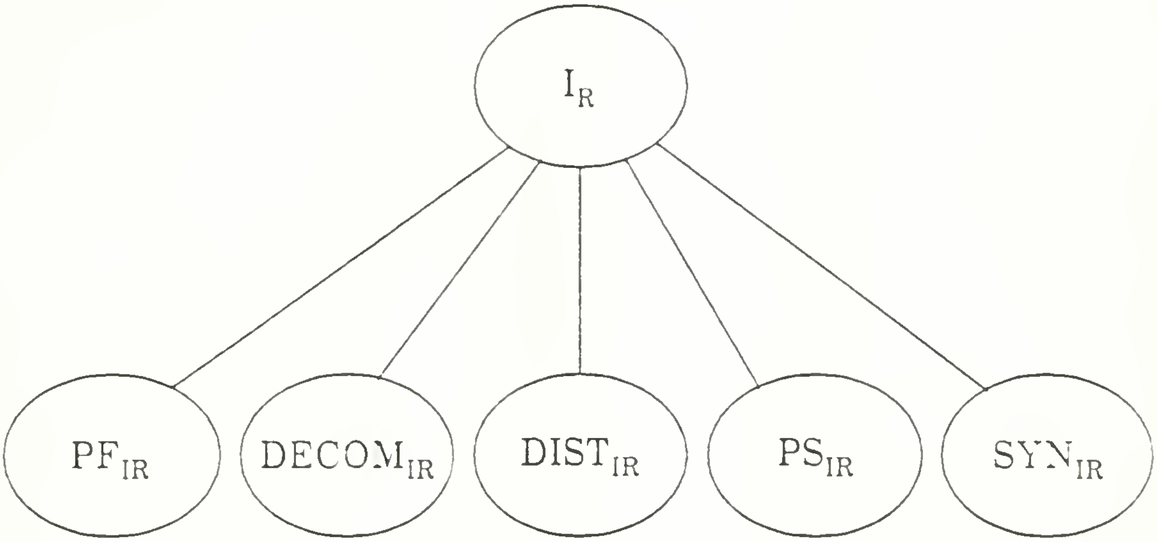
[1] This test involved members of each team filling out the questionnaire and then discussing each item in depth. Final wording for problem-solving components resulted from these pilot test interviews. Interviews lasted approximately one and one/half hours. The actual definitions used are shown in Appendix A.

Figure 1

Model for Role Involvement



I_R = Involvement of the R^{th} role
PF_{IR} = Level of Influence for the R^{th} role in Problem Formulation
$DECOM_{IR}$ = Level of Influence for the R^{th} role in Decomposition
$DIST_{IR}$ = Level of Influence for the R^{th} role in Distribution
PS_{IR} = Level of Influence for the R^{th} role in Problem Solving
SYN_{IR} = Level of Influence for the R^{th} role in Synthesis

solving model is represented as a set of distinct activities or task components for which the level of influence of a given role can be reliably attributed. Of course, Silk and Kalwani (1982) demonstrate the difficulty of developing a reliable measure that actually discriminates between such components. In the following section, the validity of the model shown in Figure 1 is tested for actual planning and design teams.

3.0 Testing the Measurement Model for Involvement

3.1 Measurement Approach

In this section, a measurement model for the involvement concept is tested. Involvement is defined as the level of influence exerted by a role for a job-related task. In this case, the task model is the five-component problem-solving model discussed above. Bagozzi and Phillips (1982) argue that construct validity for a measurement model requires demonstrating both convergent and discriminant validity. Evidence of convergent validity is obtained when multiple methods for a given trait correlate. Evidence of discriminant validity is obtained when, given convergent validity, a test of the difference between the estimates of true trait value is statistically significant.

Since involvement is a latent variable, i.e., it cannot be measured directly, a Confirmatory Factor Analysis (CFA) approach is used to assess the measurement validity for a distributed problem-solving process model (Bagozzi 1980, Jöreskog and Sörbom 1979). This approach has been used to test a variety of measurement models in disciplines such as marketing and psychology (Bagozzi 1980, Bagozzi and Phillips 1982, Jöreskog and Sörbom 1979). In particular, the CFA can be used to examine the convergent and discriminant validity in a manner analogous to, though more precise than, the multimethod-multitrait (MMMT) approach advocated by Campbell and Fiske (1959). In such an approach, the reliability of a measure can be assessed by examining the correlation among multiple measures of a single trait. Evidence of convergent validity is provided by assessing the convergence between maximally different measures of a single trait. Discriminant validity is assessed by testing to determine if the correlation between any two traits (assuming their measures are valid) is different than 1.0 (Jöreskog and Sörbom 1979). The use of structural equation models permits the researcher to explicitly test for both convergent and discriminant validity while explicitly controlling for potential method bias. This approach has been recommended as superior to a traditional MMMT analysis because it provides for explicit statistical testing of the discriminant validity for any given trait. The reader is referred to Bagozzi (1980), Bagozzi and Phillips (1982), Jöreskog and Sörbom (1979) and Venkatraman and Ramanujam (1987) for detailed discussion of this approach.

The research methodology used to examine the involvement of roles for actual planning and design teams is retrospective key informant. *Each member of a given team is asked to inform on the level of influence of every other member of the team for each component of the problem-solving model.* In addition, each individual provides a self report (i.e., respondent) of his/her own level of influence for each problem-solving activity. A t-test to examine the hypothesis that the self evaluations differed significantly from the evaluations of that individual by informants indicated no significant difference. Thus, there is no evidence of a systematic bias by respondents and this data is included in subsequent analysis.

This approach results in multiple informants assessing the influence level of each member of a team. A structural modeling approach can be used to test for the construct validity of the problem-solving model while controlling for possible position bias reflected by a given informant (Huber and Power 1985, Silk and Kalwani 1982). This influence measure is operationalized by a single item for each component of the problem-solving model. In every case, the influence across task for each individual is assessed by team members filling three roles: manager, designer and user[2]. In general, there are multiple informants within a role. Assessments of a

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[2] Role assignments were based on descriptions provided by both the project manager and the individual team member. In the few cases where conflicting descriptions occurred, phone interviews were used to clarify the individual's role.

given individual's influence from informants within a given role should correlate, thereby providing a means to assess reliability of the measure of influence. As discussed by Silk and Kalwani (1982), to the extent that the influence assessment for a given individual *across* informant roles also correlates, convergent validity is established. Figure 2 shows the measurement model to be evaluated.

Data was collected for 18 I/S design teams from 12 different organizations. In cases where several teams were from a single organization, a selection process ensured that the projects were significantly different and affected different parts of the organization. Thus, each team represents an independent data point.

In general, teams included 7-12 people from which 5-7 informants were chosen. To the extent possible, a random selection process was used within each of the three major roles[3]. All measures were taken within three months of the completion of the project. Thus, assessments reflect the judgment of informants as to the overall level of influence for an individual filling a role during a project. The task complexity is controlled through both the size of the project (in terms of dollars and personhours) and the total length of time between project initiation and completion. The time duration of each project was approximately 9-12 months[4]. Because of the limited duration of these projects, the team membership was quite stable. This, of course, suggests that these teams were teams brought together for a clear purpose. As such, a theoretical model that views design as a problem-solving process is appropriate.

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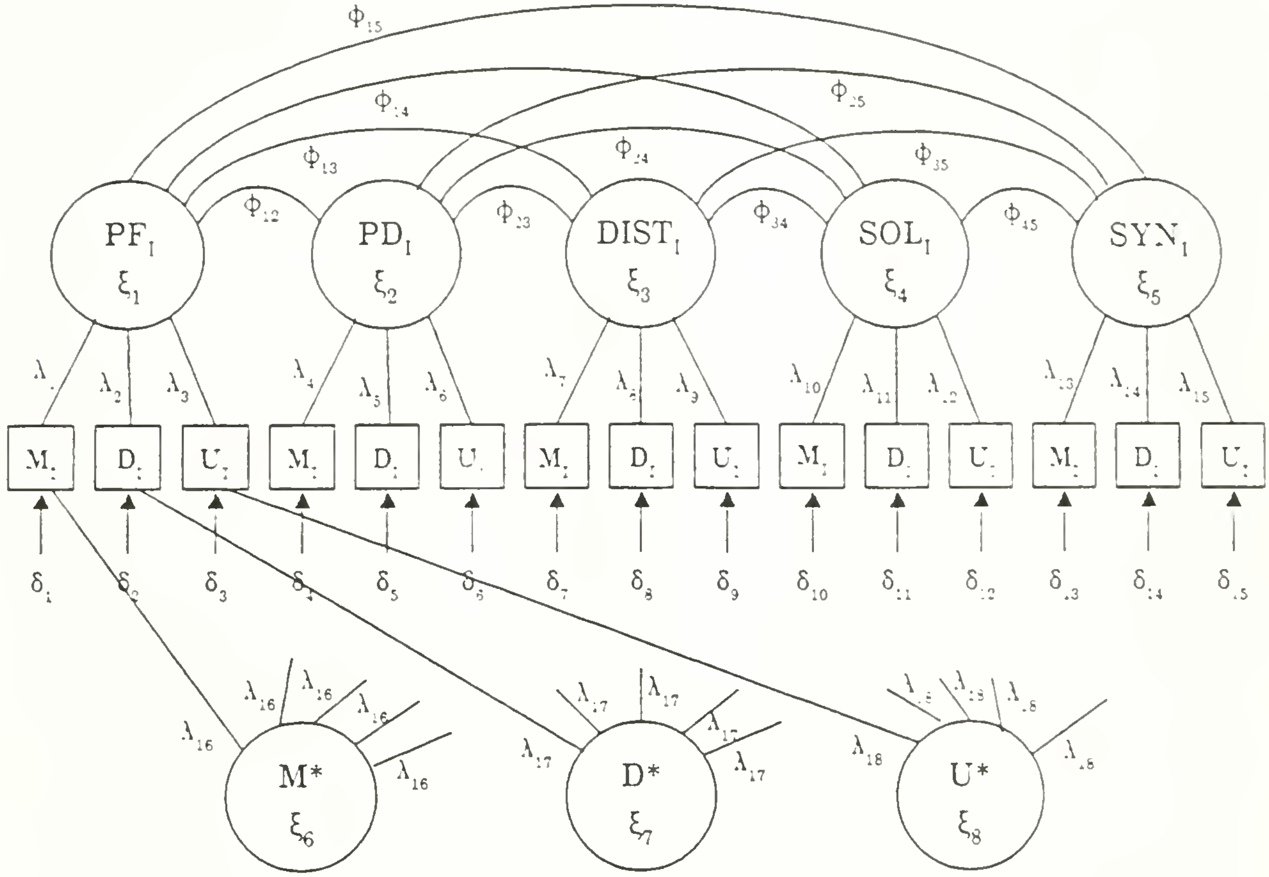
[3] Exceptions occurred only if a role had a limited number of individuals filling that role.

[4] Discussions with organizations suggest that current practice defines project goals to ensure deliverables within this time frame. In many cases, the team studied is part of a larger project that involved many deliverables and has a longer time horizon. In fact, the product of one team is often a starting point for a subsequent project.

Figure 2

Five-Component Problem-Solving Model with Method Factors



* λ's within a method are defined to be equal to reflect a common method bias across components.

Parameter	ML estimate
λ_1 =	.55 (.59)
λ_2 =	.60 (.55)
λ_3 =	.46 --
λ_4 =	.68 (.69)
λ_5 =	.66 (.63)
λ_6 =	.50 --
λ_7 =	.79 (.81)
λ_8 =	.75 (.75)
λ_9 =	.54 --
λ_{10} =	.70 (.72)
λ_{11} =	.71 (.72)
λ_{12} =	.54 --
λ_{13} =	.73 (.73)
λ_{14} =	.74 (.72)
λ_{15} =	.40 --
λ_{16} =	.53 (.51)
λ_{17} =	.51 (.52)
λ_{18} =	.70 --

Parameter	ML estimate
δ_1 =	.43 (.42)
δ_2 =	.47 (.51)
δ_3 =	.49 --
δ_4 =	.25 (.28)
δ_5 =	.28 (.31)
δ_6 =	.17 --
δ_7 =	.09 (.09)
δ_8 =	.15 (.14)
δ_9 =	.23 --
δ_{10} =	.28 (.27)
δ_{11} =	.22 (.21)
δ_{12} =	.30 --
δ_{13} =	.19 (.18)
δ_{14} =	.22 (.22)
δ_{15} =	.36 --

Parameter	ML estimate
ϕ_{12} =	.64 (.73)
ϕ_{13} =	.37 (.43)
ϕ_{14} =	.51 (.53)
ϕ_{15} =	.66 (.65)
ϕ_{23} =	.96 (.99)
ϕ_{24} =	.83 (.86)
ϕ_{25} =	.92 (.95)
ϕ_{34} =	.82 (.82)
ϕ_{35} =	.82 (.80)
ϕ_{45} =	.98 (.99)

X^2 (df = 77) = 126   p ≤ .000

Δ = .90

$\bar{\Delta}$ = .35

(X^2 (df = 23) = 41   p ≤ .011)

(Δ) = .95

Note. Values in brackets provide five-trait, two-method solution.

Analysis of results suggests no systematic variance for years of experience or assessments of level of expertise within roles across teams. In total, there were 126 informants participating in this study.

The objective is to assess the validity of using the problem-solving model to distinguish levels of influence of roles for I/S planning and design. The data reflects teams working at every stage over a limited range of the design life cycle: planning and design. Projects did not include organizational implementation or maintenance. Thus, the sample does not reflect a full range of product development as discussed by Ancona and Caldwell (1987). No attempt is made to control for the planning or design method used by the team. For example, some teams used prototyping while others used structured design techniques. This study will also examine whether the observed level of influence for roles across tasks (assuming valid measures) supports existing theories of the relationship between involvement and performance. To the extent that such a relationship holds, research can then focus on the cooperative behaviors that generate preferred levels of influence. At this future point, issues of methodology used by the team to enact an involvement strategy would be a central focus.

3.2 Assessing Convergent and Discriminant Validity

Analysis is conducted using a set of three interrelated models. The first model provides a baseline for evaluation of specific hypotheses. In the baseline model, each question is treated as an independent factor. That is, the baseline model assumes that there is no general concept of involvement that is being measured by sets of questions. As such, it provides a mechanism to characterize the total variance reflected by the instrument and can be used as a baseline for assessing the portion of variance explained by a particular hypothesized model (Bentler and Bonett 1980).

This model includes 15 questions reflecting the five components of the distributed problem-solving model and the three roles of informants. *Each measure is an average of all assessments of the informants of a given role type (method) for a particular individual for a given problem-solving component (trait).* The adequacy of a particular hypothesized model can be tested as the difference in two chi-squared values for the hypothesized and this baseline model. This difference is also chi-square distributed and removes the sensitivity to sample size associated with a structural modeling approach (Bagozzi and Phillips 1982, Jöreskog and Sörbom 1979). Further, the difference in chi-square can be scaled by the baseline chi-squared value and used as an index (Δ) of the goodness of fit exhibited for the hypothesized model (Bentler and Bonett 1980, Venkatraman and Ramanujam 1987). As an additional test, the incremental variance accounted for by subsequent restrictions to alternative hypothesized models can be evaluated by and will be reported as a modified index ($\bar{\Delta}$).

The second analysis hypothesizes a multiple-trait, multiple-measure model. Given the limited access to team members, expanding the questionnaire to include multiple items and, therefore, strengthen the reliability of the measure was not feasible. Rather, in this model, each influence level is modeled as having three measures reflecting the source of the information, i.e., informant type. The λ_i and δ_i are maximum likelihood estimates that partition variance into a trait term and an error term. The correlation between the two traits (i,j) is simultaneously estimated by the correlation ϕ_{ij}. As will be discussed, discriminant validity is determined if these correlations are significantly less than 1.0. In essence, this model tests the hypothesis that the variance found among the fifteen questions can be explained by a five-factor model. This is an intermediate analysis used to provide a basis for calibrating the effect of evaluating method bias.

The third hypothesized model tested is the basis for our analysis and is shown in Figure 2. This model extends the five-factor model to provide direct formulation of a multimethod-multitrait analysis. In this analysis, the role of the informant is also recognized as a method reflecting the possibility of a systematic bias due to position or knowledge. The principle of multimethod analysis calls for maximally different methods. Thus, while this analysis will provide evidence of convergent validity, additional power could be achieved through the use of alternative measurement approaches such as direct observation. Given the limited access for this study, such alternatives are not available.

In this multimethod-multitrait model (Figure 2), an additional set of λ_i's is incorporated to partition the total variance into a trait component, a method component and an error component. *The λ's estimated for a method across traits are assumed to be equal.* This is an interpretation of a method bias as a systemic influence not related to the structure of the model used to measure involvement. As will be discussed below, this assumption can be relaxed to provide further insight as to the quality of any given informant type.

3.3 Analysis of Results: Convergent Validity

A summary of the confirmatory factor analysis using LISREL IV analysis of the baseline and the three hypothesized models discussed above is shown in Table 1. The results indicate that the five-trait, three-method model (Figure 2) accounts for 90% of the variance reflected by the baseline model. The modified index of goodness of fit ($\bar{\Delta}$) indicates a practical significance for the multimethod-multitrait model. That is, these results suggest that a significant amount of systematic variance is due to a method (informant) bias.

Table 1

Five-Trait Measurement Model Results

Model	X^2	ΔX^2	Δ	$\bar{\Delta}$	prob.
Baseline	1274	--	--	--	NA
5 trait	570	704	.55	--	.00
5 trait, 3 method	126	1148	.90	.35	.00
5 trait, 2 method*	41	780	.95	--	.01
3 trait, 2 method	24	578	.96	--	.04

* Baseline X^2 is recalculated.

Although the five-trait, three-method model provides an adequate fit, further analysis suggests that the user informant may be an invalid source of information. Bagozzi and Phillips (1982) have argued that convergent validity for a trait is established when the portion of the variance explained by a given indicator for the trait is less than the portion explained by the aggregation across all indicators for a given trait. That is, the multiple indicators converge to provide a more reliable estimate of the true trait value than could be generated by any single indicator. This provides a type of measure, called ρ_c, that is analogous to Cronbach α (1951). It is the portion of the variance accounted for by the λ values scaled by the total variance estimate for a given trait.

The comparison of the ρ_c values and the individual λ_i is provided in Table 2a. As shown in Table 2a, the indicators fail to converge at the aggregate level for the traits Distribution and Synthesis. The likely source for a failure to converge is found by examining the estimated parameter, trait, method and error. This analysis (Table 2b) indicates that the method bias for the user informants is particularly high and

Table 2a

Convergent Validity Results for Five-Trait, Three-Method Model

Trait	Indicator	Indicator Reliability *	ρ_c **
PF	M	.31	.37
	D	.36	
	U	.24	
PD	M	.46	.48
	D	.43	
	U	.25	
DIST	M	.62	.56
	D	.55	
	U	.29	
SOL	M	.47	.50
	D	.50	
	U	.38	
SYN	M	.52	.48
	D	.52	
	U	.16	

* The value of λ_i^2 can be viewed as the indicator reliability (see Werts, Linn and Jöreskog, 1974)

** If indicator reliability > ρ_c, convergent validity test fails.

the trait reliability quite small. A subsequent LISREL IV analysis permitting the λ's for the user method to be independently estimated for each trait (note the previously discussed assumption that method variance is constant across traits.) shows the λ values (shown in brackets in Table 2b) for the Problem Formulation stage to be consistent with the other methods and significantly higher for the remaining four traits. However, the reliability of the trait is still quite low.

An interpretation of this may be found in the relationship between a measurement strategy and the theory being tested. In this case, involvement is the concept being measured. The measure of involvement calls for informants to

Table 2b
Partitioning of Variance and Measure Reliability
Five-Component Problem-Solving Model with Method Factors

Component	Indicator	Variance		
		Trait*	Method	Random Error
PF	M_I	.30 (.31)	.28 (.25)	.43 (.43)
	D_I	.36 (.36)	.25 (.28)	.41 (.47)
	U_I	.21 (.25)	.49 (.27)	.49 (.46)
PD	M_I	.46 (.48)	.28 (.25)	.25 (.25)
	D_I	.43 (.41)	.25 (.28)	.28 (.28)
	U_I	.25 (.23)	.49 (.65)	.17 (.12)
DIST	M_I	.62 (.64)	.28 (.25)	.09 (.09)
	D_I	.56 (.53)	.25 (.28)	.15 (.15)
	U_I	.29 (.27)	.49 (.51)	.23 (.24)
SOL	M_I	.49 (.50)	.28 (.25)	.28 (.28)
	D_I	.51 (.48)	.25 (.28)	.22 (.22)
	U_I	.29 (.29)	.49 (.41)	.30 (.31)
SYN	M_I	.53 (.55)	.28 (.25)	.19 (.19)
	D_I	.55 (.52)	.25 (.28)	.22 (.22)
	U_I	.16 (.17)	.49 (.46)	.36 (.38)

* This can also be interpreted as the reliability of the observed indicator (Werts, Linn and Jöreskog, 1974)

attribute levels of influence to team members that fill a given role. And yet, in a majority of design teams, users are assessed as having low influence in the components of Problem Decomposition, Distribution, Solution and Synthesis (See Section 4), i.e., low involvement. To the extent that lack of involvement is an indicator of isolation from key team activities, an informant that is not involved in the team problem-solving process is likely to be an *invalid* source of information on the involvement of other team members. In fact, these data suggest that the user is a problematic source of information for these latter phases of problem solving[5]. The

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[5] Many of the teams include non-I/S professionals in the manager role. Thus, we conclude that the lack of validity is not due to inability of non-I/S professionals to interpret the question. This conclusion was also supported by interviews.

poor reliability of this measure coupled with the high method bias supports the conclusion to eliminate the user informant as a source of measure. Analysis of a five-trait, two-method model results in a goodness of fit of 95% and achieves convergent validity for the two methods used. The results of this solution are shown in brackets in Figure 2. This model will provide the basis to test for discriminant validity among traits.

3.4 Discriminant Validity

A LISREL IV analysis can now be done to determine if the five-component problem-solving model demonstrates discriminant validity. That is, do informants, in fact, discriminate between the five components when assessing the influence of a team member. If there is no significant discrimination between components, the appropriate action would be to average the five influence assessments, treating involvement as having a single dimension. The estimates for each parameter in the adapted five-trait, two-method model are shown in brackets in the bottom of Figure 2. Analysis of these results indicates that the least differentiated traits are Solution (trait 4) and Synthesis (trait 5) ($\phi_{45} = .98$). That is, the high correlation between solution and synthesis suggests that the informants could not distinguish between the levels of influence of a team member for these two components of problem solving. A four-trait, two-method model is analyzed to test the hypothesis that solution and synthesis are distinct factors. This model includes the necessary and sufficient conditions on a solution that hypothesizes that solution and synthesis are equivalent factors. Specifically, this restriction includes defining $\phi_{45} = 1.0$ and requiring the related ϕ_{ij} to be equal (i.e., $\phi_{14} = \phi_{15}$, $\phi_{24} = \phi_{25}$, $\phi_{34} = \phi_{35}$). The difference in X^2 between the four-trait, two-method model and the five-trait, two-method model indicates no significant difference ($X^2 = 6$, d.f. $= 3$, $p \leq .1$). Furthermore, the goodness of fit index (Δ) remains high ($\Delta = .93$). Given this result, a new model involving four traits, two methods is solved. In this case, the responses for solution and synthesis are averaged.

Analysis of the LISREL IV solution for this four-trait, two-method model also shows a high correlation between the problem decomposition and distribution components ($\phi_{23} = .95$). A similar restricted model used to test for discriminant validity of these two factors indicates that these two traits can be modeled as a single trait without significant loss in explanatory power[6]. Subsequent tests for difference among the remaining three traits, i.e., (1) Problem Formulation, (2) Decomposition/ Distribution and (3) Solution/Synthesis support the conclusion that these are distinct traits. Thus, a three-trait, two-method model is used to estimate influence levels for study of the impact of involvement on team performance. The results of this analysis are shown in Figure 3[7]. This model reflects a three-component problem-solving model. The distribution/decomposition component is a distributed problem-solving model of task. Further, the ability to develop valid measures of how influence is distributed within a design team offers a strong foundation to study how planning and design teams cooperate.

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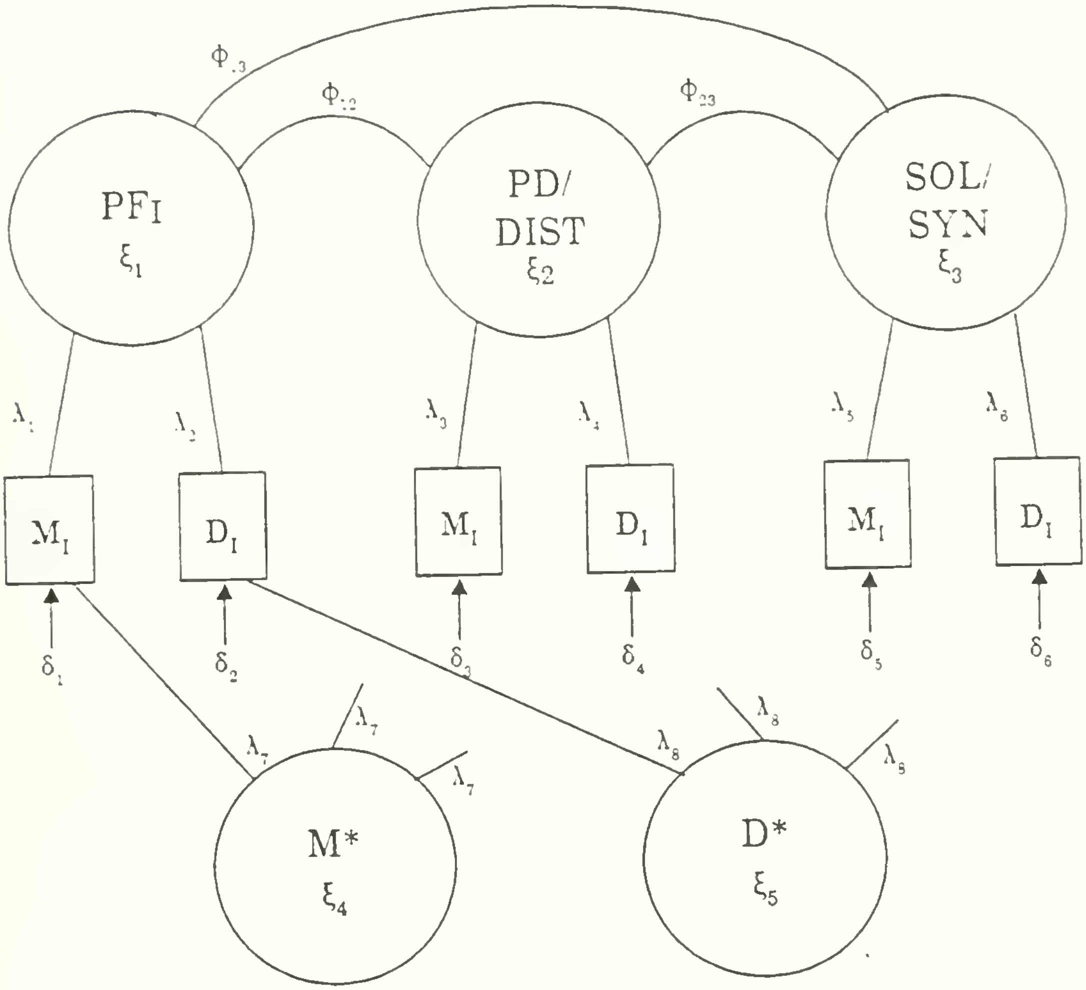
[6] The chi-square test of the hypothesis $\phi_{23} = 1.0$ can be rejected at the .10 level using a two-method model (user evaluation deleted). Given the practical implication of a .95 correlation, we conclude that informants cannot effectively discriminate between these two traits.

[7] A solution to a three-trait, two-method model cannot be specified since the number of estimated traits plus 1 is equal to the total number of indicators in this aggregated model. These values are obtained for the four-trait, two-method model that incorporates the necessary and sufficient condition that problem solution and synthesis are the same trait.

Figure 3

Three-Trait, Two-Method Measurement Model



* λ's within a method are defined to be equal to reflect a common method bias across components.

Parameter	ML estimate	Parameter	ML estimate	Parameter	ML estimate
λ_1	= .48	δ_1	= .37	Φ_{12}	= .37
λ_2	= .84	δ_2	= .10	Φ_{13}	= .45
λ_3	= .68	δ_3	= .14	** Φ_{23}	= .88
λ_4	= .76	δ_4	= .18		
λ_5	= .64	δ_5	= .21		
λ_6	= .72	δ_6	= .20		
λ_7	= .61				
λ_8	= .46				

$X^2 (df = 14) = 24 \quad p \leq .04$

$\Delta = .96$

** Note: Test of hypothesis that $\Phi_{23} = 1.0$ is rejected.

3.5 Summary of Results for the Measure of Involvement

The results of this analysis suggest that a three-component problem-solving model provides for reliable and valid measures of influence levels of individuals filling key roles on a design team. The data indicate that informants could discriminate between influence for three types of problem-solving activities: problem formulation, problem decomposition/distribution and solution synthesis. The lack of discrimination within the latter two components could be due to poorly phrased questions, so final rejection of a five-component model may be premature. Still, the three-stage model introduces the important aspect of problem disaggregation and allocation that is logically part of a group problem-solving process. This may be particularly important in the study of design teams that attempt to incorporate parallel problem-solving activities.

The results also highlight the measurement difficulty associated with the use of influence to operationalize the involvement construct. The reliability of measures used to operationalize the involvement construct is generally about .50. Further, clear method bias exists across informant types. Such circumstances may help to explain the mixed empirical results in the impact of involvement found by Ives and Olson (1984). These results suggest a need to carefully articulate a theory of involvement as well as to *account for* how the nature of an informant's involvement may bias one's measures.

These results suggest that the concept of involvement can be operationalized as a measure of influence of roles for a problem-solving model of task. The next step is to assess the predictive validity of this measure in order to provide evidence that the measurement model does reflect the concept of involvement. Of course, as Bagozzi (1980) suggests, the strongest evidence of validity is shown when this measurement model produces results that are consistent in other operationalizations of the involvement concept. The assessment of nomological validity is, however, beyond the scope of this work.

4.0 Involvement Strategy and Team Performance

In order to examine the relationship between the involvement of key roles and performance, a two-stage analysis is conducted. First, the predicted validity is evaluated at the general level of the relationship between user involvement and performance. To the extent that the measurement model conforms to expected theory, i.e., user involvement increases performance, there is evidence to suggest that the measurement model does reflect the concept of involvement.

A second analysis will be conducted, assuming predicted validity is established, to explore the pattern of influence relationships exhibited across design teams. Cluster analysis will be performed to identify potential classes of influence patterns. These classes, termed involvement strategies, will be evaluated using independent performance criteria (i.e., variables not included in the cluster analysis) and interpreted based on existing literature. Implications from this exploratory analysis for research on I/S planning and design will be discussed.

4.1 Measures of Performance

The performance of the design teams is assessed by *non-team stakeholders* in terms of both efficiency and effectiveness. The number of stakeholders per team ranges from three to nine with an average of 5.3. In every case, stakeholders are senior level managers familiar with the project. Stakeholders include at least two representatives from the user organization and one senior I/S manager.

Table 3
Measures for Design Team Performance

Efficiency items
- the amount of work the team produces
- the efficiency of team operations
- the team's adherence to budgets and schedules

Effectiveness items
- the quality of work the team produces
- the effectiveness of the team's interactions with people outside the team

Item Scale:	1	2	3	4	5
	very low	low	average	high	very high

Table 3 shows the measures for each dimension. The measures are averaged and used to assess performance in terms of the general concepts of efficiency and effectiveness. A Cronbach α of .90 and .89 respectively suggest an adequate level of reliability for each of the two aggregate measures used. A third item for effectiveness, the level of innovation of the team, is not included in this analysis since the Cronbach α calculation indicated a lack of reliability. A more detailed evaluation of the validity of these two measures using the structural modeling approach described above is not possible due to the limited sample size ($n = 18$). Therefore, this analysis of performance must be considered tentative and used primarily to motivate future research.

An informant approach to performance evaluation is used because on-site interviews indicate wide variance across organizations in the approach and quality of more objective measures such as dollars or hours reported. For example, interviews suggest a practice in some organizations of using slack resources to sponsor individual projects as one means to reward efficiency. Thus, the accounting system would not reflect actual efficiency. Similarly, teams facing budget overruns often do not report or under-report overtime hours. While the performance measures used are subjective, the use of multiple informants provides adequate reliability for this exploratory research.

4.2 Predictive Validity

The underlying logic for this research is that user involvement is positively related to design team performance. As discussed in Section 2, this view is widely advocated as a practice and has some empirical evidence to support it. Therefore, if the measures developed herein truly reflect this underlying construct, this measure of involvement should predict performance. The results of a regression model of the form

$$\text{Perf}_i = a + bU_I + \varepsilon$$

where Perf_i = i^{th} performance measure (efficiency or effectiveness)
a = intercept
b = regression coefficient of user involvement
U_I = influence level for the user role average over the three components of the problem-solving model
ε = error

show that user involvement is statistically significant for efficiency ($R^2 = .24$, $F = 5.5$, $p < .03$) and effectiveness ($R = .47$, $F = 15.2$, $p < .001$). Thus, the null hypothesis that user involvement is unrelated to performance is rejected.

These results are consistent with the theory suggesting that user involvement leads to improved performance, thus there is support for the conclusion that the influence measures provide a valid operationalization of the concept of involvement. This conclusion is tentative given the limited sample size and the use of a retrospective informant approach. A retrospective analysis permits the possibility that a project's success could influence the informant's perception of the influence held by members of the team. While using non-team stakeholders to assess performance and collecting data soon after project completion may help to moderate this effect, future research that measures influence levels during the design process is warranted. Still, the strong findings for actual design teams is encouraging. In the following section, the general involvement measure is disaggregated to the three problem-solving components , i.e., involvement strategies, to provide a means to analyze the pattern of influence existing within planning and design teams.

4.3 Involvement Strategies

Given support for the ability to measure involvement at a general level, a more detailed analysis of the pattern of influence between roles across task components can be conducted. This pattern of influence is termed an *involvement strategy* to emphasize the shift in analysis away from the impact of a general concept of involvement to a more detailed examination at a task level. This approach is consistent with prior research that has examined the relationship among roles at a task level. Edstrom (1977), for example, used the system design life cycle model as a model of task to examine how the criticality of user involvement might vary over task. Given the use of a problem-solving perspective of task, the research by Boland (1978) that views design as an inquiry process is particularly relevant. Boland (1978) studied the impact of processes of interaction between a designer and user on performance. He used a communication protocol to enact two alternative involvement strategies: a designer-driven and an interactive. The designer-driven strategy, called traditional, places the user in a relatively passive role in the design process. The user is a *source* of information concerning need and responds only to recommendations for solutions. The designer however, plays a proactive role in both formulation and solution.

The interactive strategy is described by Boland (1978) as a dance. This strategy requires both users and designers to independently formulate need and solutions and then explicitly critique each other's products. Interaction is viewed as an opportunity to teach each other and, hopefully, move toward a final solution that improves upon the original interpretations. Boland (1978) found that this strategy leads to improved design products.

An exploratory analysis is conducted beginning with a cluster analysis using the influence levels of both designer and user for each of the three problem-solving components: problem formulation, decomposition/distribution and solution /synthesis. A hierarchical cluster analysis using the Ward method (Anderberg 1973) is performed with these six variables. The Ward method sequentially combines observations in a manner that minimizes within-cluster variance. Examination of the clustering process showed that three major clusters are formed. The subsequent step that combined two of the remaining clusters resulted in a major shift in within-cluster variance and, thus, is an indication to retain three clusters. The average variable values for each cluster plus the overall average is shown in Table 4a. The clusters labeled designer-driven, user-driven and interactive, have a total membership of 7, 6 and 5 respectively.

The first step in interpreting these three clusters is to establish that they reflect distinct involvement strategies. Results are shown in Table 4b for efficiency and effectiveness for each of the three involvement strategy types. Since the sample size is small, a non-parametric test for statistical difference between types is shown. The Kruskal-Wallis (1953) sign rank test is used to test the null hypothesis that there is statistical difference between strategy types. This test is an extension of the Mann-Whitney (1947) sign rank test for analysis involving more than two populations.

Table 4a
Involvement Scenarios

Overall Average Influence

	D	U
PF	3.5	4.1
PD/Dist	3.3	2.3
Sol/Syn	3.8	2.8

N = 18

Interactive

	D	U
PF	3.8	4.4
PD/Dist	3.7	2.8
Sol/Syn	4.0	3.7

N = 4

User-Driven

	D	U
PF	3.5	4.4
PD/Dist	2.8	2.6
Sol/Syn	3.7	3.4

N = 5

Designer-Driven

	D	U
PF	3.4	3.8
PD/Dist	3.4	1.8
Sol/Syn	3.7	2.1

N = 9

Table 4b
Performance for Involvement Scenarios

	Interactive	User-Driven	Designer-Driven	General Test	Pairwise Test
Efficiency	3.98	3.62	3.16	p < .025	I * DD p ≤ .05 UD * DD p ≤ .05 I * UD p ≤ .10
Effectiveness	4.21	3.84	3.36	p < .05	I * DD p ≤ .05 UD * DD p ≤ .05 I * UD p ≤ .10
Number of teams	4	5	9		

Item Scale:	1 very low	2 low	3 average	4 high	5 very high

The test is analogous to a one way analysis of variance and tests the null hypothesis that teams across different strategies are actual members of a single population. As shown in Table 4a statistical significance exists for both efficiency ($p \leq .025$) and effectiveness ($p \leq .05$) indicating that the strategy differs significantly in terms of performance. If one assumes that the samples are independent, pairwise non-parametric tests of the strategies using the Mann-Whitney (1947) sign rank tests indicate that both interactive and user-driven are superior to designer-driven ($p \leq .05$) and that interactive has slight performance advantage ($p \leq .10$) over user-driven. Although one must be cautious in interpreting the means, the direction of difference between mean responses for each strategy type also supports the hypothesis that interactive design will produce high performance. Similarly, a user-driven strategy is preferred to a designer-driven strategy but may not represent an optimal involvement strategy.

Examining the average influence levels with an involvement strategy for each problem-solving component reveals interesting patterns. First, the influence level of users in problem formulation is consistently high. To the extent that the professionals represented on the teams accept the conventional wisdom that user involvement is good, such a finding is not surprising[8]. Similarly the influence of designers in problem solution is consistently high. Again, given the normal expectations for the designer role, such a finding is not surprising.

More interesting is the differences for user influence on problem solution between designer-driven and interactive (and to a lesser extent, designer-driven and user-driven). The shift in the role of the user is significant and corresponds to a

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[8] Interviews with project managers indicate that this belief is supported.

significant difference in performance level. While the sample size limits the ability to test for causality these findings suggest that mechanisms for increasing the involvement of users in solution generation have high potential for performance impact.

Less clear is the impact of the designer role on team performance. The user-driven strategy does suggest a decrease in the involvement of designers in problem formulation. The reduction in performance is consistent with the arguments of Boland (1978), Churchman (1971) and others that the designer role in problem formulation is important since the role may challenge the user's mental model. Such a challenge could help to stimulate debate and therefore, lead to a more effective problem formulation. To the extent that this argument holds, a decrease in designer involvement in problem formulation should decrease the performance of the team. The direction of the performance measures supports this perspective (user-driven performs lower than interactive) although the weak statistical significance ($p \leq .10$) suggests the need to be cautious.

Finally, the lower involvement of both designers and users in decomposition /distribution is also striking. Debriefings of participants suggest (and are supported by the informant data) that the managerial role dominated this activity. This result also suggests an opportunity for exploring how increasing the involvement of user and designer in this activity may impact performance. Certainly, new computer-aided design technology offers many alternatives in this area.

These results are consistent with the results found by Boland (1978) and the arguments of Churchman (1971). Extending Boland's strategies to reflect an involvement strategy dominated by users, i.e., user-driven, *may* reflect emerging trends in the decentralization of I/S and the rapid diffusion of I/S concepts and technology throughout the organization. It should also be noted that while the designer-driven teams are clearly the low performing teams (as compared to teams in this sample), the fact that the applications are business-oriented could bias results. That is, in a highly technical setting such as operating systems, a designer-driven model may show improved performance. The benefits of adequately accounting for task characteristics as well as understanding how these involvement patterns are enacted are discussed in the following section.

5. Implications and Conclusions

Several implications stem from this research. First, the need to more precisely define and carefully measure a notion of involvement is supported. Further, although the small sample size and the use of a retrospective approach requires cautious interpretation, these results support research by Boland (1978) and others that suggests that using valid measures of involvement will show that interactive design teams achieve high levels of performance. That is, we have evidence indicating that user involvement contributes to high performance.

Perhaps more importantly, these results suggest that a problem-solving perspective is an effective basis on which to operationalize the concept of involvement. Results indicate that, using this approach, valid measures of how influence is distributed among key roles can be obtained for actual design processes. However, the difficulty of this measurement task requires careful attention to be paid to the possibility that method bias may exist. Given this ability to measure, involvement can be used as an intermediate process variable to study how methodology and technology of planning may affect the performance of design teams. That is, normative theory relating method to involvement can be developed. In turn, these involvement patterns can be used to predict performance.

At an exploratory level, these results indicate low levels of influence for the user role in decomposition and distribution (see Table 4a). There is some indication that the interactive teams generate more involvement in this aspect of problem-solving but the levels do not reflect the active involvement seen in solution generation and problem formulation. Rather, it appears that the managerial role dominates these activities. To the extent that the designer and user roles add value in problem formulation and solution, one can speculate that their involvement in decomposition and distribution may also improve performance. For example, involvement of users and designers in decomposition might balance the tendency for a given problem decomposition to be overly biased by resource implications or allocation issues that are a primary concern of the managerial role.

Two other important directions for future research involve boundary management and the impact of technology on design team performance. The boundary management issue reflects the need to account for how design teams involve their non-team stakeholders. For example, do high performing design teams utilize different boundary management strategies, e.g., gatekeeper versus network, for different types of boundary tasks? Should such strategies vary depending upon the characteristics of the design task? Certainly, research by Gladstein (1984), Tushman and Nadler (1979) and others suggests that these differences may affect performance.

Secondly, the results suggest ways that computer-aided design technology might have an impact on design team performance. For example, the recognition of a decomposition/distribution stage highlights an opportunity for effective technology support. Many current I/S design aids provide support for functional decomposition. It is less clear that these tools actually have an impact on the group process used to decompose and distribute tasks to subteams or individuals. This framework can be used to explore such an issue. In general, the premise that significant benefits will result from using technology to alter the way teams work together (i.e., involvement) than by automating specific subtasks can be systematically studied within the structure of this problem-solving model.

APPENDIX A

Definitions of Five Components of Problem Solving

Problem Formulation:	A major step in managing a project is to identify, formulate, or define the problems that must be solved. The initial problem identification defines the goals and the overall scope of the project. As work on the project progresses, this definition will be refined to address new technical or managerial problems that emerge.
Problem Decomposition:	A second major phase of problem solving is to break up the project into smaller subprojects or tasks that can be solved more easily. Although problem decomposition is often done by an individual in organizing his/her own work, we include that activity under the Solution phase. The questions in the Problem Decomposition phase refer to breaking down the overall project into manageable tasks.
Distribution:	In the third phase of problem solving, tasks are distributed, i.e., matched with problem solvers. If the problem is particularly large, tasks may be initially distributed to sub-groups, and then to individuals. Please respond to these questions in relation to the initial distribution of tasks at the project level, rather than to the subsequent levels of distribution within sub-groups.
Solution:	Solving or completing the subprojects or tasks that have been distributed is a fourth phase in reaching the total solution. In this phase, individuals or small groups perform the work that addresses the tasks assigned to them. We call this the task solution phase.
Synthesis:	In this phase, the individual solutions to tasks are integrated to form the overall solution. Synthesis may be accomplished in one effort near the end of the project, may occur intermittently, or may be a continuous activity throughout the lifetime of the project.

This person has .... authority in defining the problems addressed on the (project name) project.

	Very Low	Low	Average	High	Very High	Unknown
Person *i*	1.	2.	3.	4.	5.	6.

REFERENCES

Adelson, Beth, and Elliot Soloway. "The Role of Domain Experience in Software Design." *IEEE Transactions on Software Engineering*, SE-11 (1985), 1351-1360.

Alavi, Maryam. "An Assessment of the Prototyping Approach to Information Systems Development." *Communications of the ACM*, 27 (1984), 556-563.

----------, and John C. Henderson. "An Evolutionary Strategy for Implementing a Decision Support System." *Management Science*, 27 (1981), 1309-1323.

Alderfer, Clayton P. "Boundary Relations and Organizational Diagnosis." In *Humanizing Organizational Behavior*. Eds. H. Meltzer and Frederic R. Wickert. Springfield, IL: Charles C. Thomas, 1976, pp. 109-133.

Alexander, Christopher. "The Determination of Components for an Indian Village." In *Developments in Design Methodology*. Ed. Nigel Cross. Chichester, England: John Wiley & Sons, 1984, pp. 33-56.

Ancona, Deborah Gladstein, and David F. Caldwell. "Management Issues Facing New-Product Teams in High-Technology Companies." *Advances in Industrial and Labor Relations*, 4 (1987), 199-221.

Anderberg, M. R. *Cluster Analysis for Applications*. New York: Academic Press, 1973.

Applegate, Lynda M., Gary Klein, Benn R. Konsynski, and Jay F. Nunamaker. "Model Management Systems: Proposed Model Representations and Future Designs." *Proceedings of the Sixth International Conference on Information Systems*, Indianapolis, IN, December 1985, pp. 1-16.

Bagozzi, Richard P. *Causal Models in Marketing*. New York: John Wiley & Sons, 1980.

----------, and Lynn W. Phillips. "Representing and Testing Organizational Theories: A Holistic Construal." *Administrative Science Quarterly*, 27 (1982), 459-489.

Bakos, J. Yannis, and Michael E. Treacy. "Information Technology and Corporate Strategy: A Research Perspective." *MIS Quarterly*, 10 (1986), 107-119.

Beath, Cynthia M. "Managing the User Relationship in MIS Projects: A Transaction Governance Approach." Dissertation, University of California, Los Angeles. 1986.

Bentler, P. M., and Douglas G. Bonett. "Significance Tests and Goodness of Fit in the Analysis of Covariance Structures." *Psychological Bulletin*, 88 (1980), 588-606.

Boland, Richard J., Jr. "The Process and Product of System Design." *Management Science*, 24 (1978), 887-898.

Broadbent, Geoffrey. "Design and Theory Building." In *Developments in Design Methodology*. Ed. Nigel Cross. Chichester, England: John Wiley & Sons, 1984, pp. 277-290.

Campbell, Donald T. and Donald W. Fiske. "Convergent and Discriminant Validation by the Multitrait-Multimethod Matrix." *Psychological Bulletin*, 56 (1959), 81-105.

Carroll, J., J. Thomas, and L. Miller. "Aspects of Solution Structure in Design Problem Solving." IBM Research Report, RC-7078, 1978.

Cartwright, Dorwin, and Alvin Zander. "Power and Influence in Groups: Introduction." In *Group Dynamics: Research and Theory*. 3rd. ed. Eds. Dorwin Cartwright and Alvin Zander. New York: Harper & Row, 1968, pp. 215-235.

Cash, James I., Jr., and Benn R. Konsynski. "IS Redraws Competitive Boundaries." *Harvard Business Review*, 63, No. 2 (1985), 134-142.

Churchman, C. West. *The Design of Inquiring Systems: Basic Concepts of Systems and Organization*. New York: Basic Books, Inc., 1971.

Cleland, David I., and William R. King. *Systems Analysis and Project Management*. New York: McGraw-Hill Book Company, 1968.

Cronbach, Lee. J. "Coefficient Alpha and the Internal Structure of Tests." *Psychometrika*, 16 (1951), 297-334.

Davis, Gordon B. "Strategies for Information Requirements Determination." *IBM Systems Journal*, 21 (1982), 4-30.

Davis, Randall, and Reid G. Smith. "Negotiation as a Metaphor for Distributed Problem Solving." *Artificial Intelligence*, 20 (1983), 63-109.

De Brabander, B., and G. Thiers. "Successful Information System Development in Relation to Situational Factors which Affect Effective Communication Between MIS-Users and EDP-Specialists." *Management Science*, 30 (1984), 137-155.

De Greene, Kenyon B. *Sociotechnical Systems: Factors in Analysis, Design, and Management*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1973.

Edstrom, Anders. "User Influence and the Success of MIS Projects: A Contingency Approach." *Human Relations*, 30 (1977), 589-607.

Eils, L. C., III, and R. S. John. "A Criterion Validation of Multiattribute Utility Analysis and of Group Communication Strategy." *Organizational Behavior and Human Performance*, 25 (1980), 268-2288.

Gane, Chris, and Trish Sarson. *Structured Systems Analysis: Tools and Techniques*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1979.

Ginzberg, Michael J. "Early Diagnosis of MIS Implementation Failure: Promising Results and Unanswered Questions." *Management Science*, 27 (1981), 459-478.

Gladstein, Deborah L. "Groups in Context: A Model of Task Group Effectiveness." *Administrative Science Quarterly*, 29 (1984), 499-517.

Gorry, G. Anthony, and Michael S. Scott Morton. "A Framework for Management Information Systems." *Sloan Management Review*, 13, No. 1 (1971), 55-70.

Gremillion, Lee L., and Philip Pyburn. "Breaking the Systems Development Bottleneck." *Harvard Business Review*, 61, No. 2 (1983), 130-137.

Gross, M., and A. Fleisher. "Design as the Exploration of Constraints." *Design Studies*, 5 (1984), 137-138.

Hackman, J. Richard. "Effects of Task Characteristics on Group Products." *Journal of Experimental Social Psychology*, 4 (1968), 162-187.

Henderson, John C. "Managing the IS Design Environment: A Research Framework." Center for Information Systems Research Working Paper #158, Sloan School of Management, M.I.T., Cambridge, MA, May 1987.

----------, and John G. Sifonis. "The Value Added of Strategic IS Planning: Understanding Consistency, Validity, and IS Markets." Center for Information Systems Research Working Paper #145, Sloan School of Management, M.I.T., Cambridge, MA, November 1986.

Huber, George P. "The Nature of Organizational Decision Making and the Design of Decision Support Systems." *MIS Quarterly*, 5, No. 2 (1981), 1-10.

----------. "The Nature and Design of Post-Industrial Organizations." *Management Science*, 30 (1984), 928-951.

----------. "Issues in the Design of Group Decision Support Systems." *MIS Quarterly*, 8 (1984), 195-204.

----------, and Daniel J. Power. "Retrospective Reports of Strategic-level Managers: Guidelines for Increasing Their Accuracy." *Strategic Management Journal*, 6 (1985), 171-180.

IBM Corporation. *Business Systems Planning: Information Systems Planning Guide*, Application Manual GE20-0527-4, July 1984.

Ives, Blake, and Margrethe H. Olson. "User Involvement and MIS Success: A Review of Research." *Management Science*, 30 (1984), 586-603.

Janis, Irving L. *Groupthink: Psychological Studies of Policy Decisions and Fiascoes.* 2nd ed. Boston: Houghton Mifflin, 1982.

Jöreskog, Karl G., and Dag Sörbom. *Advances in Factor Analysis and Structural Equation Models.* Cambridge, MA: Abt Books, 1979.

Keen, Peter G. W., and Michael S. Scott Morton. *Decision Support Systems: An Organizational Perspective.* Reading, MA: Addison-Wesley, 1978.

King, William R., and David I. Cleland. "The Design of Management Information Systems: An Information Analysis Approach." *Management Science*, 22 (1975), 286-297.

----------, and Jamie I. Rodriguez. "Participative Design of Strategic Decision Support Systems: An Empirical Assessment." *Management Science*, 27 (1981), 717-726.

Kling, Rob. "The Organizational Context of User-Centered Software Designs." *MIS Quarterly*, 1, No. 4 (1977), 41-52.

Kottemann, Jeffrey E., and Benn R. Konsynski. "Information Systems Planning and Development: Strategic Postures and Methodologies." *Journal of Management Information Systems*, 1, No. 2 (1984), 45-63.

Kruskal, William H., and W. Allen Wallis. "Use of Ranks in One-Criterion Variance Analysis." *Journal of the American Statistical Association*, 47 (1952), 583-621, and 48 (1953), 907-911.

Laughlin, P. R. "Social Combination Processes of Cooperative, Problem-Solving Groups as Verbal Intellective Tasks." In *Progress in Social Psychology (Vol. 1)*. Ed. M. Fishbein. Hillsdale, NJ: Erlbaum, 1980.

Lawson, Bryan R. "Cognitive Strategies in Architectural Design." In *Developments in Design Methodology*. Ed. Nigel Cross. Chichester, England: John Wiley & Sons, 1984, pp. 209-220.

Locander, William B., H. Albert Napier, and Richard W. Scamell. "A Team Approach to Managing the Development of a Decision Support System." *MIS Quarterly*, 3, No. 1 (1979), 53-63.

Locke, Edwin A., and David M. Schweiger. "Participation in Decision-Making: One More Look." In *Research in Organizational Behavior, Vol. 1*. Ed. Barry M. Staw. Greenwich, CT: Jai Press Inc., 1979, pp. 265-339.

Malone, Thomas W., Kenneth R. Grant, Franklyn A. Turbak, Stephen A. Brobst, and Michael D. Cohen. "Intelligent Information-Sharing Systems." *Communications of the ACM*, 30 (1987), 390-402.

Mann, H. B. and D. R. Whitney. "On a Test of Whether One of Two Random Variables is Stochastically Larger Than the Other." *The Annals of Mathematical Statistics*, 18 (1947), 50-60.

March, Lionel. "The Logic of Design and the Question of Value." In *The Architecture of Form*. Ed. Lionel March. Cambridge: Cambridge University Press, 1976, pp. 1-40.

Markus, M. Lynne. "Power, Politics, and MIS Implementation." *Communications of the ACM*, 26 (1983), 430-444.

----------, and Jeffrey Pfeffer. "Power and the Design and Implementation of Accounting and Control Systems." *Accounting, Organizations and Society*, 8 (1983), 205-218.

Martin, James. *Application Development Without Programmers*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1982.

Mason, Richard O., and Ian I. Mitroff. *Challenging Strategic Planning Assumptions: Theory, Cases, and Techniques*. New York: John Wiley & Sons, 1981.

McGrath, Joseph E. *Groups: Interaction and Performance*, Englewood Cliffs, NJ: Prentice-Hall, Inc., 1984.

Mintzberg, Henry, Duru Raisinghani, and Andre Theoret. "The Structure of 'Unstructured' Decision Processes." *Administrative Science Quarterly*, 21 (1976), 246-275.

Mostow, Jack. "Toward Better Models of the Design Process." *The AI Magazine*, Spring 1985, pp. 44-57.

Mumford, E. "Participative Systems Design: Structure and Method." *Systems, Objectives, Solutions*, 1, No. 1 (1981), 5-19.

Myers, Ware. "MCC: Planning the Revolution in Software." *IEEE Software*, 2, No. 6 (1985), 68-73.

Nadler, Gerald. "Systems Methodology and Design." *IEEE Transactions on Systems, Man, and Cybernetics*, SMC-15 (1985), 685-697.

Nutt, Paul C. "Design Methods Research: The Method Variable." Unpublished paper. The Ohio State University, Columbus, OH, 1975.

----------. "An Experimental Comparison of the Effectiveness of Three Planning Methods." *Management Science*, 23 (1977), 499-511.

Olson, Margrethe H., and Blake Ives. "User Involvement in System Design: An Empirical Test of Alternative Approaches." *Information and Management*, 4, No. 4 (1981), 183-196.

Pendleton, A. D. "BMT - A Business Modeling Technology." In *The Economics of Information Processing, Vol. 1: Management Perspectives*. Eds. Robert Goldberg and Harold Lorin. New York: John Wiley & Sons, 1982, pp. 96-126.

Pfeffer, Jeffrey. *Power in Organizations*. Marshfield, MA: Pitman, 1981.

Robey, Daniel, and Dana Farrow. "User Involvement in Information System Development: A Conflict Model and Empirical Test." *Management Science*, 28 (1982), 73-85.

Rockart, John F., and M. S. Scott Morton. "Implications of Changes in Information Technology for Corporate Strategy." *Interfaces*, 14, No. 1 (1984), 84-95.

Rowe, Peter G. *Design Thinking*. Cambridge, MA: The MIT Press, 1987.

Schein, Edgar H. "Management Development as a Process of Influence." *Industrial Management Review*, 2, No. 2 (1961), 59-77.

Schon, D. A. "Problems, Frames and Perspectives on Designing." *Design Studies*, 5 (1984), 132-136.

Seeger, John A. "No Innate Phases in Group Problem Solving." *The Academy of Management Review*, 8 (1983), 683-689.

Silk, Alvin J., and Manohar U. Kalwani. "Measuring Influence in Organizational Purchase Decisions." *Journal of Marketing Research*, 19 (1982), 165-181.

Simon, Herbert A. *Administrative Behavior: A Study of Decision Making Processes in Administrative Organization*. 3rd ed. New York: The Free Press, 1976.

----------. *The Sciences of the Artificial*. 2nd ed. Cambridge, MA: The MIT Press, 1981.

Stevens, W. P., G. J. Myers, and L. L. Constantine. "Structured Design." *IBM Systems Journal*, 13 (1974), 115-139.

Thomas, John C., and John M. Carroll. "The Psychological Study of Design." In *Developments in Design Methodology*. Ed. Nigel Cross. Chichester, England: John Wiley & Sons, 1984, pp. 221-235.

Tong, C. "Knowledge-based Circuit Design." Diss. Stanford University. 1984.

Turner, Jon A. "System Design as a Creative Art." Draft Paper. Graduate School of Business Administration, New York University, 1983.

Tushman, Michael L., and David A. Nadler. "Information Processing as an Integrating Concept in Organizational Design." In *Managerial Behavior*. 4th ed. Eds. David A. Nadler and Michael L. Tushman. New York: Columbia University Press, 1979, pp. 157-190.

Van Maanen, John, and Edgar H. Schein. "Toward a Theory of Organizational Socialization." In *Research in Organizational Behavior, Vol. 1.* Ed. Barry M. Staw. Greenwich, CT: Jai Press, 1979, pp. 209-264.

Venkatraman, N., and Vasudevan Ramanujam. "Measurement of Business Economic Performance: An Examination of Method Convergence." *Journal of Management*, 13 (1987), 109-122.

Werts, C. E., Robert L. Linn, and Karl G. Jöreskog. "Intraclass Reliability Estimates: Testing Structural Assumptions." *Educational and Psychological Measurement*, 34 (1974), 25-33.

Witte, Eberhard. "Field Research on Complex Decision-Making Processes - The Phase Theorem." *International Studies of Management and Organization*, 2 (1972), 156-182.

Zachman, J. A. "A Framework for Information Systems Architecture." IBM Los Angeles Scientific Center Report # G320-2785, March 1986.

Zmud, Robert W. "An Exploratory Study of User Involvement Role Sets." Working Paper, School of Business Administration, University of North Carolina, 1981.