

**From Embedded Knowledge to Embodied  
Knowledge: New Product Development  
as Knowledge Management**

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**ISBM Report 3-1996**

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U.Ed. BUS 96-073

**From Embedded Knowledge to Embodied Knowledge:  
New Product Development as Knowledge Management<sup>#</sup>**

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## **From Embedded Knowledge to Embodied Knowledge: New Product Development as Knowledge Management**

### **Abstract**

In this paper, new product development (NPD) is viewed as a process of knowledge creation through the syndication of diverse streams of knowledge. Cross-functional teams, which are increasingly becoming the preferred mode for organizing NPD efforts, are effective because they are ideal vehicles for such synergistic combination of complementary knowledge.

Knowledge may be categorized as explicit--knowledge that is clearly spelt out and relatively easy to transfer--and tacit knowledge--which cannot be easily transmitted via books, blue-prints, or lectures. The knowledge potentially realizable by the combination of individual team members' stocks of tacit knowledge is conceived of as embedded knowledge. Since embedded knowledge is difficult to manage, firms that are effective at managing it can potentially enjoy distinctive competitive advantage in developing new and better products. It is this embedded knowledge that is the focus of this paper. While embedded knowledge itself is an unobservable construct, we take the instrumental positivist position that a theoretical framework built around it is valuable if it can explain and help improve the performance of NPD teams.

Based on a conceptualization of NPD as a process of converting *potential* new knowledge **embedded** in the team to *realized* new knowledge *embodied* in a product, we develop propositions on how the NPD process may be managed effectively. The propositions are grounded on an extensive review of the literature on individual and organizational knowledge, as well as in-depth interviews with managers drawn from three NPD teams.

## INTRODUCTION

**As** a result of intense global competition and fast-paced technological change in the current business environment, new product development (NPD) has emerged as one of the most important functions in today's organizations. In many industries, competitive advantage stems from being the first to the market and survival often depends on the speed at which new products can be developed (e.g., Hamel and Prahalad, 1991; Wheelwright and Clark, 1992). Because of the increasing competitive significance of NPD as an organizational *capability*, researchers have studied the phenomenon extensively. For example, the Marketing Science Institute has, on several occasions in the recent past, rated research in this area as one of its top priorities. Researchers have examined the relationships between many independent variables and outcomes such as innovativeness and speed of completion of new product development projects (e.g., Cooper and Klienschmidt, 1987); new product design (e.g., Shocker and Srinivasan, 1979); market assessment of new product (e.g., Jamieson and Bass, 1989; Urban, Hauser and Roberts, 1990; Urban Weinberg and Hauser, 1996); organizational variables that impact the propensity of an organization to be successful at new product development (e.g., Nonaka, 1990; Olson, Walker and Ruekert, 1995); and role of national culture in development of new products (Nakata and Sivakumar, 1996).

Within the NPD literature, considerable interest has been devoted of late to forms of sub-organizational structure--i.e., cross-functional teams--that lead to a high probability of success of NPD activities (e.g., Gupta, Raj and Wilemon, 1986; Ruekert and Walker, 1995; Hise, O'Neal, Parasuraman and McNeal, 1990; Wheelwright and Clark, 1992; Workman, 1993). Underlying this institutionalization of teams as the primary organizational vehicles for NPD is the realization that the process of NPD involves the syndication of diverse streams of knowledge. For

example, pharmaceutical firms depend on a confluence of knowledge from chemistry, biology, medicine, and biotechnology (Henderson, 1994). The cross-functional team for NPD is a vehicle for such integration of functional knowledge and competencies, and has been the subject of numerous managerial and academic discussions (e.g., Fortune, 1991; Wheelwright and Clark, 1992). The effectiveness of cross-functional teams as knowledge syndication vehicles is illustrated by the following quote from a Polaroid executive: “Our researchers are not any smarter, but by working together [in teams] they get the value of each other’s intelligence almost instantaneously” Fortune (1991). Responding to the urgency of the NPD imperative, as well as to managerial interest in organizational vehicles such as cross-functional teams, scholars have become intrigued by what constitutes an organization’s ability to integrate individual and functional competencies, and to focus them on meeting NPD goals (e.g., Nonaka, 1991; Hutt, Walker and Frankwick, 1995).

Right from the “idea generation” phase to the “launch” phase, the creation of new knowledge can be viewed as the central theme of the NPD process. Using such a “knowledge creation” lens, this paper develops propositions on how to manage the NPD process so as to optimize the creation of new knowledge. Since teams are organizational forms that seek to integrate the knowledge resident in a group of individuals, the extant findings in the organizational knowledge literature are helpful in developing propositions about knowledge creation in teams. Therefore, we begin with an analysis of what knowledge is in an organizational context. Building on the dichotomy of explicit knowledge--i.e., knowledge that is clearly spelt out and relatively easy to transfer--and tacit knowledge--which cannot be easily transmitted via books, blue-prints, or lectures--, we develop the construct of embedded knowledge. Since embedded knowledge, as defined here, is an unobservable construct, we

explain the instrumental positivist position that theories built around unobservable constructs can be useful as long as they plausibly explain empirically observable reality. The embedded knowledge construct leads us to a conceptualization of the NPD process as the *realization* of new knowledge that is *potentially* resident in the team. Further examination of this knowledge translation process suggests several NPD team characteristics that may significantly influence the efficiency and effectiveness with which the new knowledge is realized. Propositions developed on the basis of the organizational knowledge literature are validated and refined through interviews with managers drawn from three separate NPD efforts.

The knowledge management perspective of NPD proposed here can potentially benefit the marketing literature in two ways. First, it complements the current political (e.g., turf barriers), cognitive (i.e., interpretive barriers) and behavioral (e.g., communication barriers) treatments of cross-functional cooperation in organizations (Hutt, Walker and Frankwick, 1995) by offering an epistemological treatment. The added value in the knowledge management perspective is that it enables us to explicitly model those variables that impact upon knowledge creation and utilization in NPD teams. Such explicit modeling can potentially form the basis for designing managerial processes that specifically enhance knowledge interaction within the cross-functional team. Second, it suggests some interesting research and managerial questions related to the current context of new product development. For example, what is the real impact of “Virtual Offices” on the effectiveness of new product development? What are the considerations that become important when NPD is undertaken in a strategic alliance context, where team members may not share the experience and cognitive background ideal for effectively creating knowledge? These questions illustrate the kind of real-life concerns that can be more fruitfully studied using the knowledge management perspective of NPD.

The rest of the paper is organized as follows. The following section discusses the current treatments of organizational knowledge. The difference between tacit and explicit knowledge is emphasized, as a basis for developing the construct of embedded knowledge. The importance of embedded knowledge in the NPD team context is then established. The next section briefly describes the methodology for selecting and interviewing team members of three different new product development teams. Thereafter, based on extant research findings and the interviews, propositions are developed. The paper concludes with some implications for researchers and managers.

## **KNOWLEDGE AND ORGANIZATIONS**

Against the background of what several analysts have called the knowledge society (e.g., Drucker, 1993; Toffler, 1990), researchers in strategic management and organization theory have shown renewed interest in organizational knowledge (e.g., Kogut and Zander, 1992). The construct of knowledge is fundamental to understanding firms, as firms are essentially organizations that know how to do things (Winter, 1991). This assumption is reflected in the long tradition, from Selznick (1957) to Zander and Kogut (1995), of emphasizing organizational competencies and knowledge as key to strategic performance. While the topic of organizational knowledge has attracted much research attention, the inherent complexity of the construct has meant that researchers in different streams have conceptualized organizational knowledge differently. Fortunately, many of these conceptualizations are useful in the context of NPD, and we address the relevant ones next. Subsequently, we draw upon each one of the conceptualizations in order to advance some propositions.



1. *Organizational Knowledge as Routines*: Organizational knowledge can be viewed from a “*routines*” perspective, which has had a long and enduring tradition in the organizational literature (Stene, 1940; Simon, 1947; March and Simon, 1958; Cyert and March, 1963; Neison and Winter, 1982). The concept of routine refers to *the set of regular and predictable patterns of organizational behavior* (Nelson and Winter, 1982). According to this view, firms are repositories of productive knowledge (Winter, 1991), and this knowledge resides in the routines that underlie the behavior of organizational participants in working together. Nelson and Winter (1982) suggest that routines are the organizational counterpart of individual skills.

2. *Organizational Knowledge as Memory*: While a routine-based conception of organizational knowledge focuses on how organizations do things (Winter, 1991), other researchers have concentrated on how organizations store and retrieve information from its history when making current decisions (Walsh and Ungson, 1991). According to this perspective of organizational knowledge, *organizational memory* is viewed as the *stored information from an organization’s history that can be brought to bear on present decisions* (Walsh and Ungson, 1991: 61). Employing an information processing approach (Galbraith, 1977; Tushman and Nadler, 1978), this perspective emphasizes three aspects of organizational memory: (1) its retention structure; (2) the processes by which information is organized, stored, and retrieved; and (3) the ways in which organizational memory affects outcomes (Walsh and Ungson, 1991).

3. *Organizational Knowledge as Absorptive Capacity*: Named “*absorptive capacity*” by Cohen and Levinthal (1990), this conceptualization of knowledge relates the firm's level of knowledge to its *ability to recognize the value of new, external information, to absorb it, and to apply it productively*. It is argued that the development of absorptive capacity is path-dependent,

and that early lack of investment in a particular skill area may foreclose developing that capability later (Cohen and Levinthal, 1990). Analogously, Kogut and Zander (1992: 384) have proposed the notion of a *combinative capability*, which they see as the ability to “synthesize and apply current and acquired knowledge. ”

**4. Organizational Knowledge as Group Intelligence:** Finally, organizational knowledge can be studied from the “*group intelligence*” perspective. This perspective has received attention in the psychology area (e.g., Hill, 1982; Williams and Stemberg, 1988) but does not appear to have been directly applied to the study of organizational knowledge. However, this perspective does have utility from an NPD viewpoint, as we shall demonstrate later. Studies in this area have shown that groups perform significantly better than individuals at tasks which emphasize divergent and creative solutions (Hill, 1982; Sneyzek and Henry, 1989). However, groups were not necessarily better than individuals in all situations. For example, Hackman (1983) argued that homogeneous group members, while getting along well together, may lack necessary diversity, while excessively heterogeneous groups may be ineffective in putting their rich talent to use due to differences in values and perspectives (Williams and Stemberg, 1988). Further, it was found that both cognitive (e.g., IQ), and social-cognitive (e.g., self-awareness) attributes were related to group performance (Williams and Stemberg, 1988), emphasizing that group composition needs to take into account both the technical abilities of members, and their competence at combining their knowledge with that of their colleagues.

### **The Tacit Component of Organizational Knowledge**

One factor that is increasingly being considered in many of the above treatments of organizational knowledge is the role of tacit knowledge. The philosopher Polanyi (1967) is

credited with being the first to conceptualize tacit knowledge as knowledge that *cannot be fully explicated even by an expert and can be transferred from one person to another only through a long process of apprenticeship*. His famous dictum, “We know more than we can tell” (Polanyi, 1967: 4), points to the phenomenon that much that comprises any human skill remains unarticulated and known only to the person who has that skill. In contrast, explicit knowledge is relatively easy to articulate and communicate, hence to transfer between individuals and organizations. Explicit knowledge resides in formulae, text books, or technical documents. Analogous to the tacit and explicit dichotomy, Zuboff (1988) makes a distinction between embodied or action-centered skills and intellectual skills. Action-centered skills are developed through actual performance (learning by doing). In contrast, intellectual skills combine abstraction, explicit reference, and procedural reasoning making them easily represented as symbols, and therefore easily transferable (Zuboff, 1988).

Though initially conceived of at the individual level, tacit knowledge has been recognized as existing in the organization as well. For example, Nelson and Winter (1982) point out that a great deal of organizational knowledge remains tacit because it cannot be efficiently explicated using formal language, and because it is impossible to describe all aspects necessary for success & performance. They argue that creating an effective organization is not a matter of implementing a set of “blueprints”; much of the crucial know-how required resides only in the minds of the organization’s members. In a similar vein, Kogut and Zander (1992) differentiate between information (e.g., facts) and know-how (e.g., how to organize factories). The listing of ingredients in a recipe consists of information, but the description of action steps is at best an imperfect representation of the know-how required. Spender (1993) has hinted that an appreciation of tacit knowledge is key to understanding the relationship between knowledge and

strategy. The conceptual distinction between tacit and explicit knowledge also appears in Reed and DeFillippi's (1990) discussion of causally ambiguous competencies as a source of sustainable competitive advantage. They argue that a basic ambiguity about the causal links between actions and results can be an effective barrier to imitation, and thus be a possible source of sustainable competitive advantage. They describe tacitness as residing in the inability of even a skilled individual to explicitly spell out the decision rules and protocols that form the basis of performance. Similar distinctions between explicit and largely tacit knowledge in organizations have been made by Scribner (1986), Nonaka (1991), Hedlund and Nonaka (1993), and Bohn (1994).

The above discussion points to the theoretical and empirical validity of a tacit component of organizational knowledge. Recently, the notion of tacit knowledge in organizations has been further refined. Spender (1993) suggests that the tacit component of organizational knowledge can be subdivided into two categories - one that exists in individuals and another that exists in groups. The group component or the social element is “communal knowledge”, and draws on communal memory and institutions. Thus, organizational participants operate as part of a cohesive community of practice (Brown and Duguid, 1991). For example, studies have shown that repairmen learn more about fixing copiers by “hanging around swapping stories” than from company manuals (Fortune, 1991: 50). Similarly, Badaracco (1991) conceives of tacit knowledge as existing in individuals or groups of individuals. Badaracco (1991) argues that the social and administrative networks of the organization carry complex information patterns. Knowledge resides in social relationships, and in patterns of coordination between individuals in a team. Badaracco (1991) refers to such knowledge in individuals and in social groups embedded knowledge.

We borrow the term embedded knowledge from Badaracco (1991) but define it more precisely. As soon as members of a team get together, there is potential for the team to create new knowledge. This new knowledge is a result of a combination of explicit as well as tacit knowledge. Combining explicit knowledge is rather easy; whereas the degree to which the potential new knowledge due to the integration of tacit knowledge is realized depends on several variables. It is this domain of integration of tacit knowledge that is interesting and, therefore, we conceive of *embedded knowledge as the potential **knowledge** resulting from the combination of the individual team members' stores of tacit knowledge.*

In the new product development context, a cross-functional team is brought together because its members have collective knowledge that cannot be efficiently held by any of its individual members. However, this collective knowledge is not present by definition when the team is assembled--it is only **potentially** present. We characterize the NPD team as a product development vehicle that brings to its task knowledge that is embedded in its members and in their interactions as a team. Further, the new product that emerges from the successful NPD team may be characterized as embodying that collective knowledge (Nonaka, 1991). The NPD team has embedded knowledge; the new product is embodied knowledge--therefore, one way to describe the task of NPD is as **managing the transition from embedded knowledge to embodied knowledge**. From this perspective, knowledge management is an important component of NPD. Such a conceptualization of NPD allows us to leverage the findings of the knowledge management literature, an evolving body of work yet to be properly utilized by marketing scholars, into the current inquiry into **NPD** teams.

## METHODOLOGY

Since our goal was to develop an knowledge-based treatment of the NPD process, we chose a theory development orientation for the paper. We used the literature on organizational knowledge as a starting point for examining NPD as the transition from embedded knowledge to embodied knowledge. Each conceptualization of organizational knowledge motivated propositions linking NPD team characteristics and the transition from embedded to embodied knowledge.

Parallely with the development of the propositions from the theory base, we conducted in-depth interviews with team members involved in three separate new product development ventures in three different organizations. The purpose of these interviews was two-fold: First, we sought to get a first-hand feel for the relevance and face validity of our framework. While the results are not being proffered as “proof” of our framework, the interviews helped us to confirm that our theory-based assertions were in line with managerial experience, and thus provided a sound basis for theory development (Yin, 1989). Second, we looked for input from managers that could be used to guide the theory development process itself. In this aspect, we followed the spirit of grounded theory development (Glaser and Strauss, 1967).

*Sample:* Following the systematic replication logic advocated by Yin (1993), three NPD teams from three different corporations were carefully chosen to reflect a range of relevant characteristics. Three different industries were represented: traditional manufacturing, high-tech, and business services. The corporations varied substantially in size as well. One company was a very large Fortune 500 company, another was a large manufacturing firm with global business dealings and the third was a small regional firm. Finally, the projects were chosen so as to reflect a varying level of innovativeness of the new product being developed. One team was

engaged in developing better processes for order management. Even though sophisticated robotics equipment were being incorporated, the innovativeness of the output was not high. The cross-functional diversity in this team was the least, as most members were operational staff who were involved in the day-to-day functioning of the order fulfillment system. The second team was developing a software product. Compared to the previous team, this team was “more” cross-functional in the sense that they brought in diverse knowledge bases, including Human Resources, Payroll, and MIS (System and Programming) departments. The third team consisted of individuals from R&D, marketing and manufacturing. This team had developed and commercialized a really innovative product on which the company held several patents. Thus, the three cases together represent a wide variety of NPD contingencies.

***Data Collection and Analysis:*** Following the guidelines available in the literature (e.g., Eisenhardt, 1989), we conducted semi-structured interviews with team members. Though we guided the discussion to ensure that the interviewees covered the topics we were interested in, we were careful to allow them to use their own words to describe the dynamics of their NPD teams. We also avoided leading questions, such as “Do you think Rich Personal Interaction is helpful in creating embedded knowledge”? Each interview lasted approximately one hour. All interviews were tape-recorded and transcribed.

In analyzing the interview data, we looked for interviewee opinions that fell into three classes: 1) those that supported our current thinking; 2) those that conflicted with our current thinking; and 3) those that presented new thoughts. In the latter two cases, we went back to the literature to help clarify the issues concerned. This “grounded” (Glaser and Strauss, 1967) process resulted in the theoretical framework presented next. In our presentation of the hypotheses, we do not make any distinction between the hypotheses that were stimulated by the

literature and those that were motivated by interviewees' comments. It is perhaps important to point out that not every member of all teams made comments related to all the hypotheses which points to the contribution of such a study.

#### PROPOSITIONS: EMBEDDED KNOWLEDGE TO EMBODIED KNOWLEDGE IN TEAMS

The construct of embedded knowledge plays a different role in the propositions developed here as compared to constructs in some other nomological frameworks. Essentially, in our development the construct of embedded knowledge remains unobservable. From a philosophy of science perspective, such a usage has both legitimacy and merit. Logical positivists, in general, have espoused a verificationist stance with respect to unobservable constructs, arguing that only empirically *verifiable* objects have meaning (Hacking, 1983). However, this extreme position has attracted criticism, since it has rendered logical positivism unable to handle theories heavily reliant on unobservable constructs, such as quantum physics (Putnam, 1990). In response, positivists have moved towards a more flexible *instrumental* position that acknowledges the value of unobservable constructs in science (Godfrey and Hill, 1995). The essence of the instrumental positivist view is that unobservable constructs can have value if their use leads to empirically verifiable predictions (Friedman, 1953). For example, the economist's construct of marginal utility is valuable, even if human beings can never be observed to be computing marginal utilities, as long as it helps in accurately predicting human economic behavior (Godfrey and Hill, 1995). In sum, in the instrumental position unobservable constructs need not be converted to observable constructs to have merit. In this view the



unobservable construct can remain in the background as long as it can make predictions about the relationship between two or more observable constructs.

Unobservable constructs, that remain unobservable, can often be seen playing a useful role in organization and management theory development. A number of influential theories in marketing and strategic management, including transaction cost theory and the resource-based view of the firm, have unobservable constructs at their core (Godfrey and Hill, 1995). In their study of organizational memory, Walsh and Ungson (1991) conceptualize the organizational memory construct as one that the researcher invokes to explain a part of a system that is not easily observable. Thus, the construct was not treated as a variable with dispositional properties that interacts with other variables to produce observable outcomes (Walsh and Ungson, 1991: 61). It is in the same spirit that we conceive of the construct of embedded knowledge.

Consistent with the instrumental positivist position, we argue that the construct of embedded knowledge, though unobservable in itself, serves as a basis for the observable relationships between other variables hypothesized in our framework.

Embodied knowledge is the tangible new product that is developed because of the conversion of embedded knowledge. To judge the success of a new product development process, several dependent variables can be assessed, including but not limited to - the time it takes to develop the product, the number of iterations the product goes through to remove errors and flaws in the product, the fit with the market it was intended for, and the commercial success of the new product. In our case, the management of the NPD process from an epistemological perspective impacts all these variables in the same manner. We, hence, state the dependent variable as “efficiency with which embedded knowledge is converted to embodied knowledge”. In testing of hypotheses, any one or more of the measurable dependent variables can be used.

## Hypothesized Relationships

When a team of individuals come together to develop a product, the individuals' stocks of tacit knowledge gives rise to embedded knowledge. Whether this embedded knowledge gets efficiently converted to embodied knowledge (the new product) depends on how the NPD is managed. (The term efficiency as used here takes into account both the input as well as the output of the process.) The major issues addressed by our framework are: the identification of the controllable NPD process variables that impact the efficient conversion of embedded knowledge to embodied knowledge, and the nature of the impact. More specifically, we attempt to provide tentative answers in form of propositions to questions such as: In what ways does the cross-functional team facilitate the sharing and syndication of individual tacit knowledge? What factors can help or hinder this process? Ultimately, what factors determine whether embedded knowledge is efficiently translated into embodied knowledge?

*Past Experience in NPD Teams:* The first conceptualization of organizational knowledge discussed above was the routines perspective. In this view of organizational knowledge, organizations develop and retain effective routines by doing. Nelson and Winter (1982) assert that doing is important because a significant portion of organizational knowledge is tacit.

In the context of the NPD teams we studied, the notion of tacit knowledge was expressed by respondents from all the three teams we interviewed. For example, some of the comments were:

“(regarding using documents instead of personal communications) it would be a massive document ... (moreover) you and I all reading the same 3 pages would walk away with 3 interpretations. ... Who is going to read those 3 papers and interpret. Where do you find that one person ... I don't know anybody who can sit down and pull it all together\_”

“It’s very difficult to explain something with text, or even with pictures. You need interactive communications to gain understanding.” “(for developing a high -tech product) so there is what I’ll call ‘fundamental intuition’ as to the components that we needed to succeed.”

In the context of MDTs, the knowledge (routine) of how individual stock of tacit knowledge is to be combined is tacit. Team members who have worked in NPD teams earlier would have developed their own routines for the combination of individual stores of tacit knowledge and hence would be more effective NPD team members. As one member of a team claimed,

“at any rate, the team members that have been on successful team would be something to shoot for ... they know how to work on teams.”

Hence we propose:

**P1a:** Past Experience in NPD teams is positively related to the efficiency with which embedded knowledge is converted to embodied knowledge.

In addition, if team members have worked with current team members earlier as well, their routines of how to combine individual stocks of tacit knowledge are more specific to the personalities of the team members. Such a combination of team members would be more effective than a group that has not worked as a team before. Following quotes from some members of the teams reflect this:

“We didn’t have a hard time working together ... but that could have been from the fact that we worked together before.” “The fact that we knew each other and the way we worked, we were able to expedite things slightly.” “ I think it’s significant from this standpoint: when we were brought together, we had worked together (before) ...I think that we have a relationship that we can work and build on; we’ve got a certain element of trust and confidence in one another; it would be a very easy transition to do.” “If there was any strength that came from that, is that we knew one another.” “And this

knowledge base that we gathered dealing with one another . . . we continue to add to what we've got, but if we go into another job, we have had the element of some experience to take on to some other.” “And I think one of the reasons that we have been successful (in this new product) is that we have been together since the formation of this business unit.”

We thus propose:

P1b: Past Experience in NPD teams with current team members is more positively related to the efficiency with which embedded knowledge is converted to embodied knowledge than Past Experience in NPD teams with other individuals.

*Shared Experience* : The second conceptualization of organizational knowledge discussed was the memory perspective. Organizational memory is the stored information from organization's history that can be brought to bear on present decisions (Walsh and Ungson, 1991). In the new product development team context, the common memory of organization's history, of the functioning of various departments and of the stereotypes in use in the various departments can impact the perceptions and decisions the team members. This *common memory base among team members is referred to as Shared Experience* here. Following Nonaka (1991) and Hedlund and Nonaka (1993), it may be argued that the articulation, internalization, and reflection of tacit knowledge are facilitated by the availability of a common “language” that is rich in symbolic imagery and metaphor. This assertion is undergirded by the premise that the organization is a network of intersubjectively shared meanings sustained by a common language and interpretive schema (Walsh and Ungson, 1991; Daft and Weick, 1984; Burrell and Morgan, 1979). Since the transfer of tacit knowledge is heavily dependent on figurative language and symbolic meaning, e.g., metaphors (Nonaka, 1991), it is facilitated by the availability of a common language that all MDT members feel comfortable with. We argue that the amount of Shared Experience that team members bring to the team is an important factor in the availability

of such a common language which would aid the process of conversion of embedded knowledge to embodied knowledge. Thus, a team with members who have had cross-functional experience before will be more effective than one with members who have had narrow, one-function careers. Prior cross-functional experience provides team members with a common base of experience, and thus compatible interpretive schema. This would explain why the Japanese, whose managers typically rotate through many functions during their career, have had relatively greater success with cross-functional teams. Several comments from respondents point to the importance of Shared Experience.

“That is where cross training is very important to understand everyone’s needs. That was one problem we had without the team, I was buying most of the stuff. There were 3 salespersons upstairs sending down information, I didn’t know what was important because I wasn’t involved with the customer at that time.” “We want them to walk in the other guys shoes to see what goes through. You go out there and it is 100 degrees and you wonder why someone might be upset or it is cold, the door opens every time and you think do I want to be back there. We want those guys up here and get 100 phone calls everyday, the ridiculous demands the customer has. It is real easy to sit in the shop and tell them no. You go up there and tell the customer no and look at the ramifications.” “(if the five team members did not know one another’s job) it wouldn’t be a team.”

However, the relationship between Shared Experience and the effectiveness of knowledge use and creation is not a linear one. While a certain amount of Shared Experience is necessary for the effective articulation, internalization, and reflection of tacit knowledge (Hedlund and Nonaka, 1993) and, hence, conversion of embedded knowledge to embodied knowledge, too much of it may be counterproductive. As an example, the prevalence of groupthink in highly cohesive groups has been extensively documented (Janis, 1982). Besides, too much of Shared Experience would negate the very premise of a cross-functional team, which is that the interaction of different functional perspectives leads to creative solutions (Simon, 1985). The following comments elucidate this point.

“I have been here 5 years, I have a basic working knowledge of what they do in a lot of areas but there is no way I could do \_\_\_\_\_’s job because the knowledge that he has. He can accomplish a lot by the contacts he has, the people he knows ...so there is no way that I could duplicate.” “I had a little understanding of what their motivations were, and what their metrics were, so I knew where we were alike and where we were different.”

Thus, we argue that there will be an inverted-U-shaped relationship between the level of Shared Experience within the MDT and its effectiveness in the use and creation of knowledge.

As such:

- P2: The extent of Shared Experience within the MDT will be related in a curvilinear fashion to the efficiency with which embedded knowledge is converted to embodied knowledge. At very low and very high levels of Shared Experience, the efficiency will be low. The efficiency will be highest at medium levels of Shared Experience.

*Information Redundancy:* The absorptive capacity notion of organizational knowledge leads us to another process variable that is under management control. It was mentioned earlier that absorptive capacity is the ability to acquire and process new information (Cohen and Levinthal, 1990). It is well accepted by now that the value of a piece of information lies in “the eye of the beholder”. Research in developmental psychology suggests that the individual’s ability to make sense of new information depends on the breadth of categories into which prior knowledge is organized, the differentiation of those categories, and the linkages across them (Bower and Hilgard, 1981). Since the categorization of prior knowledge is highly specific to an individual, this provides the rationale for why different NPD team members will draw different meanings from an identical piece of information. A potentially important piece of information may go unnoticed if viewed from a wrong lens. Thus, *Information Redundancy--the sharing of*

*information over and above the minimal amount required by each person to do the job--is* fundamental to innovation (Nonaka, 1990). A policy of actively promoting Information Redundancy is a good way to encourage the serendipitous interaction of ideas and people that is often the source of innovation (Mezias and Glynn, 1993; Nonaka, 1990). If the design of the team incorporates traditional gatekeeper roles (Rogers and Rogers, 1978) either in the interests of reducing information overload, or out of political motives, there is a danger of losing these advantages. Information Redundancy has an additional advantage as well. As Zand (1981) pointed out, information sharing is very closely associated with trust, Nonaka (1990) argues that Information Redundancy increases the possibility of trust between organization members. Comments from team members support this notion.

“Anything we do, we are putting on the table so the 3 of us can (figure out) the best way to attack.” “It might be recognized that somebody may make a decision thinking this doesn’t affect anybody, when it may have significant impact in other areas.” “We, as a management team, decided that we need to share information on anything that affects our interaction together, or outside interaction.”

However, as in the case of Shared Experience, Information Redundancy could also be related in a curvilinear fashion to the team’s effectiveness of knowledge use and creation. Excessive Information Redundancy can potentially engender both groupthink (Janis, 1982) and information overload (Nonaka, 1990). Thus, we argue that there will be an inverted-U-shaped relationship between the level of Information Redundancy within the team and its efficiency in converting embedded knowledge into embodied knowledge. Typical remarks regarding this notion were:

“(the more information the better?) definitely, within the context of the project, ... I don’t want to know every possible use for The 65 Screen, just related to payroll.” “(what information he shares?) probably only if it is relevant.. . I wouldn’t say I wouldn’t, but it wouldn’t be a big priority on my (list).” “If I have a problem with the machine I might not bring it to the team because I might be able to fix it, but if it is going to impact the customer or the performance (of the team) then I will bring it (to their notice).” “ You can’t bring everything that happens to the team, you are going to bog it down with trivial detail and not get a lot back out of it. At the same time you want everyone in the team to know what is happening to the customer, (if) the team is going to be responsible when something goes right or something goes wrong, the members (should) know about the business make-up . . . you would like to keep people educated to some extent on issues,” “If you have a customer that has a requirement, everyone on the team should know that because we are all trying to please that customer .. (otherwise) ... it would depend on whether they really need it.” “For example, manufacturing ... how well that is done depends on the design. So I can’t just say that design is somebody else’s job; I really want to get in the face to try to make them more knowledgeable in the (manufacturing) process. Yet I know that there is a gap there in between; to where you have different responsibilities; you don’t get in my back yard, and I don’t get in yours.”

As such:

- P3: The extent of Information Redundancy within the cross-functional team will be related in a curvilinear fashion to the efficiency with which embedded knowledge is converted to embodied knowledge. At very low and very high levels of Information Redundancy, the efficiency will be low. The efficiency will be highest at medium levels of Information Redundancy.

*Richness of Personal Interaction:* The recognition that knowledge has a tacit component increases the importance of some other dimensions to managing cross-functional teams. One such dimension is Rich Personal Interaction - consisting of *Direct* (i.e., face-to-face), *Frequent*, and *Informal* communication - between team members. It is well accepted that interactive communication among organizational participants is beneficial to the functioning of the organization (Luthans, 1992). As contrasted with vertical communication, interactive communication is believed to facilitate task coordination, problem solving, information sharing,



and conflict resolution (Goldhaber, 1974). While some researchers have argued that open, interactive communication is not always equally beneficial (Eisenberg and Witten, 1987), it is generally accepted that the richness of personal interaction within a team is a crucial determinant of effective knowledge utilization and creation within the team. Open and extensive communication among team members is a factor that is also emphasized by political, cognitive, and behavioral, treatments of NPD. In those treatments, it is implicitly assumed that Rich Personal Interaction will produce, as a *by-product*, the combination of individual and functional stocks of knowledge. However, the current epistemological treatment, which recognizes the tacit component of knowledge, adds value by suggesting directly knowledge-based reasons for why such communication should be a part of NPD team practice. Thus, the suggestion here is that cross-functional teams are more than “touchy-feely” exercises (Fortune, July 11, 1994), and that they have direct, “technical” effects on knowledge integration. By isolating the effect on knowledge interaction, such a perspective allows us to develop specific mechanisms *aimed squarely* at stimulating such interaction, rather than as a *by-product* of social interaction. Our reasoning is as follows.

Nonaka (1994) has proposed a model of organizational knowledge creation as a continuous dialogue between tacit and explicit knowledge. Although ideas are born in the minds of individual human beings (Hudson, 1994), their development is critically shaped by the interaction between individuals. Thus, knowledge development has two dimensions: epistemological (i.e., tacit versus explicit knowledge), and ontological (i.e., the level of social interaction which serves to amplify and crystallize knowledge that resides in individuals). This leads to the expectation that team members cannot effectively utilize or create new knowledge without being able to interact directly (Le., face to face). Since much of the knowledge being

shared cannot be articulated, team members will benefit from being able to work together and to see each other working. *Direct* interaction allows the use of a “multiplex” communication pattern, employing both verbal and non-verbal means. In comparison, indirect interaction, through e-mail or telephone, for instance, will not be as effective. It is widely accepted that people who work closely together also communicate more with each other (Gullahom, 1952). Both Keller (1986) and Pinto, Pinto and Prescott (1993) have found that the physical proximity of project participants is associated with project success. There is also evidence that managers take this into consideration when designing work settings. For example, Reich (1992) reports that a research facility was built with escalators rather than elevators, because it was found that engineers tended to interact with their counterparts on other floors if escalators were available. Similarly, a recent Fortune article (July 11, 1994) notes the paradox that the more dispersed a Workgroup, the greater is the need to meet face-to-face. A recent article in the *New York Times* (1995) also points to the necessity of direct contact. “Prodigy Services Company, one of the country’s leading on-line computer services, is relocating its corporate headquarters from White Plains to lower Manhattan, its president and chief executive, Edward A. Bennett, said today. Prodigy’s move says much about the way business is conducted in the age of cyberspace. For all the efficiency of communicating by E-mail, modem and fax, even high-tech companies still put a premium on old-fashioned, face-to-face contact. Mr. Bennett said he hoped to spruce up Prodigy’s on-line offerings by relocating programmers, producers and marketing executives to Manhattan, where they can draw on the talents of a growing subculture of graphic artists, writers, software designers and film makers.”

Nowhere is the need for direct contact greater than in the case of the cross-functional team, where merely “transactional” encounters over e-mail, fax, or occasional meetings are not effective vehicles for the creative integration of knowledge. Interviewees confirmed this notion:

“I can’t really tell by talking on the phone if you have a frown on your face because you are concerned about the detail on the graph. So based on how someone is presenting their self is how comfortable they are about what they are presenting.” “When you get a group of people in the room together, you build a team. I can have 4 people on the phone and not have a team atmosphere.” “So what I found out that talking to people on the phone is fine for a few general questions, but to have a in-depth talk it is better getting together.” “You see facial expressions, hand actions ...” “Let me go to the beginning where we were all separated among the building . . . so the 2 floors lost a lot of communications and urgency with the customer ... when the phone rings and the customer needs 10 orders out today. They (workers in the distribution area) don’t understand that at this point. So we have to get the distribution in the office to see how this works.” “Our biggest problem that we had was there was a wall between purchasing and sales and there was another wall between the shop and the sales. Everything was done by (computer screen), the two departments were on two different floors, you couldn’t get an answer. One was blaming the other. But now everyone is working on the third floor together.” “Information would lose its meaning ... to hand someone a piece of paper ... just the way people talk, you can get something out of their voice ... body language ... to let everyone know the degree of urgency ... if I send out a piece of paper ... no one is going to do anything about it.” “The job done is more accurately with face-to-face ... ‘if I had known that you needed 500 pieces I would have quoted you differently’ ... with team it happens less now.” “The old way, for us to get cost information, we had to do it through the computer, it would create a request that was costly. That would go to another floor in the building, we couldn’t see face-to-face. We get a cost estimate based on whatever information I could provide them and they would have to fill in the holes.” “We kept doing things like enhancing the phone system, communication screens, all these tools ... but as much as we tried this company (in the distribution business) had a problem with sales department and purchasing department ... a lot of pushing back and forth. We had trouble understanding what the other guy was going through. We always had trouble getting things accomplished quickly enough . . . You can’t say enough on the screen to get the other guy to get the information to you on time. You can’t convey enough on the screen to get the other guy to get the information to you on time, You can’t convey enough.” “Put these people together in one room so they could all experience the urgency.”

Thus:

P4a: The ability of MDT members to interact *Directly* will be positively related to the efficiency with which embedded knowledge is converted to embodied knowledge.

Another aspect of rich interaction is the *Frequency* with which team members are able to interact. If interaction is direct, but occasional, it is unlikely that team members will get sufficient opportunity for articulation and internalization and, hence, for conversion of embedded knowledge to embodied knowledge (Hedlund and Nonaka, 1993). The physical proximity finding, cited earlier, that proximity alone may not be sufficient underscores this point (Pinto, Pinto and Prescott, 1993). A response regarding co-location by one manager highlights this argument,

“even if factory was in this office, R&D was in the next office, market management in the next office. co-located, we could have the same problem if we weren’t talking to one another.”

Given the nature of communication required for the combination of tacit knowledge stores, team members would need to interact on an almost continuous basis. In addition, frequent interaction between team members can contribute to the building of strong ties between them (Krackhardt, 1993), which further facilitates the use and creation of knowledge within the team -

“the frequency of face-to-face tends to kind of establish that bonding that takes place between individuals.. . you renew a sense of trust.”

Office culture (“We encourage our staff getting together and brainstorming”), and personal preferences (“I keep an open door”) are likely to influence the frequency of interaction

Thus:

- P4b: The ability of MDT members to interact *Frequently* will be positively related to the efficiency with which embedded knowledge is converted to embodied knowledge.

A third aspect of rich interaction is the *Informality* of interaction within the cross-functional team. Warren Bennis has noted that “informality inevitably increases” in networks (Fortune, July 11, 1994). The need for direct observation and figurative communication (Nonaka, 1991) implies that informal interactions are a must in MDTs. In contrast to traditional models of information processing in organizations, which implied that formal procedures and designated roles would determine information flows, current research confirms the intuition that social ties between individuals affect information flows. For example, Stevenson and Gilly (1991) found that managers often avoid dealing with formally designated problem solvers, and use personal ties to pass on information. Since patterns of information flow can determine who gets what kind of information when, and such information is the basis for managerial decisions, it can be argued that the set of social arrangements has a major influence in the effectiveness of the organization. A study by Meyers and Wilemon (1989) found that informal networks (informal discussions, knowledge transferred with team members to other projects, and friendship ties) were much more significant than formal channels in transferring learning.

In addition, recent research indicates that formal, planned approaches may be less than optimal in inducing innovation (Mezias and Glynn, 1993). Increasingly, the role of chance and serendipity in creative problem-solving is being recognized. Some authors have described innovation as arising from the “interaction between necessity and chance, order and disorder, continuity and discontinuity” (Nonaka, 1990: 27). Simulation studies have demonstrated the

need to introduce variance into routine processes designed to generate innovation (Mezias and Glynn, 1993). Japanese firms, for example, are reported to encourage informal mixing after hours, and some U.S. high-tech firms are known for their “Friday afternoon beer busts”. These devices encourage informal knowledge-sharing, and may also be useful in introducing random variance into the innovation process. An article that appeared in the Wall Street Journal (1994) emphasizes the importance of informality in today’s environment. “Paul O’Neill, the chairman of the Aluminum Co. of America, is moving out of his lush executive suite into a spartan cubicle. And it’s all in the name of speedier decision making ... Mr. O’Neill and nine other top Alcoa executives will spend their workdays in a cluster of cockpit offices: L-shaped desks anchored with small tables for *impromptu* round-table meetings. The executives need only lean over a makeshift wall to confer, instead of waiting for *formal* meetings and wading through long-winded memos. Alcoa’s existing offices were a “difficult place to have spontaneous association”, Mr. O’Neill says.”

A cross-functional team where the dominant mode of interaction is formal would not enjoy such an advantage. The following comments by members of the three teams support the importance of informal communications.

“The guys doing purchasing are 15 feet away from me. Sometimes I hear stuff just from overhearing a phone call. I will hear on the phone, you think you are working on your own desk but things have a way of building up . . . *you* are picking up things all the time.” “I got a long cord on the phone and I walk over to his desk ... and I have an instantaneous response for our customer ... and I will walk back to the machine shop, my cord reaches back there.” “There are things that you pick up just by being there.” “He would not have thought that it would have been important to me. But I picked it up because, you know, my antenna was up listening.” “(Informality) moves the process along much quicker, just by bumping into one another in the hallway, in the men’s room, over lunch.”

· Thus we propose:

P4c: The ability of MDT members to interact *Informally* will be positively related to the efficiency with which embedded knowledge is converted to embodied knowledge.

*Degree of Professional Trust:* Given the emphasis on tacit knowledge, which is unarticulable by definition, it may be argued that a high degree of Professional Trust between team members is necessary to ensure the effectiveness of knowledge use and creation within the team. This is because members may need to accede to the professional judgments of their colleagues from other functions, without being able to understand fully how those decisions were made. Authors such as Zand (198 1) have established that trust is critical to the effectiveness of problem solving groups. The lack of an atmosphere of trust will lead to the withholding of information, attempts to influence decision making towards narrow interests, and attempts to divert resources away from team goals (Zand, 198 1). If trust is a crucial factor in organizations in general, it is even more critical in a cross-functional team. The withholding of information due to a lack of trust can be especially harmful to the process of knowledge articulation, internalization, and reflection (Hedlund and Nonaka, 1993). Krackhardt (1993) has argued that change is facilitated by strong ties between organization members, which constitute a basis of trust. Thus, we posit that the degree of Professional Trust in a cross-functional team would be a good predictor of the **efficiency** with which it converts embedded knowledge into embodied knowledge.

Research has identified several factors that determine the level of trust between organization members (Zand, 198 1). One of the most important of these factors is the estimated

*Competence* of other members (Zand, 1981). All other things being equal, the higher the perceived *Competence*, the higher is the degree of Professional Trust accorded. Depending on the task at hand, team members may use proxies such as credentials or years of experience to estimate *Competence*. Comments such as those listed below support this conjecture.

“I knew that both of them were involved in their areas for sometime and knew the ins and outs of their areas. So it was easy for me to trust them.” “Without the team there was lack of trust - other units didn’t react to salespeople’s rush delivery requests ‘which rush do you want to rush ... you guys are always doing this so who cares.’ So by doing this team everyone knows what is important.” “I assume that he is doing his job ... I would need proof that he *hasn’t* covered all the basis ... if I had to question everyone on the team whether they are doing their job or not then I don’t have the right people on the team.” “Again it was a trust issue. When we came together we understood each others strengths and weaknesses. For example, he knew I had an R&D background and he knew the products that I had developed. It was not the fact that this was my first R&D job; or \_\_\_\_’s first manufacturing job. So we got an understanding of our backgrounds and our capabilities.”

Thus:

P5a: The level of perceived individual *Competence* in the team will be positively related to the efficiency with which embedded knowledge is converted to embodied knowledge.

In addition to perceived technical *Competence*, *Team Orientation* is also important.

Team Orientation implies that team members view each other as “team players”, in that they trust each other to work toward team goals rather than narrow functional agendas. A member’s cross-functional track record can be used as one of the indicators to judge the member’s team orientation. For example, a person who has had experience in several different **functions** may be seen as having a better cross-functional track record than another person who has spent a whole career in one function. Proxies used to assess an individual’s cross-functional track record may include variety in career background, the number of contacts/friendship relations outside the



function, and past performance in cross-functional teams. A typical comment supporting the argument of the importance of Team Orientation is:

“I think a lot depends on their past track record ... each person has a certain reputation that travels with them. You either become a good guy, you can count on him, (or) watch out - he’s got a hidden agenda.”

Thus:

P5b: The trust in ***Team Orientation*** of team members will be positively related to the efficiency with which embedded knowledge is converted to embodied knowledge.

Propositions P5a and P5b collectively imply that the effectiveness of cross-functional teams depend, among other factors, on the prior technical and cross-functional track record of their members. When putting together cross-functional teams, managers undoubtedly consider these aspects. However, the crucial component is *management* of the team to efficiently create and embody knowledge in the new product. Within the context of team dynamics, how one participates as a team-player, and how one perceives others as team-players are critical to the effective functioning of the team. In a broader context, research in psychology has established that social-cognitive attributes (such as dominance) were better predictors of group performance than purely cognitive attributes (such as IQ) (Williams and Stemberg, 1988). This motivates the argument that the “social-cognitive” trust in the team orientation of a fellow team member may be more significant than the more “cognitive” trust in that individual’s professional capability. This might be so because if a particular capability is not available in a team, the relevant team member can always “buy” that resource from outside the team.

Corroborating the above points are the following quotes:

“As we were pulling together the teams, it wasn’t the knowledge level of that was the issue, and it wasn’t my knowledge level and it wasn’t really \_\_\_\_’s knowledge level; it was their managerial skills ... and having the confidence in them that they would bring in the right people that would allow us to get to these things.” “I just don’t take any electrical engineer. I look at how well they get along with people, ... communicate, ... leadership.” “I would have to know that the person knows what he is suppose to (Competence) . . . you can have a very knowledgeable person but he will stab you right in the back so you have to make sure they are trust worthy.” “It depends on how you interact with the person. Is the person willing to listen? Does the person do all the talking? There are people that I would not want to work with, they may be very competent, but the interaction is so difficult that it is painful.”

Hence, we propose:

P5c: The trust in *Team Orientation* of team members is more positively related to the efficiency with which embedded knowledge is converted to embodied knowledge than trust in other team member’s individual *Compe tencies* is.

*Nascency of the Project:* The findings on group intelligence and group decision making show that groups perform better than individuals in tasks when the problem is unstructured (David and Toseland, 1987; Williams and Stemberg, 1988, Sneizek, 1990). Such a situation is expected to be present during the initial phases of the NPD task. In the initial phases, the focus is on finalizing the specification of the product to be developed during the subsequent phases. Input from all the functional areas can significantly influence the specifications of the product. A continuous interaction between R&D, engineering, manufacturing, marketing, etc. is necessary in order to arrive at a final product that will have good customer acceptance. Once the specifications are frozen, each functional representative can work relatively independently, with interaction only on a need basis. In general, over the life of the project, the NPD “problem”

becomes increasingly more structured and explicit. Accordingly, the role and significance of team mechanisms based on embedded knowledge will be highest in the initial stages of the project.

As some team members put it:

“the biggest struggle was trying to decide what it was that we were trying to accomplish.” “(Without face-to-face) it would have been difficult, especially in the beginning. In the beginning, it would have been impossible.” “Initially when we started, we found that getting together very frequently was imperative. Even though our style right now is we communicate almost daily by telephone, whether we get together is not so critical. But during the early phases of the project it was critical that we were together face-to-face.” “Monthly video conferences can work, but you really need the face-to-face meetings initially to understand each other’s strategy, and where we’re going, and where they are going. I’m not saying it can’t be done, only I don’t think it’s efficient.” “It started out by sharing too much. Then I finally got to the stage where I would ask, are these topics important ... things that I used to share that I don’t share anymore are like project status where they get into a lot of detail. Too much information. Too much detail that they don’t need to know . . . **we** have agreed on critical areas (on which to share information).” “I think initially it (personal interaction) helped to build trust, but after we met and passed the trusting phase, it’s not required.” “(Now) it’s (information sharing) somewhat more selective, but it’s still open; I mean there’s no hidden information; there’s no hidden plans, no hidden agendas.” “In the formulative stage of these projects, face-to-face meetings are much more productive.”

Hence, we propose:

- P6: The impact of the above variables on the efficiency with which embedded knowledge is converted to embodied knowledge will be moderated by the stage of the NPD process. The above variables will have more impact in the initial stages of the project than in the later stages.

***Innovativeness of the Product:*** The finding in the group intelligence literature that groups perform better than individuals in tasks that require creativity (Williams and Stemberg, 1988) also suggests another moderating variable - ***Innovativeness*** of the product. Heany (1983) has

proposed that new products can have varying degrees of innovativeness. The most innovative level is the one that competes across categories (Lehmann 1994). At the least innovative level the new product probably has one or more new attributes - tangible or symbolic. By definition, the more the innovative the product, the more the creativity that goes into its development. Also, the more the innovative the product the more the need for different kinds of expertise (Chi, Glazer and Farr 1988). Thus, methods to manage knowledge among a group of experts would be more crucial in a innovative setting (Riggs, Goodman, Finley and Miller 1992). The extent of embedded knowledge and the difficulty of its conversion to embodied knowledge is minimal for minor makeovers; whereas the opposite is true for “really” new products.

Empirical evidence from our interviews support this contention:

“The more complex the task the more you need to talk to people.” “If you are in a commodities market where it’s just another generation of a , \_\_\_\_\_ then trust is not as important. The higher the risk, the more you need to have trust among the people.”

Hence we propose:

**P7:** The impact of the above variables on the efficiency with which embedded knowledge is converted to embodied knowledge will be moderated by the degree of *Innovativeness* of the product. The above variables will have more impact the more the innovative the product.

## SUMMARY AND DISCUSSION

Figure 1 graphically presents the theoretical framework linking **NPD** team characteristics and the efficiency with which the **NPD** team converts embedded knowledge into embodied knowledge, while Table 1 summarizes its theoretical underpinnings and key ideas.

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The notion of “how organizations do things” as a source of competitive advantage is being received more readily now, as evidenced by the current popularity of the resource-based perspective (Wernerfelt, 1984; Barney, 1991; Mahoney and Pandian, 1992) and associated constructs such as core competence (Prahalad and Hamel, 1990). How new products are developed can therefore be a source of competitive advantage (Wheelwright and Clark, 1992). The theoretical framework (see Figure 1 and Table 1) advanced here has several implications for the development of an organizational NPD capability. For example, based on an epistemological perspective of NPD, we have argued that Past Experience with NPD teams is important in successfully developing new products. This suggests that it may be worthwhile for organizations to have a structure wherein one or more teams are dedicated to developing new products. Note that in the propositions related to trust we argued that it was more important for team members to have trust in other team members’ Team Orientation (and hence their ability to get the job done, perhaps even by calling on outside resources) rather than their technical ability to do the job done themselves. Therefore, it might not be more effective to create teams for each new product to be developed based on selecting individuals with maximum individual professional Competency. Or in other words, the notion of having teams that are dedicated new product development might be a feasible idea (design centers vis. Olson, Walker and Ruekert 1995). At

the very least, the NPD team could retain some “core” managers across projects, with other individuals entering and leaving the team as and when their particular expertise is required.

The construct of Shared Experience also has broad implications for management. At the most basic level, it underscores the importance of a distinctive and widely shared set of beliefs and practices that comprise the organization’s culture. If the team members share this cultural “substrate”, they have potential access to a set of commonly understood symbols and mythologies that will facilitate the task of articulating and transferring tacit knowledge. Cross-functional experience within a common cultural framework provides for an appreciation of functional “sub-cultures” and their associated languages. However, excessive levels of Shared Experience should be avoided by actively seeking out outside influences through means such as hiring middle managers from other companies, strategic alliances, and so on. Another important implication has to do with NPD efforts that spread beyond the single organization. For example, when suppliers are involved in NPD, it is important to ask how well their engineers can communicate with in-house engineers. Similarly, in an NPD effort between strategic alliance partners, there is a need to identify and capitalize on the commonality of experience that may exist between team members, despite their differences in background.

Information Redundancy also has clearly significant implications for the design and management of the cross-functional team. Since complementarity of expertise is a key rationale for forming the cross-functional team, there may be a tendency for team members to leave seemingly functional decisions entirely to the appropriate counterparts. However, such a policy would negate the potential benefits of the mingling of functional perspectives. Thus, actively encouraging the sharing of even seemingly functional information can be beneficial to the team. At the same time, such sharing of information should not degenerate to a “watering down” of

functional responsibility. As the proposition regarding the Nascency of the project suggests, after the problem has been well defined in terms of the specifications of the product, individual functions take over to do their part of the job. This is essential in getting the project completed in a timely manner. Or in other words, both differentiation and integration is required in a cross-functional team engaged in NPD. The skill of the team designer and manager comes in balancing these conflicting objectives.

The above discussion raises some significant questions about the optimal way of organizing the NPD effort, especially in a global context. Over the last few years, there has been a trend towards creating “virtual” MDTs that are distributed across several cities or even continents. Driving this trend have been strategic factors such as the creation of competency centers (which may need to work together on specific projects), as well as more tactical goals such as taking advantage of time differences among team members’ locations. However, systematic evidence is now beginning to develop that such “virtual” MDTs may not be the best vehicles for NPD (Datar, Jordan, Kekre, Rajiv, and Srinivasan, 1994). In the practical world, too, there are indications that this trend may have been carried too far--consider GE’s current attempts to bring together far-flung NPD staff in “one-coffee-pot” teams. Our framework suggests some reasons why this trend may continue to gather force. Direct, frequent and informal communication also helps in overcoming the problem of how much information to share. By “just being there” team members pick up information which might not have been communicated formally.

One of the intriguing research possibilities suggested by or framework of NPD is to combine the knowledge management perspective with the network perspective

(e.g., Nohria and Eccles, 1992) in opening a new line of inquiry into NPD team effectiveness. By providing a well-established toolkit for mapping relationships among NPD team members, the network perspective will allow us to systematically investigate how successful teams differ from less successful ones along the dimensions described here. Apart from the implications for marketing and organization pointed out above, our framework has potential significance for the study of regional and national competitiveness. For example, Porter (1990) has suggested that the geographical clustering of related and supporting industries is often a prerequisite for global competitive advantage. Such geographic clustering, as illustrated by Silicon Valley, provides the infrastructure for the knowledge syndication process we have described in this paper.

To summarize, we have argued that embedded knowledge is a useful construct in the analysis of NPD as knowledge management, and demonstrated its value by applying it in the context of cross-functional teams. Validating the notion of embedded knowledge and its role in organizational effectiveness of NPD processes can eventually lead to the development of managerial routines for the effective integration of functional knowledge. Since the focus of these routines will be the socially complex aspects of organizations, they can potentially form the basis of distinctive competencies that competitors will find difficult to imitate (Reed and DeFillippi, 1990). Thus, developing the idea of embedded knowledge and its implications for NPD can point the way for sustainable competitive advantage in the global marketplace.



## REFERENCES

- Radaracco, J. L. (1991), *The Knowledge Link*. Boston: Harvard Business School Press.
- Barney, Jay B. (1991), "Firm Resources and Sustained Competitive Advantage," *Journal of Management*, 17, 99- 120.
- Bohn, Roger E. (1994), "Measuring and Managing Technological Knowledge," *Sloan Management Review*, Fall 1994, 61-73.
- Bower, G. H. and E. R. Hilgard (1981), *Theories of Learning*. Englewood Cliffs, NJ:Prentice - Hall.
- Brown, J. S. and P. Duguid, (1991), "Organizational Learning and Communities of Practice: Toward a Unified View of Working, Learning and Innovation," *Organization Science*, 2(1), 40-57.
- Burrell, G. and G. Morgan, (1979), *Sociological Paradigms and Organizational Analysis*. London: Heinemann.
- Chi, Michelene T.H., Robert Glazer, and Marshall J. Farr (1988), *Nature of Expertise*, Hillsdale, NJ:Earlbaum.
- Cohen, W. M. and D. A. Levinthal (1990), "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly*, 35, 128- 152.
- Cooper, Robert G. and Elko J. Kleinschmidt (1987), "Success Factors in Product Innovation," *Industrial Marketing Management*, 16, 215-23.
- Cyert, R. and J. March (1963), *A Behavioral Theory of the Firm*. Englewood Cliffs, NJ: Prentice-Hall.
- Daft, R. L. and K. E. Weick (1984), "Toward a Model of Organizations as Interpretation Systems," *Academy of Management Review*, 9, 284-295.
- Datar, Srikant, Clark Jordan, Sunder Kekre, Surendra Rajiv, and Kannan Srinivasan (1994), "New Product Development Structures and Time to Market," Working Paper. Carnegie Mellon University, Pittsburgh, PA.
- David, Liane and Roland W. Toseland (1987), "Group vs. Individual Decision Making: An Experimental Analysis," *Social Work with Groups*, 10(2), 95-110
- Drucker, P. F. (1993), *Post-capitalist Society*. New York: Harper.
- Eisenberg, E. M. and M. G. Witten (1987), "Reconsidering Openness in Organizational

- Communication,” *Academy of Management Review*, July, 418-426.
- Eisenhardt, Kathleen M. (1989), “Building Theories from Case Study Research,” *Academy of Management Review*, 14 (Oct), 532-50.
- Fortune (1991), “Brainpower,” June 3, 44-60.
- Fortune (1994), “Managing in a Wired Company,” July 11, 44-56.
- Friedman, M. (1953), *Essays in Positive Economics*, University of Chicago Press, Chicago, IL.
- Galbraith, J. R. (1977), *Organizational Design*. Reading, MA: Addison-Wesley.
- Glaser, B. and A. Strauss (1967), *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Chicago: Aldine.
- Godfrey, Paul C. and Charles W. L. Hill (1995), “The Problem of Unobservables in Strategic Management Research,” *Strategic Management Journal*, 16, 5 19-533.
- Goldhaber, G. M. (1974), *Organizational Communication*. Dubuque, IA: Brown.
- Gullahom, J. T. (1952), “Distance and Friendship as Factors in the Gross Interaction Matrix,” *Sociometry*, 15, 123-134.
- Gupta, A. K., S.P. Raj and David Wilemon (1986), “A Model for Studying R&D-Marketing Interface in the Product Innovation Process,” *Journal of Marketing*, 50,(April), 7-17.
- \_\_\_\_\_ and D. L. Wilemon (1990), “Accelerating the Development of Technology-Based New Products,” *California Management Review*, 32(2), 24-44.
- Hacking, I. (1983), *Representing and Intervening*. Cambridge University Press, Cambridge, UK
- Hackman, J. R. (1983), “A Normative Model of Work Team Effectiveness,” (Research Program on Group Effectiveness, Technical Report #2). New Haven, CT: Yale School of Organization and Management.
- Hamel, Gary and C. K. Prahalad (1991), “Corporate Imagination and Expeditionary Marketing,” *Harvard Business Review*, 69 (July-August), 81-92.
- Heany, Donald S. (1983), “The degree of Innovation,” *Journal of Business Strategy*, 3( Spring), 3-14.
- Hedlund, G. and I. Nonaka, (1993), “Models of Knowledge Management in the West and Japan,” In Lorange, Peter, Bala Chakravarthy, Johan Roos and Andrew Van de Ven (Eds.), *Implementing Strategic Processes: Change, Learning and Cooperation*, pp.117-144. Oxford, UK: Basil Blackwell.

- Henderson, Rebecca (1994), "Managing Innovation in the Information Age," *Harvard Business Review*, 72 (Jan./Feb), 100-105.
- Hill, G. W. (1982), "Group Versus Individual Performance: Are N+1 Heads Better Than One?" *Psychological Bulletin*, 91, 517-539.
- Hise, Richard T., Larry O'Neal, A. Parasuraman and James U. McNeal (1990), "Marketing/R&D Interaction in New Product Development: Implications for New Product Success Rates," *Journal of Product Innovation and Management*, 7, 142-155.
- Hudson, William J. (1993), *Intellectual Capital: How to Build It, Enhance It, Use It*, Wiley, New York.
- Hutt, Michael D., Beth A. Walker and Gary L. Frankwick (1995), "Hurdle the Cross-Functional Barriers to Strategic Change," *Sloan Management Review*, Spring 1995, 22-30.
- Jamieson, Linda F. and Frank M. Bass (1989), "Adjusting Stated Purchase Intention Measures to Predict Trial Purchase of New Products: A Comparison of Models and Methods," *Journal of Marketing Research*, 26(August), 336-45.
- Janis, I. L. (1982), *Groupthink*. Boston: Houghton Mifflin.
- Keller, R. T. (1986), "Predictors of the Performance of Project Groups in R&D Organizations," *Academy of Management Journal*, 29(4), 715-726.
- Kogut, B. and U. Zander (1992), "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology," *Organization Science*, 3(3), 383-397.
- Krackhardt, D. (1993), "The Strength of Strong Ties," in Nohria, N. and Eccles, R. (Eds.), *Networks and Organizations*, pp. 216-239. Boston: HBS Press.
- Lehmann, Donald R. (1994), Talk at The Marketing Science Institute's Conference on "Really" New Products, Boston, MA: Marketing Science Institute.
- Luthans, F. (1992), *Organizational Behavior*, 6th ed. New York: McGraw-Hill.
- March, J. and H. Simon (1958), *Organizations*. New York: Wiley.
- Meyers, P. W., and D. L. Wilemon (1989), "Learning in New Technology Development Teams," *Journal of Product Innovation Management*, 6, 79-88.
- Mezias, S. J. and M. A. Glynn (1993), "The Three Faces of Corporate Renewal: Institution, Revolution, and Evolution," *Strategic Management Journal*, 14, 77-101.
- Mahoney, Joseph T. and J. R. Pandian (1992), "The Resource-Based View Within the

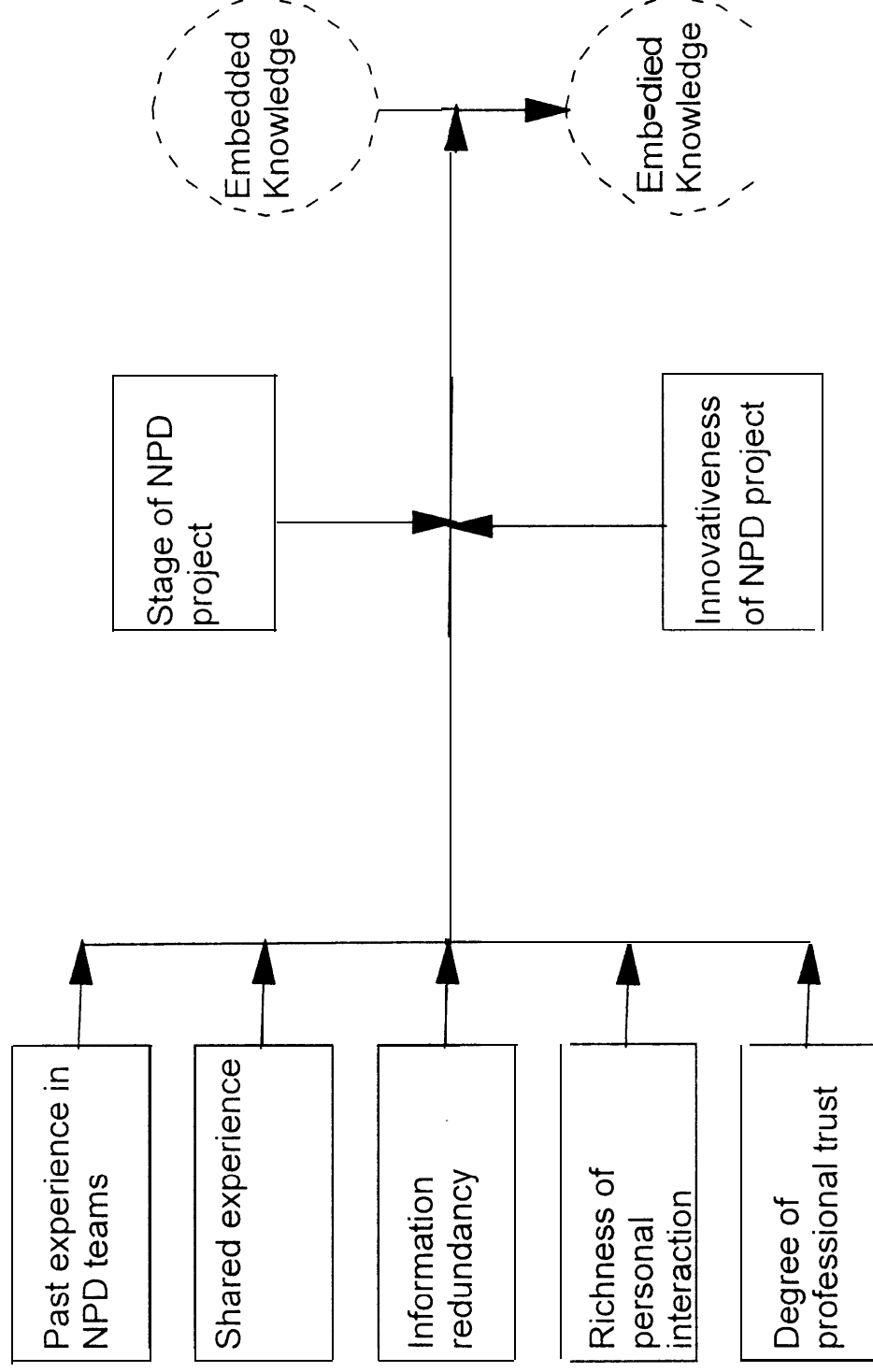
- Conversation of Strategic Management,” *Strategic Management Journal*, 13, 559-584.
- Nakata, Cheryl and K. Sivakumar (1996), “National Culture and New Product Development: An Integrative Review,” *Journal of Marketing*, 60 (January) 61-72.
- Nelson, R. and S. Winter (1982), *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap.
- New York Times (1995), “Prodigy Computer Service is Moving to Manhattan,” June 3, p16.
- Nohria, Nitin and Robert G. Eccles (1992), *Networks and Organizations: Structure, Form and Action*, Harvard Business School Press, Boston, MA.
- Nonaka, I. (1990), “Redundant, Overlapping Organization: A Japanese Approach to Managing the Innovation Process,” *California Management Review*, 32 (Spring (1990), 27-38.
- \_\_\_\_\_ (1991), “The Knowledge-Creating Company,” *Harvard Business Review*, November-December (1991), 96-104.
- \_\_\_\_\_ (1994), “A Dynamic Theory of Organizational Knowledge Creation,” *Organization Science*, 5(1), 14-37.
- Olson, Eric M., Orville C. Walker and Robert W. Ruekert (1995), “Organizing for Effective New Product Development: The Moderating Role of Product Innovativeness,” *Journal of Marketing*, 59(January), 48-62.
- Pinto, Mary Beth, Jeffrey K. Pinto and John E. Prescott (1993), “Antecedents and Consequences of Project Team Cross-functional Coordination,” *Management Science*, 39(10), 1281-1297.
- Polanyi, M. (1967), *The Tacit Dimension*. Garden City, NY: Doubleday.
- Porter, Michael E. (1990), *The Competitive Advantage of Nations*, Free Press, New York.
- Prahalad, C. K. and G. Hamel (1990), “The Core Competence of the Corporation,” *Harvard Business Review*, May-June, 79-91.
- Putnam, H. (1990), *Realism with a Human Face*, Harvard University Press, Cambridge, MA
- Reed, R. and R. J. DeFillippi. (1990), “Causal Ambiguity, Barriers to Imitation, and Sustainable Competitive Advantage,” *Academy of Management Review*, 15(1), 88-102.
- Reich, R. B. (1992), *Made in America*. PBS Video.
- Riggs, Jeffrey L., Maria Goodman, Rosemary Finley and Tracy Miller (1992), “A Decision

- Support System For Predicting Project Success,” *Project Management Journal*, 23(2), September 3 7-43.
- Rogers, E. M. and R. A. Rogers (1978), *Communication in Organizations*. New York: Free Press.
- Ruekert, Robert W. and Orville C. Walker (1987), “Marketing’s Interaction With Other Functional Units: A Conceptual Framework and Empirical Evidence,” *Journal of Marketing*, 51 (January), 1 - 19.
- Scribner, S. (1986), “Thinking in Action: Some Characteristics of Practical Thought.” In Sternberg, R. and Wagner, R. K. (Eds.), *Practical Intelligence: Nature and Origins of Competence in the Everyday World*, pp. 13-30. Cambridge, UK: Cambridge University Press.
- Selznick, P. (1957), *Leadership in Administration: A Sociological Interpretation*. New York: Harper Row.
- Shocker, Alan B. and V. Srinivasan (1979), “Multiattribute Approaches for Product Concept Evaluation and Generation: A Critical Review,” *Journal of Marketing Research*, 16(May), 159-80.
- Simon, H. A. (1947), *Administrative Behavior*. New York: Macmillan.
- Simon, H. A. (1985), “What We Know about the Creative Process,” in Kuhn, R. L. (ed.), *Frontiers in Creative and Innovative Management*, pp. 3-20. Cambridge, MA: Ballinger.
- Sneizek, Janet A. and Rebecca A. Henry (1989), “Accuracy and Confidence in Group Judgment,” *Organizational Behavior and Human Decision Processes*, 43, 1-28 .
- \_\_\_\_\_ (1990), “A Comparison of Techniques For Judgmental Forecasting by Groups With Common Information,” *Group and Organization Studies*, 15(1), March, 5-19.
- Spender, J-C. (1993), “Competitive Advantage from Tacit Knowledge? Unpacking the Concept and Its Strategic Implications,” paper presented at the *Academy of Management* meetings, Atlanta, Georgia, August.
- Stene, E. (1940), “An Approach to a Science of Administration,” *American Political Science Review*, 34, 1124-1 137.
- Stevenson, W. B. and M. C. Gilly (1991), “Information Processing and Problem Solving: The

- Migration of Problems Through Formal Positions and Networks of Ties,” *Academy of Management Journal*, 34(4), 9 18-928.
- Toffler, A. (1990), *Powershift: Know/edge, Wealth, and Violence at the Edge of the 21<sup>st</sup> Century*, New York: Bantam.
- Tushman, M. L. and D. A. Nadler (1978), “Information Processing as an Integrating Concept in Organizational Design,” *Academy of Management Review*, 3,6 13 -624.
- Urban, Glen L., John R. Hauser and John H. Roberts (1990), “Pre-Launch Forecasting of New Automobiles,” *Management Science*, 36(4), April, 40 1-42 1.
- \_\_\_\_\_, Bruce D. Weinberg and John R. Hauser (1996), “Premarket Forecasting for Really-New Products,” *Journal of Marketing*, 60 (January), 47-60.
- Wall Street Journal (1994), “Executive Suites’ Walls Come Tumbling Down,” June 29, p B1.
- Walsh, J. P. and G. R. Ungson (1991), “Organizational Memory,” *Academy of Management Review*, 16(1), 57-91.
- Wheelwright, Steven C. and Kim B. Clark (1992), *Revolutionizing Product Development*. New York: The Free Press.
- Williams, W. M. and R. J. Sternberg (1988), Group Intelligence: Why Some Groups are Better Than Others,” *Intelligence*, 12, 3 5 1-377.
- Winter, S. G. (1991), “On Coase, Competence, and the Corporation,” in Williamson, O. E. and Winter, S. G. (Eds.), *The Nature of the Firm: Origins, Evolution, and Development*, pp. 179-195.
- Workman, John P. (1993), “Marketing’s Limited Role in New Product Development in One Computer Systems Firm,” *Journal of Marketing Research*, 30 (Nov), 405-42 1.
- Yin, Robert K. (1989), *Case Study Research: Design and Methods*. Sage, Newbury Park, CA.
- Yin, Robert K. (1993), *Applications of Case Study Research*. Sage, Newbury Park, CA.
- Zand, D. E. ( 1990 ), *Information, Organization, and Power: Effective Management in the Knowledge Society*. New York: McGraw-Hill.
- Zander, Udo and Bruce Kogut (1995), “Knowledge and the Speed of the Transfer and Imitation of Organizational Capabilities: An Empirical Test,” *Organization Science*, 6(1), 76-92.
- Zuboff, S. (1988), *In the Age of the Smart Machine*. Boston: HBS Press.

Figure 1

# From Embedded Knowledge to Embodied Knowledge: New Product Development as Knowledge Management



Consistent with the instrumental positivist position, embedded knowledge is treated as an unobservable construct that, nevertheless, contributes to the development of testable propositions.

**Table 1**  
**From Embedded Knowledge to Embodied Knowledge:**  
**Theoretical Underpinnings**

Conceptualization of organizational knowledge	Key references	Key point	Link to current model
Routines	Stene (( 1940); Simon (( 1947); March and Simon ((1958); Cyert and March (( 1963); Nelson and Winter (( 1982); Winter ((1991)	-Organizations know and remember by doing	- Successful NPD teams develop effective routines for knowledge management; prior experience in NPD teams help in the conversion of embedded knowledge to embodied knowledge
Organizational memory	Walsh and Ungson (( 199 1); Galbraith (( 1977); Tushman and Nadler (( 1978)	-Memory is stored information from an organization's history that can be brought to bear on present decisions	-Shared Experience is the basis for shared organizational memory that is necessary for articulation, internalization and reflection of tacit knowledge that facilitates the conversion of embedded knowledge to embodied knowledge
Absorptive capacity	Cohen and Levinthal ((1990; (1994; Kogut and Zander (( 1992)	-Absorptive capacity resides in rich networks of knowledge "receptors" that are exposed to the environment	-Information that is redundantly available to a rich network of "receptors" leads to the extraction of maximum meaning to aid the NPD effort
Group intelligence	Hill (( 1982); Williams and Sternberg (( 1988)	-Groups perform significantly better than individuals at tasks that emphasize divergent and creative solutions	-Hypothesized relationships will be strongest and at the early stage of projects and in the case of innovative projects
Tacit knowledge	Polanyi (( 1967); Zuboff (( 1988); Nonaka (( 199 1); Spender (( 1993)	-Tacit knowledge cannot be easily explicated or transferred	-Rich Personal Interaction and trust is necessary for the combination of individual stores of tacit knowledge.