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LEARNING AND KNOWLEDGE MANAGEMENT IN TEAM-BASED NEW PRODUCT DEVELOPMENT ORGANIZATIONS

CEO Publication
G 98-2 (330)

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February, 1998

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Abstract

Configuring organizations into cross-functional new product development teams introduces new knowledge management and learning challenges. Discipline knowledge, which used to be managed through functional hierarchies, is dispersed; new mechanisms for maintaining and advancing discipline knowledge are needed. Cross-functional teams must learn new work processes for conducting cross-functional work. These processes constitute a new knowledge domain that must itself be advanced and managed. Finally, dispersion of knowledge requires greater attention by the organization to making sure that learning occurs within and across teams and business units. This chapter provides a conceptual overview of this learning domain and of various approaches and dynamics that contribute to organizational learning.

Introduction

The use of cross-functional teams for new product development (NPD) has become commonplace and many companies report improvement in cycle time, cost, and market responsiveness as a consequence. Cross-functional teams have been advocated for new product development in order to improve coordination and integration of the various streams of work and the expertise from the multiple functions required to develop a new product (Denison, Hart, & Kahn, 1996). They do this primarily by focusing all participants on the task of developing the new product. By moving decisions into cross functional units, the delays inherent in the movement of decisions through multiple functional hierarchies are often avoided, as is the defocusing that occurs when cross functional trade-offs are made through political processes at higher levels in the organization that are quite removed from the realities and requirements of the particular new product development project.

Much of the literature on the use of cross-functional teams for new product development has presented models and advocated use based on results of successful case studies. A growing body of research has examined both the internal processes and contextual factors that relate to outcomes (e.g., Donnellon, 1996; Mohrman, Cohen & Mohrman, 1995; Purser, Pasmore & Tenkasi, 1992; Pinto, Pinto & Prescott, 1993). Much of this literature focuses on the factors that promote collaboration within teams; a strong message is that the internal processes of the team are shaped by its context, including support for capability development, clear charter and direction, shared goals, team reward systems, and the existence of cross-functional leadership from above. One of the greatest barriers to cross-functional collaboration is the competing tug for attention of team members by functional management, a classic tension in a matrix (Ford & Randolph, 1992). This pattern of findings has led to the conclusion that doing work in teams constitutes a revolutionary change for organizations, and that management should focus less on delineating teams and more on creating the organizational conditions for their success (Hackman, 1997). Based on a multiple year study of ten cross-functional team settings, Mohrman, Cohen and Mohrman (1995) have concluded that the team-based organization has to be designed from scratch; almost all aspects of the organization have to be tailored to support the new reality that teams, not individuals, are the basic performing unit of the organization. Indeed, many firms have concluded that in order to create true collaboration in cross-functional work units, and to avoid the competing pulls on people's time that defocus the team and work against necessary empowerment, they must eliminate or radically change the role of the traditional functional management structure.

New product development work has been a prime candidate for cross-functional team design because it is a systemic task in that it inherently requires contribution from and entails interdependence of experts from multiple knowledge bases (Ancona & Caldwell, 1992; Clark & Fujimoto, 1991; Nonaka, 1990). Additionally, it entails the resolution of uncertainty, which requires high levels of integration in the organization (Lawrence & Lorsch, 1967; Galbraith, 1973). The organizational design argument is that cross-functional structures help solve an information processing challenge by creating integration mechanisms unavailable in the traditional

functional, bureaucratic organization that further reduce the cost of organizational communication and coordination (Kogut & Zander, 1996). In essence, lateral information processing within small focused units supplements and in some respects replaces vertical information processing, making it possible for the organization to be agile, responsive, and quick. Additionally, it is argued that innovative approaches are more likely to result when problems are solved by a team of people who bring different perspectives to bear. Although making the transition to a cross-functional structure from the bureaucratic, vertical organization is difficult, the benefits of coordination and focus attained when all relevant disciplines are focused on the development of a new product are clear.

However, the literature also suggests that in today's environment, the organization needs to focus on capabilities beyond quicker speed, better coordination, and more innovation and creativity. Competitiveness increasingly rests on the learning capability of the organization — on the ability of the organization to capture, generate, disseminate and embed new knowledge into its work systems (Senge, 1990). Quinn, Anderson and Finkelstein (1996) argue that the organization needs to be designed to facilitate enhancement of intellectual capabilities. This perspective raises some difficult issues for organizations that have begun to perform work in cross-functional teams. A common observation within these organizations is that their cross functional units have become the new "silos" of the organization; and that the movement of knowledge and integration between these units does not occur naturally or easily. A concern of many organizations is that their discipline knowledge is now dispersed, making the maintenance, leverage and enhancement of discipline knowledge more difficult.

Although organizations are increasingly doing work through cross-functional teams, this does not mean that the need for generalist knowledge will replace the need for deep specialist knowledge. While it is true that cross-functional work is facilitated by overlapping knowledge bases, it is also true that in many arenas deep specialist knowledge continues to advance and is necessary for the generation of innovative solutions and the solving of complex systemic problems. Effective teams house contributors with deep knowledge who can solve problems that others in the team cannot (Klein & Maurer, 1995). The cutting edge of many technical applications lies at the intersection of diverse and deep knowledge sets rather than in comparatively shallow generalist exploration. Technical firms require both the separate development of competencies and their combined application (Tenkasi & Boland, 1996; Leonard-Barton, Bowen, Clark, Holloway, & Wheelwright, 1994).

NPD cross-functional units are design solutions to the need to integrate various knowledge sets; however, when they become the predominant mode of work accomplishment, they may become barriers to the ongoing enhancement of specialized knowledge bases. Within the cross-functional team, the most obvious learning challenge is to find ways to promote a true integration of diverse knowledge and perspectives to solve problems and achieve goals. However, the cross-functional unit may not naturally generate and nurture new discipline knowledge to differentiate the organization from competitors; this has been the traditional purview of the functional organization. Furthermore, the team may not encode and disseminate

cross-discipline knowledge that emerges from its collaborative work. Thus, the organization faces multiple knowledge management challenges: to support the cross-functional application of knowledge and the generation of cross-functional knowledge; and to support the advancement of deep discipline knowledge. Both may be part of the core competencies of the firm.

Based on theory and on extensive case studies of organizations learning to operate through cross-functional NPD units, this paper proposes a beginning framework for understanding the learning and knowledge management approaches that fit with and meet the diverse learning needs of cross-functional NPD organizations. We first present a model of the team-based organizational system that will serve as the backdrop for the discussion of the learning challenges faced in a team-based NPD organization. Finally, we will generate some key issues that have to be addressed in the design of structures and processes to facilitate knowledge management.

A Systems View of the Team-Based Organization and its Learning Requirements

We use a systems framework to portray the differences in the learning challenges that exist in the hierarchical, functional organization and the team-based organization. Organizations are conceptualized as open systems: organized, cohesive, complexes of elements standing in interaction with each other and with the environment (Von Bertalanffy, 1955). The structural differences between the two forms are displayed in Figures 1 and 2.

Figure 1 depicts a system in which individuals are clustered in vertical structures, or sub-systems, that are functionally delineated by the nature of the knowledge and processes that they contain. The work of the organization is similarly broken into functional tasks that are housed within a functional organization. Cross-functional integration occurs at high levels in the organization, by managers who plan and control work that flows across functional divides. The NPD process, for example, might be conducted sequentially and move from product marketing organizations which conduct intelligence with respect to the needs of the marketplace; through research and development organizations which yield technical knowledge and design products that embody it; through manufacturing organizations which determine the processes to manufacture and test the products; through distribution organizations which physically get the product to the customer; and finally into field marketing and sales which prepare documentation and training for the field and transact the deals that result in the sale of the product. Each of these major functions may in turn be subdivided into smaller specialized units such as electrical engineering, mechanical engineering and software units that might comprise the development function. Within these functions and sub-units, a functional management hierarchy ensures that functional work is of high quality and the work of the sub-units is integrated.

Insert Figure 1 About Here

In this traditional functional organization, the new product development process occurs sequentially across functions. Each sub-system yields only a portion of the value that is ultimately delivered to customers and focuses only on certain aspects of the NPD process. Each functional area has its own "thoughtworld" or world view, shaped by its knowledge base, experiences, responsibilities and concerns (Dougherty, 1992). The work processes of the various sub-systems and the value they yield are generally not well understood and in fact are often invisible to members of different sub-systems. Decisions that involve trade-offs between the concerns of various sub-systems (such as the R&D concern for elegance of functionality of product versus manufacturing's concern for cost of manufacturing and marketing's concern for time to market) are often made at the top because that is the only place that people knowledgeable about each of the sub-systems come together in a formal decision-making capacity. In this process, each manager often advocates the particular world view of her function.

This functional organization is often advocated because theoretically it makes it easy to inculcate, enforce, monitor, and improve discipline processes that embody state of the art discipline knowledge. This is because the vast majority of employees are focusing on their own discipline, and resource control and decision-making authority for the most part lies within the discipline hierarchy. People work alongside other people from the same discipline who can help solve discipline problems, and are supervised by managers who are expert in the discipline, speak the same technical language, and see the world the same way. Discipline managers are expected to stay abreast of current practice and knowledge and to generate or import new knowledge.

The weaknesses of this organization lie in its inability to effectively manage processes that cut across disciplines. From a learning perspective, it builds in very little opportunity for cross-discipline process and content learning and reduces the amount of innovation because strong organizational boundaries prevent the juxtaposition of world views and knowledge bases that yield novel solutions (Kanter, 1983; Pinchot, 1985).

Figure 2 depicts the NPD organization as a system composed of nested performing units (for a more complete description of the logic of this kind of organization, see Mohrman, Cohen & Mohrman, 1995). The sub-systems in this organization are cross-functional performing units. They exist at various levels of the system. In the example shown, the largest unit is a division or a company that has a number of product line business units, each of which houses a set of NPD projects that are being carried out by a cross-functional team. Each team conducts an entire NPD process that delivers value to the customer, works interdependently, and carries out the deliberations involved with accomplishing its goals. Cross-functional integration occurs laterally at many places in the organization. Much of the integration required to carry out the complete NPD process occurs laterally within the team. The cross-functional integration required for a product line occurs laterally within the cross-functional management

team and through other cross unit mechanisms and structures. Cross-functional integration occurs at each system level rather than occurring primarily at the top of the organization.

Insert Figure 2 About Here

Although each NPD project is established to be relatively self-contained, the reality is that in complex knowledge work settings, interdependency between teams abounds. This may be because the teams share some scarce resources, such as laboratories and factory equipment, draw from the same talent pool, vie for the same investment dollars, or yield products that sell in the same market and/or have to be compatible with or differentiated from one another. Given the lateral logic of a cross-functional team-based organization, many interdependencies between teams are resolved laterally, through formal or informal processes that work across teams. Some interdependencies may require hierarchical resolution, such as charter clarification when the product plans of two teams infringe on one another or when both are demanding incompatible process changes in a shared manufacturing facility. The resolution of such issues may require focus at the broader system level, in order to optimize overall system performance. Cross-functional management teams at the business unit and divisional level provide cross-functional direction and resolution of issues, thus precluding functional managers from holding progress hostage to their internecine squabbles. Thus, through their actions and decisions, the elements at a higher systems level provide the context for the elements within. For example, the division-level decision-making structure provides direction and support for the business units and NPD teams; the business unit provides direction and support for its teams. Through a combination of self-regulation and external regulation, each cross-functional unit contributes to the overall system performance.

This organization poses a diverse set of learning challenges. It will be as dependent as its functional organization counterpart would have been on ongoing discipline content and process knowledge to maintain predominance in the market place. This is especially true in disciplines that comprise the core competencies of the organization. In addition, the cross-functional team-based organization creates the opportunity for, and in fact requires, cross-functional process and content learning. In the NPD teams, relevant cross-functional learning pertains to the processes of work coordination and integration of the knowledge of different disciplines and functions to solve problems and yield innovation. At the management levels, cross-functional business planning such as strategic planning and value chain optimization techniques, and other cross-functional leadership processes must be learned and refined. In addition, the cross-functional management teams must learn how to develop the organization structures and processes required to provide an infrastructure to support cross functional NPD.

The cross-functional work organization depicted in Figure 2 may or may not exist simultaneously with a functional structure. A matrix structure is created if the cross-functional structures of the organization are “laid over” the existing functional organization. Its dual

authority establishes the potential for conflict between the directions received from the cross-functional structures and those received from functional hierarchies (Davis & Lawrence, 1977; Ford & Randolph, 1992; Galbraith, 1973), thus offsetting some of the advantages derived from a clear focus on the NPD project and its goals. On the other hand, by maintaining a functional structure, the organization keeps a focus on discipline knowledge and learning. There is, however, a danger that disciplines will continue to operate independently of one another, and that knowledge will advance independently of the way cross-functional work is being performed and without attention to the cross-functional knowledge that is created and needed to pursue chosen product-line strategies. Alternatively, the cross-functional teams may become the locus of power if resource control is vested in project managers. In this case, the authority of the discipline-based structure may be weakened, and the organization may fear the erosion of discipline-based processes and knowledge. This fear is magnified in organizations that have dealt with the tensions of dual authority by eliminating discipline-based management structures.

Although ongoing discipline-based learning is critical in a cross-functional organization, learning to advance cross-discipline and cross-functional capabilities is equally critical. This is especially true during the transition to a cross-functional organization (Tenkasi, Mohrman & Mohrman, 1998), when the cognitive, behavioral and structural elements of such an organization are being established. Cross-functional learning remains an ongoing requirement. New integrative knowledge domains are formed from an increased understanding of how the contents of various knowledge bases interact to form new integrative knowledge domains, the evolution of processes for integration across knowledge bases, and the generation of new cross-functional tools.

Figure 3 portrays the various learning challenges of a cross-functional NPD organizational system that must be addressed to yield ongoing improvement capability. In some senses it is overly simplistic, as it only deals with two systems levels, the cross-functional project team and the larger organizational system. In actuality the learning challenge is far more complex, since there may be multiple levels of nested systems, including product line organizations, divisions, groups, and the corporation. In the discussion below we will examine the learning processes internal to NPD teams, across NPD teams, and across the larger system.

Insert Figure 3 About Here

Learning Within the New Product Development Team

The development of new products entails the application of knowledge to new problem-oriented situations, and thus requires uncertainty reduction. Team members have to incorporate new information into their understandings in order to solve the technical challenges they face. Thus, learning is inherent in the work they do (Mohrman, Mohrman & Cohen, 1995). The knowledge gained can be explicit and formal, as when members learn new analytical procedures to deal with a new phenomenon or go to a textbook or other publication

to learn the properties of a new material that they are using for the first time. Alternatively, their work may lead to tacit learning (Polanyi, 1962; Spender, 1996) that occurs as the individual learns from experience and develops a deep but unarticulated sense of the phenomena at hand, or to informal learning as members consult with one another to take advantage of each other's personal knowledge stocks. Learning can be personal and remain within the heads of individual contributors, or become public when it is shared with others and perhaps systematized.

It has been argued that collaboration is made possible when knowledge is made visible, shared and is systematized, and that up to that point work is craftwork (McDermott, 1995). Team or organizational learning has only occurred to the extent that knowledge is shared across the unit and incorporated into new understandings, behaviors and structured activity (Tenkasi, Mohrman & Mohrman, 1998).

Cross-functional NPD teams are fertile grounds for learning, although they vary greatly in the extent to which they are able to establish the dynamics to support it (Purser, Pasmore & Tenkasi, 1992; Tenkasi, Mohrman & Mohrman, 1998). A number of types of learning can potentially occur within the team. Three dimensions are important, as is illustrated by the cube in Figure 4:

1. Learning can be about the *content* of work or about the *process* of doing work.

2. Learning can occur within a function or discipline or across multiple disciplines.

3. Learning can occur within the team or in interaction with external agents.

Insert Figure 4 About Here

Learning may fit in any combination of the three dimensions. For example, a team may generate its own ways of displaying and analyzing cross-functional data pertinent to the optimization of return on investment, an example of internal, cross-functional learning about the process of doing work. Alternatively, it might "pull" such a methodology from outside — either from a company support group, another team, or from the larger environment. Within a team, learning might occur among several software engineers who develop a new architectural configuration to cope with limited code space on a system. This would constitute internal content learning within a discipline. It might pull such an approach from another project that members know encountered a similar constraint. To solve the same problem, the hardware and software engineers might jointly learn a new way to distribute functions between software, hardware and firmware, which would constitute cross-discipline learning.

Limited learning occurs in many cross-functional teams, which maintain rather firm discipline boundaries between the tasks of members and consequently house only personal

learning that neither takes advantage of nor contributes to the knowledge of others. Such teams may still experience the performance benefits of cross-functional coordination and awareness, but they will fall short of the benefits to be derived by generating novel or innovative solutions through doing collaborative cross-functional work. Additionally, even if learning is going on among some members of the team, the larger membership may not share this learning, which means that learning cannot be incorporated in team methods and processes. Finally, the team may not pull practices from the larger organization or from the external world, which means that it is destined to rediscover the wheel, or to do without it.

A comparative case study of one high and one low learning NPD project (Purser, Pasmore, & Tenkasi, 1992) found four kinds of barriers to learning within projects, which were shortcomings in: (a) knowledge acquisition; (b) knowledge retention; (c) knowledge sharing and planning; and (d) the integration of different frames of reference. In a more extensive longitudinal study, we have found (Tenkasi, Mohrman &Mohrman, 1998) that fast learning projects are characterized by a number of dialogue-intensive internal dynamics that enable the creation of shared meaning across diverse project participants that become embodied in agreed-to work practices. Other important dynamics foster "open-system" learning whereby project members are influenced by and learn from each other and from their collective experience as well as from the larger environment.

Learning Across Teams

Team learning occurs when knowledge is shared among team members and incorporated into collective practices; it primarily emerges either from collective work or from team efforts to import knowledge in order to solve problems and/or achieve goals. The same forces drive learning across teams. Cross-team learning occurs between various elements at the same systems level of the organization. Teams can collectively learn as they perform work together. The focus of learning may be the content of their development activities, such as through conjoint market sensing and modeling that enable two new product development teams to understand how each other's activities impact total market share. Or they may collectively develop a test approach capable of testing a broader spectrum of phenomena than would be required to support either of their development processes. The focus of cross-team learning may also be about processes of doing cross-team work, such as learning to use nested planning tools or simulation tools that enable joint optimization.

Cross-team learning can also occur when teams share their internal approaches with one another. For example, when one team has found a new way to orient new members to the project, it might share its approach with another team that is facing a similar task. This learning process involves the conscious "importing" of knowledge by the adopting team, and "exporting" of knowledge by the disseminating team. Although this kind of diffusion often happens informally when a team member becomes aware of something that has happened in another team or when people transfer between teams and carry knowledge in their heads,

internal "benchmarking" processes are examples of formalized attempts to locate and pull knowledge from other teams. Cross-team learning can occur in cross-functional, single discipline and/or functional knowledge domains.

Learning Across the Organization

Although both within team and across team learning adds to the stock of knowledge in the organization, and both have influence on cognition, behavior and design within the organization, organization-wide learning requires that knowledge becomes accessible throughout the organization, and that organization-wide cognitions, behaviors and designs are informed by it. Within functions and disciplines, organization-wide learning has been one of the responsibilities of functional managements in many organizations. More specifically, it has often been the purview of specially constituted staff groups within the function that looked after functional methods, processes, and knowledge and skills development and diffusion. These groups have operated largely through developing or purchasing new applications and "rolling them out," through formal training and orientation programs, and through mentoring and auditing roles. These staff groups have often been the agents that maintained close connection to the external environment in order to make sure the company stayed up-to-date in its practices. Their power and legitimacy in influencing organizational practice derived from the authority of the functional management hierarchy. In most organizations, these groups were open to criticism for failing to incorporate the local learning (and needs) of the individual contributors and workgroups that were doing the discipline work of the organization; they were perceived as hierarchically powerful but distant parties who generated programs and processes based on "theory".

Team-based organizations pose new challenges for organization-wide learning. Cross-functional units are subject to operational direction from a cross-functional structure, which breaks the tight, unambiguous link between functional hierarchies and team members. Thus the legitimacy of the central staff group in dictating new approaches is undermined. Additionally, in the cross-functional team-based organization, the learning from work that is occurring in the organization is dispersed in different units, and is neither shared across the functional members in the organization nor easily visible to central groups. Finally, much of the pertinent learning going on in the organization is cross-functional, and organizations do not have well developed central groups perceived as having legitimate authority to impact cross-functional practice.

Organization-wide learning requires that the organization establish forums and mechanisms to accomplish three purposes, which represent increasing levels of embedding new knowledge in the organization:

1. Pulling knowledge from within the organization and from the external environment;
2. Encoding the knowledge and making it accessible to the different parts of the organization;

3. Embedding knowledge in tools and methods that are widely shared.

McDermott (1995), in his discussion of instilling collaboration in new product development teams by making knowledge work visible and promoting learning-in-action, talks about setting up forums for collective learning. He recommends that organizations find ways to seek out and disseminate new ideas and learning in both discipline and cross-discipline arenas. Many organizations hold special learning diffusion events or create data banks of "lessons learned" or "best practices". Some have systematically built these approaches into the design of their organization, such as through the establishment of benchmarking functions, the institutionalization of cross-functional innovation-sharing mechanisms, and the redesign of role descriptions and reward systems to include contribution to and participation in these forums as an expected part of a team's performance. Some are going the next step to embed these learning activities in the way work is done, such as in making available standard tools and methodologies that build on the learning from within and outside the organization, and can be tailored by the local unit to fit the work at hand. Other examples are the inclusion of a section in project stage reviews where the team recounts what parts of their plans have been impacted by a review of lessons learned from other projects, and requiring that the team document its own lessons learned before it can receive its performance bonus.

In essence, the role of organization-wide mechanisms is to provide forums and resources for pulling learning both internally and externally, and mechanisms to make it accessible to projects throughout the organization. This differs from the mode of operation of many functional staff groups where the direction of knowledge dissemination is often from the center to the performing groups. Dispersed performing units play an active role, both in generating learning to be shared across the organization, and in pulling relevant learnings from elsewhere back into the unit. Our research has found that organizational learning occurs most quickly when learning activities occur at multiple levels. Organization-wide learning mechanisms build on the learning of local units, and local units refine, alter and extend what they have pulled from the rest of the organization (Tenkasi, Mohrman & Mohrman, 1998). The legitimacy for this multi-directional learning comes from the cross-functional hierarchy, which expects and monitors both cross-functional and discipline learning, and conveys legitimacy to the various forums and mechanisms set up to foster it.

Dynamics of Collective Learning

Albeit emergent, research and theory is opening up increased understanding of the key dynamics that underpin successful collective learning between distributed knowledge agents in organizations that have implications for learning within cross-functional teams, between teams, and across the organization (Weick & Roberts, 1993; Kogut & Zander, 1996; Capaldo & Zollo, 1994). Research and theory suggest that these dynamics are central for collective learning that enables novel or innovative solutions from a creative merging of disparate knowledge domains that enables performance improvement beyond what would be expected because of the increase in communication and coordination that constitutes the immediate benefit from organizing into cross-functional teams. Three process areas underlie successful

collective learning in cross-functional teams. They are (a) collective identity and collective learning, (b) heedful interrelating and collective emergent knowledge, and (c) surfacing and integrating tacit knowledge for collective learning.

Collective Identity and Collective Learning

As organizations rely more and more on collective knowledge they also have to deal with the inherent difficulties in achieving communication and coordination among individuals with diverse competencies. Kogut and Zander (1996) argue that the inherent difficulty of cooperation arises from firms traditionally having promoted and reinforced division of labor as the key organizing principle and means to create competence. The division of labor and consequent specialization creates competence as individuals explore locally around their assigned tasks and become increasingly more knowledgeable and competent in their specialization. However, specialization also implies a narrow identification with a specialized group of individuals that compounds the problem of coordination and communication across competences. Identity provides more than a definition of membership. It also can contribute to a narrow world-view and a pattern of self-interested behavior of maximizing the benefits for the sub-group one identifies with that is motivated in part by the attribution of self-interested behavior on the part of other groups. This frequently results in a tendency to want to direct everything in accordance with one's own sub-group's world view.

Tajfel, Billig, Bundy and Flament (1971) tested whether the simple fact of belonging to a group was enough to affect one's judgment. In their experiment they found that simply being told that one belongs to a particular group causes one to discriminate in favor of that group motivated by the attribution of self-interested behavior on the part of other groups. In an organizational context this problem of narrow identity can manifest itself in each function trying to push for their specific needs and concerns at the expense of others (such as R&D promoting its concerns for elegance for functionality of product while discounting marketing's concern for time to market). In sum, the narrow identity fostered by the traditional division of labor gives rise to an incentive problem to cooperate in organizations.

Given this inherent dilemma of cooperation, Kogut and Zander (1996) pose the question how can organizations transcend the limitations of a narrow identity fostered by a division of labor and establish the motivation to cooperate and coordinate at the level of the firm?. They suggest that it requires a transformation in identity, where the identity of an individual with a group or sub-group is replaced with a shared organizational identity as a higher organizing principle.

This argument is not new. Durkheim (1859) first argued that the evolution of society required movement beyond a mechanistic solidarity to an organic solidarity where the individual identifies more with the larger society than with his or her own sub-group. A sense of shared identity in a firm provides a sense of community by which mutual cooperation, coordination and

learning can be structured. Through shared identities, individuals start sharing cognitive models of the world based upon similar categories (Dutton, Dukerich & Harquail, 1994). Shared identity promotes cooperation since the act of common identifying gives rise to shared cognitive schemas and moral values that people apply to how others are categorized including the a decrease in the attributions of self-interested behavior on the part of dissimilar others (Albert & Whetten, 1985). For example, a study by Taylor and Jaggi (1974) showed that by fostering a common group membership and common identity, actors completely reversed their attributions of intent and behavior made to individuals who were not previously part of the group. What had been regarded as self-interested behavior was reversed with common group membership and this brought in an inducement to cooperate.

Kogut and Zander (1996) tested these ideas in the context of the prisoner's dilemma game. They found that when players were deprived of a common shared identity, they experienced more problems with coordination, cooperation, and communication, and they experienced protracted conflicts with regard to norms and perceptions of equity. However, when players shared a common identity, there were less conflicts around norms of equity and players believed that the other players were motivated to cooperate. That resulted in a situation of mutual cooperation and coordination.

The attribution that people belonging to the same group are less self interested has reinforcing consequences for cooperation. Expected cooperation induces cooperative behavior, because of the confidence held in the common knowledge that both parties to the exchange have the intention to cooperate and are not looking to maximize their own interests. A sense of shared organizational identity is therefore critical to induce cooperation, learning and coordination across individuals and groups of diverse specialized competencies. Therefore to understand the dynamics of cooperation and learning in cross-functional teams, between teams, and across the organization, we have to understand better the dynamics of shared identity as a higher organizing principle by which learning and coordination are facilitated.

Heedful Interrelating and Emergent Collective Knowledge

Scholars such as Walsh and Ungson (1991) have attempted to understand how collective knowledge emerges among a group of specialized individuals. Their framework views collective knowledge as the summation of the participating individuals' knowledge. According to them the process of summation produces a body of shared knowledge and meanings that equals the collective knowledge of the group. This has been typically the model for understanding knowledge integration in cross-functional teams (Wang, 1996).

However, others have argued that this process of summation is not sufficient for enabling collective learning and knowledge (Spender, 1996). While summation and linking is important, this view treats the process of knowledge integration as the mechanistic combination of a static collection of elements of knowledge through mutual communication. An alternative

view is held by scholars such as Weick and Roberts (1993), who have taken inspiration from Durkheim's (1893) idea that collective organizational properties are more than the summation of individual capabilities, that they are systemic properties that emerge at the social level. For example, emergent collective knowledge in a NPD team is more than a software and a hardware person integrating their respective tasks after some mutual communication. Such integration may take place without change in their basic approaches. Rather, organizational learning may entail the mutually generated emergence of a completely new design based on redefining their fundamental approaches and creatively interrelating the software and hardware configurations (Mohrman, Cohen, & Mohrman, 1995).

Attempting to understand how individual minds, knowledge and actions creatively integrate to effectively constitute a larger emergent whole, Weick and Roberts have developed the notion of collective mind/knowledge to explain the exceptionally high reliability and performance of certain complex organizations. Drawing on their research on an aircraft carrier, Weick and Roberts (1993) argue that creative, collective knowledge emerges when specialized individuals construct their actions (contribution) while envisaging a social system of joint actions (representation), and interrelating their constructed action with the system that is envisaged (subordination). An individual's contribution helps enact the collective mind or knowledge to the extent to which it is closely or heedfully interrelated with the envisaged or imagined requirement of the other contributing individuals in a situation of joint action, while bearing the total activity system in mind.

Rather than being a summation of the capabilities of individuals, the collective knowledge or 'collective mind' calls for each individual's mindful attention to the system level consequences of each individual's contributing, representing and subordinating behavior. A system's collective knowledge emerges from interrelated social practice when these practices are conducted "mindfully" by the individuals involved and as individual contributions become more heedfully interrelated over time.

Having provided this basic framework, Weick and Roberts raise several questions for future research about the dynamics that underlie heedful interrelating. For example, how do specialized individuals go about representing the total activity system in their minds?; how do they envisage the requirements of other contributing individuals in a system of joint actions?; and what allows heedful interrelating with others? Finally, how does this result in change over time that makes possible the emergent collective knowledge? These questions have implications for understanding learning within and between cross-functional teams and the organization.

Surfacing and Integrating Tacit Knowledge for Collective Learning

There has been increasing recognition that most problem solving situations, especially complex ones, rely on a system of diverse knowledge forms, and that tacit knowledge is an integral and important part of this ecology of organizational knowledge (Barley, 1996). Polanyi

(1962) originally expressed the distinction between 'objective' and 'tacit' knowledge. Resemblances can be found in Capaldo and Zollo's (1994) notion of 'strong' facts and 'weak' facts, Simon's (1969) category of 'facts' and 'values', and the Weberian (Weber, 1922) classifications of wertrationalitat, or 'traditional knowledge' and zweckrationalitat, or 'affective knowledge'.

Tacit knowledge is defined as that which is gained experientially and which has not been abstracted from practice. Much of it is deeply internalized, automatic, embedded in practice and used without explicit awareness that one is using it (Spender, 1996). Tacit knowledge often deals with private, non-explicit awareness of 'how things relate' and 'how things work' and includes personal value judgments, expectations, beliefs, general assumptions, emotions and intuitive notions about what to do, how to proceed and how to arrive at conclusions. These are not easily transformed to formal, precise expressions (Capaldo & Zollo, 1994). Tacit knowledge can be contrasted with analytical or objective knowledge that can be represented through formal expressions, numerical values or precise, unequivocal verbal terms.

The fact that an actor cannot articulate and communicate his or her tacit knowledge explicitly through formal language or in unequivocal precise terms does not mean that such knowledge is any less important than analytical knowledge in solving organizational problems. In fact research has shown that as individuals gain expertise and become more accomplished in their disciplines, knowledge becomes more tacit and automatic and is invoked rather effortlessly in the process of conducting work. Dreyfus and Dreyfus (1987), leading researchers in artificial intelligence, summarize this phenomenon: "The expert performer...understands, acts, and learns from results without any conscious awareness of the process....People do not usually make conscious deliberative decisions, when they walk, talk, ride a bicycle, drive or carry on most social activities. [Likewise] An expert's skill has become so much part of him that he need be no more aware of it than he is of his own body" (p. 338). Other researchers have suggested that in some functional domains such as medical diagnosis and molecular chemistry more than 50% of expert knowledge is tacit in nature (Duda & Shortliffe, 1983).

In sum, tacit knowledge is an integral part of any functional knowledge domain and must be duly integrated with other functional domains in a cross-functional setting for effective collective learning to occur. Cross-functional knowledge integration that is deprived of tacit knowledge of any functional domain only partially reflects the complexity of knowledge and abilities that come into play in cross-functional problem solving. However, therein lies the dilemma — since tacit knowledge operates automatically and outside day-to-day awareness, special efforts must be made to surface and represent such knowledge in the cross-functional knowledge integration process. Compounding the problem is that tacit knowledge cannot be adequately expressed in formal, explicit language, although it does not mean that it cannot be represented and communicated in other ways such as exchanging war stories, conscious self-elicitation, and recording and depicting episodes (Spender, 1996). An additional issue pointed out by recent studies (Capaldo & Zollo, 1994) is that most organizational situations and procedures are not supportive of representing tacit knowledge since such knowledge can be

ambiguous, heterogeneous, and contradictory and as such is not easily transformed into logical structures or expressions. Organizational procedures do not allow for shades of meaning. Perceptions that cannot be fully verbalized or intuitions that are not demonstrable are less favored not so much because they are less important or less meaningful but because they are more uncertain and ambiguous. Firms tend to simplify their decision making situations to analytical knowledge that can be expressed in more certain terms or to those more easily demonstrable although it is frequently tacit knowledge that forms the interpretive background that individual's use to weigh or adjust the formal knowledge.

The whole arena of surfacing, representing and integrating tacit knowledge in cross-functional teams presents interesting issues for future research. Likewise, designing organizational procedures and policies that are supportive of representing tacit knowledge present another set of interesting challenges.

Key Issues in Fostering and Enabling Learning

We have argued that NPD organizations that operate through cross-functional teams require new approaches to knowledge management and learning. Cross-functionality has introduced the need for a whole new set of competencies that have to be learned as well as a new way of learning through cross-functional and cross-discipline collaborative work. We have identified some key dynamics that affect cross-functional learning and the creation of collective knowledge. Nevertheless, discipline learning remains critical in firms where deep discipline knowledge is part of the core competencies of the firm. At the same time, restructuring into cross-functional units has dispersed discipline activities and disrupted the traditional modes of knowledge management and organizational learning. Finally, because cross-functional units at all levels in the organization are carrying out whole processes that deliver value to the customer, each unit and each level must continuously learn and incorporate a broad array of knowledge, while at the same time being tasked with ever increasing here-and-now performance requirements for the cost, speed, and technical capability of the new product.

Cross-functional organizations offer great promise for helping the organization adapt to its turbulent and increasingly demanding environment if they can set in motion dispersed learning and create an infrastructure for capturing, encoding and disseminating knowledge. On the other hand, organizations do not have much experience with such complex knowledge management processes; nor are there readily available models and tools. In this section we discuss three related challenges and emerging frontiers: (a) building the capability for collaborative performance and learning across disciplines; (b) finding approaches to foster both deep *and* broad knowledge; and (c) building learning and knowledge management into the work of the organization. These will be briefly discussed below.

Building Capability for Cross-Discipline Collaboration and Learning

Barriers to working across disciplines have historically been seen as stemming from different cognitive frameworks and organizational orientations; attempts to get beyond these barriers have primarily focused on education about and awareness of these issues. Building a cadre of "interpreters" has also been recommended to bridge the gap between contributors (Galbraith, 1994). Interpreters are people who have had multi-functional experience and who understand and can operate within and at the intersection of multiple functions. Although these approaches are helpful, they just scratch the surface in the development of cross-functional competency that is required to actually do work collaboratively when multiple deep knowledge bases are entailed. Having a few people who are able to individually integrate is not enough when the day-to-day conduct of work occurs in interaction between multiple disciplines and the solution of problems entails the integration of the knowledge bases of those disciplines. There is a need to expand the number of people who can work comfortably across disciplines and functions, and to build new algorithms and routines to support these new ways of working.

One promising approach is the development of computer tools to facilitate cross-functional processes. Groupware and program management tools are already being used to foster collaboration in coordination and planning. Lotus Notes, for example is used extensively in some companies to support new product development and is able to provide within team and across team access to project information, data bases, and expertise (Rangaswamy & Lilien, 1997).

Advanced tools entail the display of multiple cognitive frameworks and facilitate their integration (Boland, Tenkasi & Te'eni, 1994; Dykstra & Carasik, 1991; Malone, Lai & Fry, 1992). These are mechanisms to aid thinking, reflection, and interpretation — the cycle that constitutes experiential learning as well as the conduct of knowledge work in general. They include "blackboards" for capturing and displaying the integrative dialogue and problem-solving activities across disciplines, methods of drawing connection to organizational data bases, and other applications for the conduct of systems work such as simulations and rapid prototyping. Some software applications use tools and models such as cognitive maps or cause-effect diagrams to help individuals surface their specific perspectives and unique understandings of a situation and engage in mutual dialogue to arrive at a shared interpretation. Such tools can be particularly useful in surfacing and representing tacit knowledge of specialized individuals and envisaging and interrelating with the requirements of other contributing individuals in a system of joint actions. These are both key dynamics that underlie collective learning in cross-functional settings.

An example of such a tool is the Product Portfolio Support System developed and described by Cohen, Eliashberg, and Ho (1997), a decision support tool for making product line extension decisions. It is intended to be used by multi-functional teams, and builds a common data base including customer information and historical product performance data that feed into models that can be used to predict market and financial performance of line extension concepts. It can incorporate and build on the various knowledge bases and perspectives of the

functions involved in the decision processes, as well as building in learning from past projects and continually updating and extending the predictive model.

As with all computer tools, it is essential to remember that computerized knowledge management tools are supports to a human work system; they supplement rather than replace human interaction. If they are to be effectively utilized for learning, they must fit into a system where there is a collective identity that provides the foundation for the interrelating of participants' work and for developing, surfacing and exchanging tacit knowledge.

Providing Tools and Organizational Approaches to Foster Both Deep and Broad Knowledge Across a Dispersed and Often Virtual Organization

When work entails the integration of knowledge from multiple disciplines and functions, work process improvement demands the generation of information processing frameworks that enable simultaneous focuses on and the linking of deep and integrative knowledge. Organizationally this requires a workforce that understands and is capable of operating in such a complex cognitive space. It calls for a diversity of learning focuses and processes in the organization, comprising diverse and often overlapping networks of people for whom the various kinds of knowledge are relevant.

An obvious need is for compatible data sets and applications across functions and disciplines. These enable work in multiple disciplines to be connected so that deep knowledge can be applied in solving discipline puzzles within the context of cross-discipline projects so that cross-discipline problems can be worked at the interface of the discipline work. This ongoing juxtaposition of deep and integrative work will constitute a core competency in an era when the knowledge and competency frontiers in organizations lie at the intersection of knowledge bases.

Organizations must find mechanisms to capture and distribute organizational knowledge, and to quickly embed it in work routines. One promising approach is to build computer based expert systems that embed expertise that can be distributed across the organization to support work (Quinn et al., 1996). Finding user friendly approaches to encoding and making organizational memory available is another way to expose people to both discipline and cross-discipline knowledge and learning, and to help avoid endless rediscovery of the wheel (Roth & Senge, 1996). One approach is to use "standard work" frameworks that evolve as learning occurs through time and is incorporate into these work processes. Companies are still struggling with how to make these frameworks user friendly and how to apply them in ways that enable and encourage creativity. The product portfolio support system mentioned earlier has the advantage of building learning from past program into the predictive model so that the company's collective experience is embedded in a tool that becomes part of the way product line extension planning is done.

One technical firm that we have studied is using WEB pages on its intranet to collect and distribute complete cases that demonstrate various systems interactions that can lead to immediate or gradual system malfunction. These pages are carefully indexed for rapid access, and include pictures, background documentation, diagnostic test data, and documentation of the final solution. One responsibility of project managers is to identify examples of such complex interactions that can be added to the data base. Cross-discipline project members are expected to identify systems interactions that occur in their new product, search the WEB page for previous learning and experience, and eventually to pull out relevant cases to be put into project documentation and shared broadly throughout the team. Another company has developed a norm of convening (electronically or in person) members of multiple disciplines when projects run into cross-discipline interactions when raising awareness and fostering learning is viewed as widely useful. These organizations have focused their technologists on the intersections of their knowledge bases, as manifested in the functioning of the system they are developing. These approaches are methods for accelerating the process by which employees develop a rich systems understanding, advancing systemic knowledge, and making the systemic learning accessible across the organization and through time.

Building Knowledge Management and Learning as Explicit Organizational Focuses, So That They Are Not Seen as Extra or Optional Activities

Knowledge management activities such as encoding, disseminating, searching, and applying the knowledge stock of the organization must be seen as everyone's responsibility — not as the responsibility of "management" or of special staff support groups. Achieving this state entails finding ways to create resources and forums that can serve as key nodes in the organizational learning process. Finding the right numbers and mix of technical staff support, creating new cross-discipline technical support roles, making knowledge available in user friendly media or forums, and building and supporting networks where people share and can pull needed knowledge from one another efficiently are key challenges in making knowledge management part of the ongoing activities of the organization.

Providing support and the knowledge sharing infrastructure for knowledge management is only one aspect. Learning needs to be embedded in the way work is done and become an explicit focus of the organization. Work routines need to be redefined to include the knowledge management activities of the firm, both those that apply the firm's stock of knowledge and those that contribute to it. Roles need to be explicitly defined so that carrying out responsibilities in these arenas is not seen as optional activity. Explicit measures and goals in the area of knowledge generation, dissemination, and reuse are required and organizational incentives need to be aligned. Some organizations, for example, have explicit reuse goals in their software projects. Others require that prior to budget approval, projects document key framework ideas that they have gotten from the review of lessons learned in other similar projects. One company requires that the lessons learned be entered in the company's data bases before the project is eligible for bonus payouts. Others have begun giving out "I got this idea elsewhere" awards for

applications of knowledge from other places in the organization that contributed significantly to company performance. All of these approaches aim at embedding organizational learning in the fabric of the work organization rather than having it occur as "extra" activities.

And, finally organizations have to pay attention to creating a shared organizational identity that can act as a higher organizing principle and re-orient primary identification with a functional or other sub group toward cooperation for the achievement of common and shared goals. A sense of shared identity in a firm provides a sense of community and provides the foundation for trust, upon which mutual cooperation, coordination and learning can be based . Shared identity promotes cooperation since common identity yields shared cognitive schemas and values that people apply to how others are categorized, including reducing the attributions of self-interested behavior on the part of dissimilar others. Management of cultural artifacts and symbolic processes such as vision, key organizational metaphors, and stories can help organizational actors produce a shared understanding of the nature of their reality that can become guides for cooperative norms, values and actions, including learning.

Conclusion

As organizations increasingly operate through cross-functional structures that disperse discipline experts into many different performing units, new ways need to be found to manage knowledge. Today's competitive world requires cross-functional focus that enables rapid cycle time and the generation of new solutions and innovative approaches. It also requires leverage of knowledge and rapid organizational learning and competency enhancement.

We have argued that both deep and cross-functional skills and knowledge are required, and that organizations need to find diverse mechanisms to foster learning and manage knowledge creation and dissemination. This will entail defining new roles, establishing new forums, enabling lateral sharing, and developing new tools. It will also require organizational approaches that make learning and knowledge management a core focus of the firm. Finally, organizational learning depends on establishing a collective identity that provides a foundation for collaborative work.

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Figure 1
(Partial) Hierarchical, Functional Organization

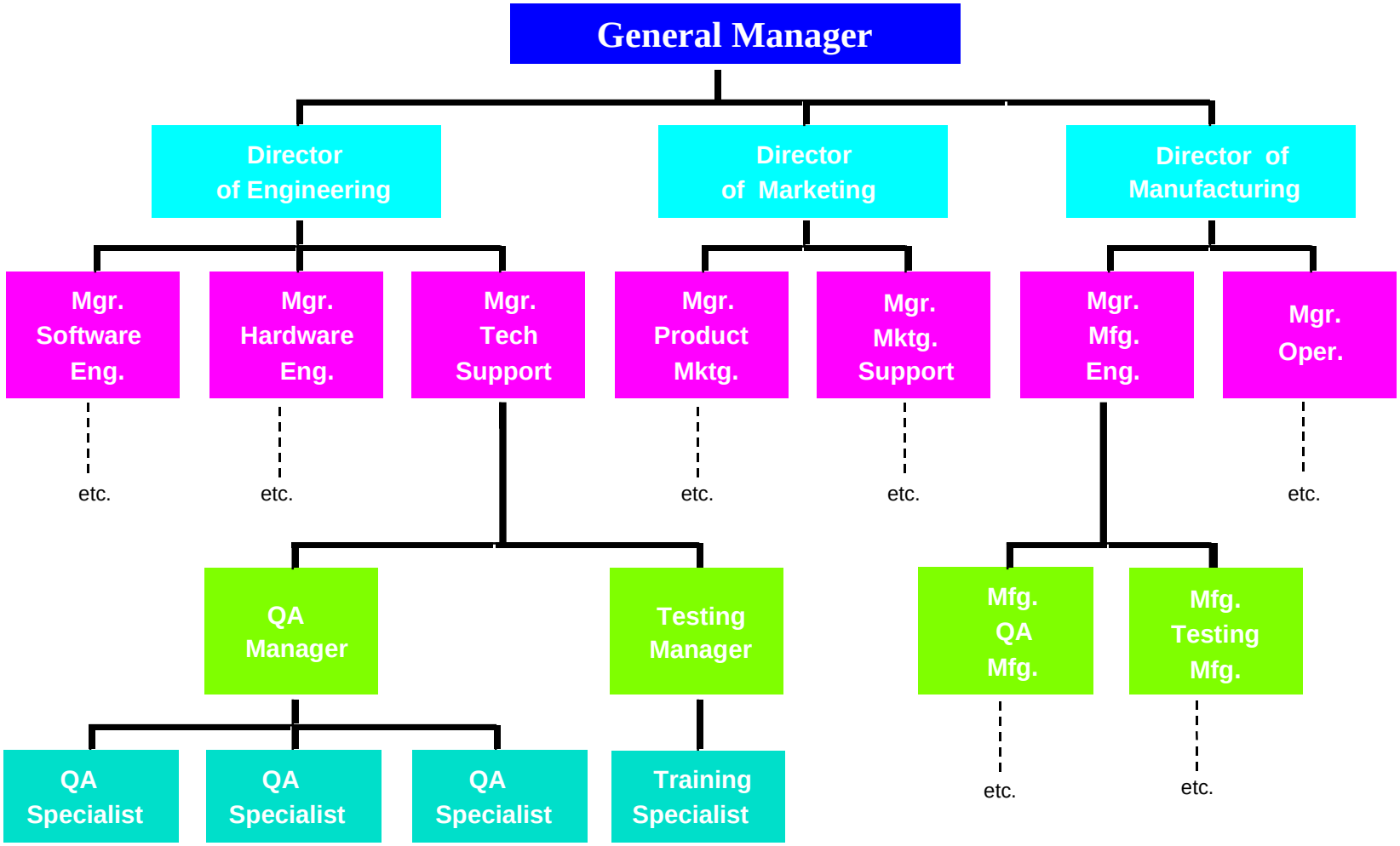

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Figure 2
Team-Based NPD Organization

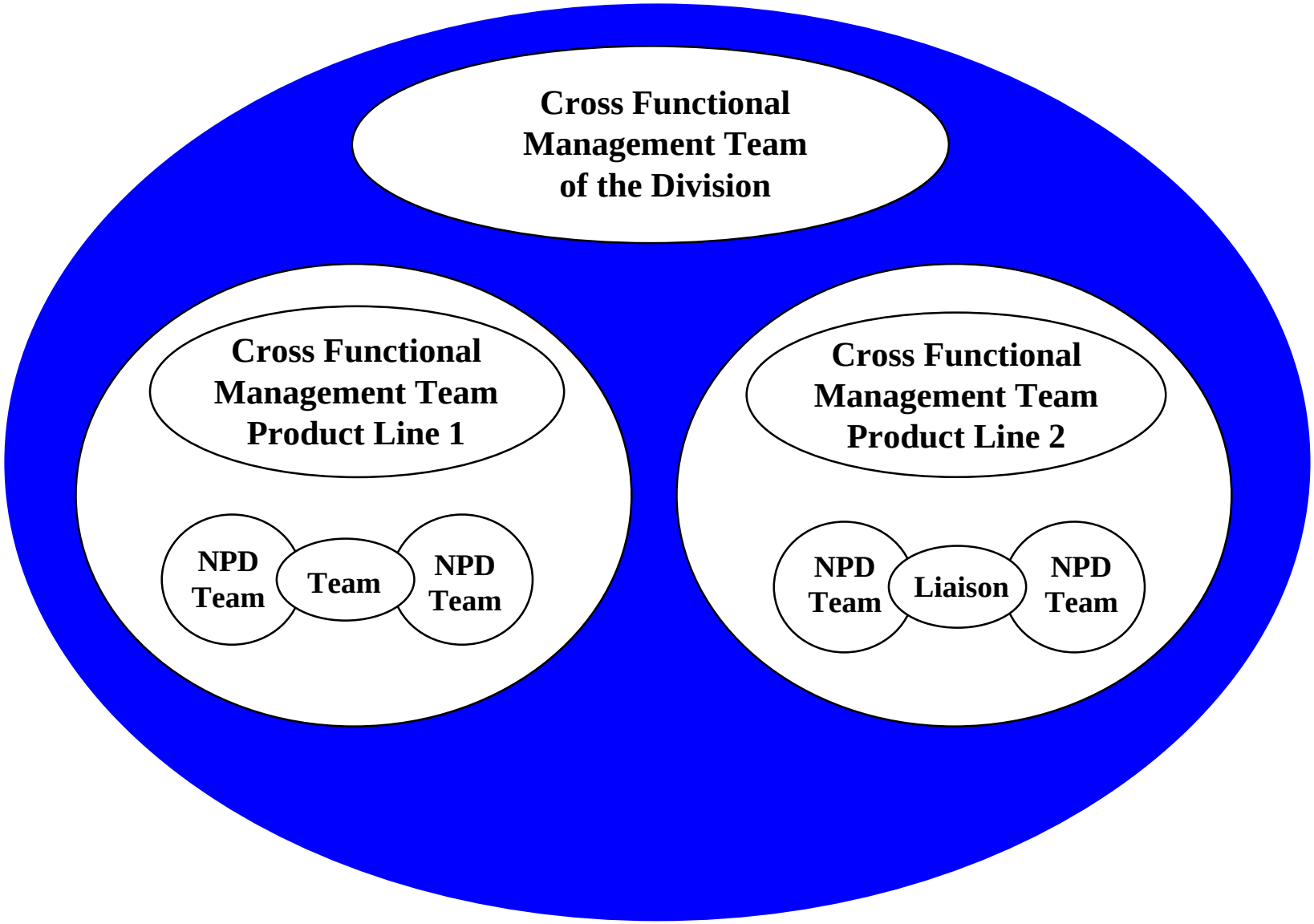

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Figure 3
Locuses of Learning Processes in a Cross-Functional NPD Organizational System

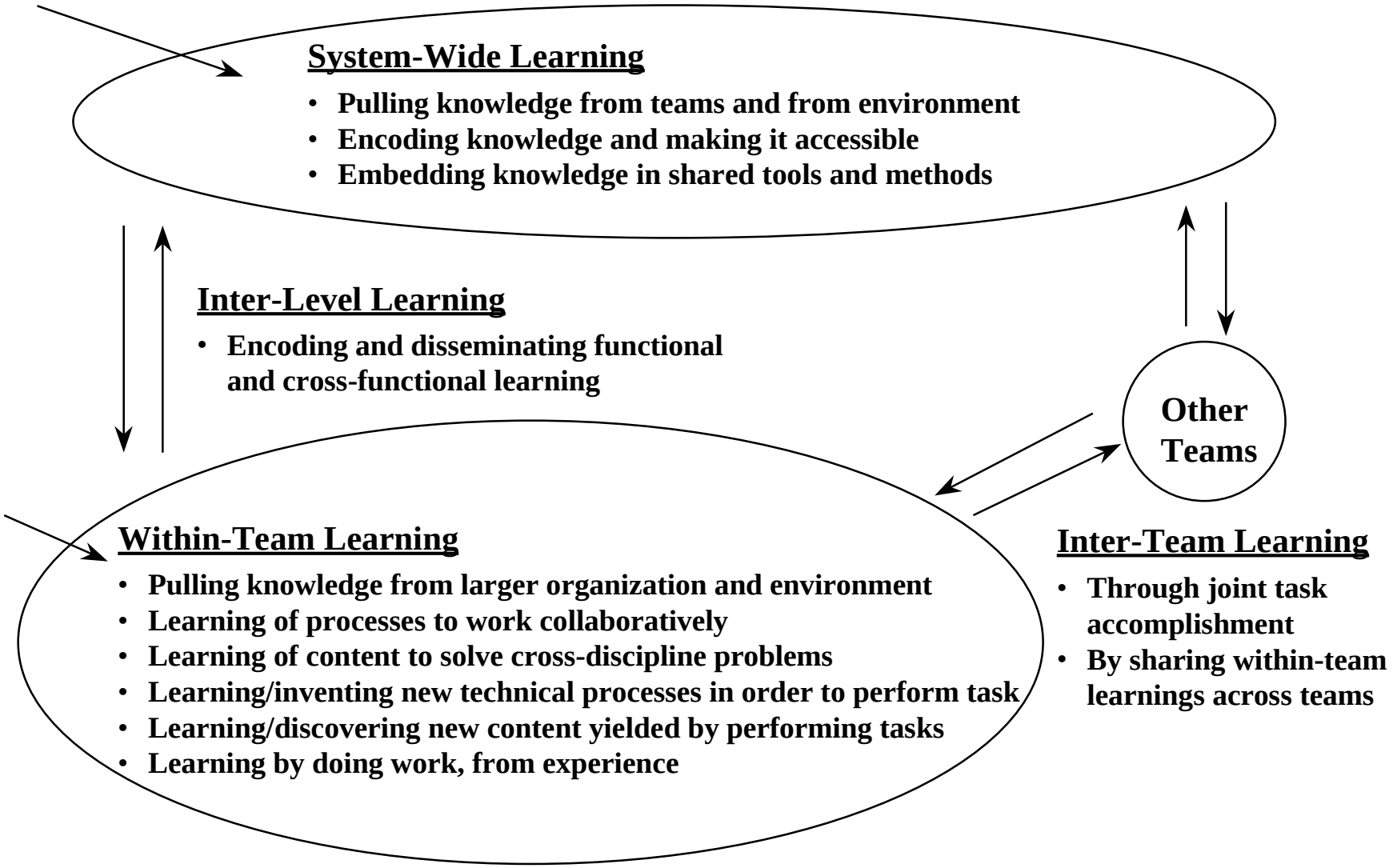

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Figure 4
Dimensions of NPD Team Learning

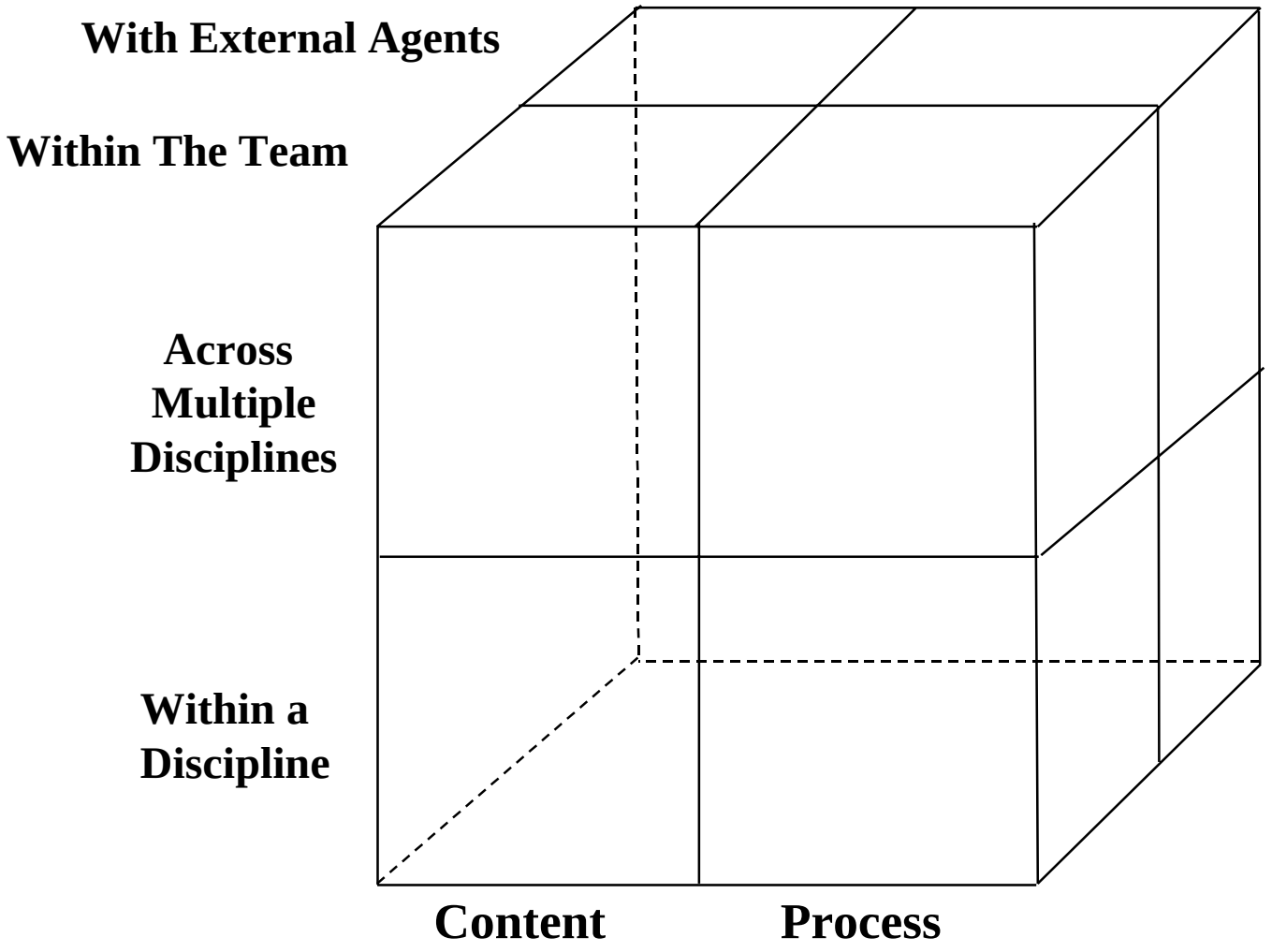

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Figure 5
Key Issues in Building Learning Capabilities

- **Providing tools, training, and organizational approaches for cross-discipline work and learning**
- **Providing tools and organizational approaches to foster both deep and broad knowledge**
- **Building knowledge management and learning as explicit organizational focuses and goals**

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