

Knowledge Density and Success of New Product Development Teams

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Abstract

To explore the problems of sustained innovation within large corporations, we followed 31 new product development teams within a mature chemical company. Based on our findings, an early stage team's entrepreneurial culture can be considered a necessary condition for team effectiveness and continuous funding. In order to receive continuous funding, a team's goal-orientation and knowledge density between the team and its stakeholders increasingly matter.

Introduction

Innovation is critical for the growth and competitiveness of organizations (Van de Ven, 1986). When companies develop new products or processes they innovate and renew themselves thereby adapting to changing market conditions. Although the literature on the “ideal” set-up for an innovative organization has grown (Jelinek and Schoonhoven, 1990; Van de Ven 1986, Kanter, 1983), many organizations are still faced with the difficulty of sustained innovation. One of the reasons for the difficulties of corporate innovation lies in the challenges surrounding the transfer of knowledge between new product development teams (NPD) and their stakeholders.

Theories on knowledge creation suggest that new product development teams able to bridge across different organizational stakeholders, thereby creating dense knowledge networks (Clark and Fujimoto, 1989; Myers and Marquis, 1969; Nonaka and Takeuchi, 1995) are more successful in creating new businesses (Ahuja, 2000; Obstfeld, 2002). Dense networks foster shared understanding that lead to the creation of knowledge necessary to mobilize innovative action. Empirical evidence suggesting that dense knowledge networks and innovation have a strong positive relationship have started to emerge (Ahuja, 2000; Obstfeld, 2002), yet remain limited and do not focus on the type of tasks around which dense knowledge has been created. This research seeks to extend existing theory on new product development teams by focusing on the link between knowledge density on innovation tasks across new product development teams and innovation success.

A Conceptual Model of New Product Development

New product development (NPD) includes all activities needed to conceive, design, produce and deliver a product to the market by trying to solve a steady stream of problems (Clark and Fujimoto, 1989; Myers and Marquis, 1969). Solving these problems requires knowledge creation and collective implementation (Sheremata, 2000). In prior studies researchers have adopted a knowledge creation perspective to study new product development and have linked different types of knowledge and knowledge creation to product development contexts (Nambisan, 2002; Nonaka and Takeuchi, 1995). In order to implement the multiple ideas generated, new product development efforts require structures and processes, which facilitate collective action (Nord and Tucker, 1987). To facilitate collective action, most organizations create new product development teams, mostly multifunctional teams with the goal of launching new products on the market. These teams need, on the one hand, to generate ideas while at the same time collectively implementing the ideas generated. Consequently, new product development teams need to overcome the apparent contradiction between creative and collective action.

In classic studies of organizational design, researchers have proposed design elements, which help foster creative action, i.e. organic designs and those that help achieve collective action, i.e. mechanistic designs. In organic designs creativity is fostered through principles such as decentralized decision-making and information-

sharing across hierarchical divisions. Mechanistic designs, in contrast, integrate dispersed knowledge by directing the creative processes with plans and schedules towards commonly established goals. In order to support innovation, organizations require both design elements similar to high-performing organizations (Eisenhardt, 1989; Nard and Tucker, 1987).

Based on organization theory, innovation management and new product development literature, researchers have discussed several design elements that support innovation within organizations. We have identified three themes that build on the foundation of a set of design elements necessary to support organizational innovation. The three themes are a product development team's customer focus, its goal-orientation and its entrepreneurial culture, themes that have recently been identified in a study on transnational project teams and networks (Schweiger et al., 2003). Although the categories may not be exhaustive, they do focus the attention on the most important management practices within innovative organizations. Customer focus and an entrepreneurial culture are design elements that increase the quantity and quality of ideas and knowledge that NPD teams can access. Goal orientation, on the other hand, address the internal dynamics of a new product development team and contributes to integrating dispersed ideas and knowledge leading to collective action.

Customer Focus

With the underlying knowledge base of most products becoming more diverse and dynamic, NPD teams are increasingly seeking out external resources to overcome the

learning curves related to new technology and markets (Holmes, 1999; Schilling and Hill, 1998). Customer focus, the external orientation of a NPD team, has been recognized both in theory and in practice for a long time (Leonard-Barton, 1995; Brown and Eisenhardt, 1995, von Hippel, 1988). Drawing on work in various areas, most commonly in organization theory and innovation management, the role of the customer has been one of supplying information and wealth to firms by providing new ideas, by involvement in the design and development of products and by testing and supporting the product (Nambisan, 2002). In Cooper and Kleinschmidt's work (1995) customer focus intends to capture the needs of the customers in the new product development process. Customers who have participated in successful new product development projects have a high commercial attractiveness, the characteristics of a lead user and maintained a close relationship with the manufacturer (Ernst, 2002). These factors are directly linked to new product development success.

Hypothesis 1: An NPD team's customer focus is positively linked to innovation success.

Entrepreneurial Culture

Drawing on work in new product development (Cooper and Kleinschmidt, 1995; Barczak, 1995), researchers have identified the existence of an entrepreneurial culture as key to innovation. Having a systematic scheme for suggesting ideas, solving new product development related problems and rewarding risk-taking behavior influence

the effectiveness of new product development projects. Given this link, it is somewhat surprising that "...the innovation-enhancing culture ... has, to date, hardly been analysed for its influence on success of new products" (Ernst, 2002:24). As a result, the concept of an entrepreneurial culture is ill-defined in new product development research. Culture embraces a pattern of basic assumptions developed by a group as it learns to cope with its problems (Schein, 1985). Within an innovation environment, an entrepreneurial culture requires rapid adaptation to market and customer necessities thereby necessitating rapid changes and risk-taking behavior. These characteristics are said to be directly linked to innovation success.

Hypothesis 2: A NPD team's entrepreneurial culture is positively linked to innovation success.

Goal-Orientation

Research studies on success of teams have pointed towards the importance of explicitly establishing goals (Locke and Latham 1990, O'Leary et al. 1994). The development of goals helps to increase the efficiency of teams as goals have a binding effect and will thereby increase the commitment of team members towards the fulfillment of these goals. „Goal theory suggests that goals are associated with enhanced performance because they mobilize effort, direct attention, and encourage persistence and strategy development" (O'Leary et al. 1994). In a summary study on the goal-orientation of teams by Locke and Latham (1990), the authors concluded that in 93% of studies the development of team goals has a positive effect on performance.

More recently, this has been confirmed by O'Leary et al. (1994) who pointed towards the necessity of having precise and realistic goals.

Hypothesis 3: An NPD team's goal-orientation is positively related to innovation success.

Managing Knowledge Density Across New Product Development Teams

While the team's innovation design elements are a necessary condition for success, studies have increasingly pointed towards the importance of the relationship between the team and its stakeholders (Dougherty and Hardy, 1996). Each new product development team needs to put in place collaborative structures and processes which allow getting access to resources laterally and vertically so that people throughout the organization can provide the necessary input to the team at each stage of the decision-making process (Ancona and Caldwell 1992; Kanter, 1983, 1988). Keller (1994, 2001) and Lutz (1994) have conducted empirical analyses, which pointed towards the importance of a NPD team's external communication and innovation success. Inter-functional interaction, as Dougherty (1990) found is increasingly seen to be key to innovation as knowledge flow between different functions is necessary to selecting the right product, developing customer understanding or refining the service provided.

Dense knowledge networks in contrast to sparse knowledge networks are characterized by extensive collaboration between team members and stakeholders.

Efficient knowledge exchange in innovation, characterized by density, is frequently associated with overcoming problems at two levels: those affecting the team and those affecting the relationship between the new product development team and the rest of the organization (Dougherty and Hardy, 1996). Inside the team, knowledge networks are formed to overcome problems, which include understanding the customer or implementing the next hurdle in a stage gate process (Cooper, 1983, Leonard-Barton, 1991). When team level problems are resolved, innovation still does not seem to occur (Dougherty and Hardy, 1996). There is a second level of problems, which affects the team's interface to its stakeholders. At this level, managing the relations to functions such as production, marketing and sales, securing expertise and managing external relations have been shown to be crucial (Kazanjian, 1988). When problems outside the team, i.e. between the team and its stakeholders are resolved at multiple stages of innovation, new businesses can develop (Dougherty and Hardy, 1996).

In order to solve problems, interactions between NPD teams and their stakeholders are key to the success of an innovation project. One of the critical success factors in this interaction is the degree of overlapping mental models between these actors on the tasks and success of the NPD teams. Studies have shown that common mental models within the team have a positive effect on team processes and team success (Klimoski and Mohammed 1994, Mathieu et al, 2000). Mental models are socially constructed structures based on common perceptions about the environment (Senge 1990, Druskat and Pescosolido 2002). These models influence team behavior and improve interaction within teams since a common perception provides the basis to

anticipate team member behavior (Weick and Roberts 1993). Studies within the team literature come to the conclusion that a greater degree of team agreement leads to a higher convergence of mental models within the team and thereby increases the performance of teams (Mathieu et al 2000, Druskat and Pescosolido 2002). Other studies using terminology like „shared understanding“, „shared cognition“ or “collective sensemaking” are similar to the concept of mental models with each concept postulating that common perceptions at the team level have a positive impact on team outcome (Bettenhausen 1991, Klimoski and Mohammed 1994, Hastie and Pennington 1991). The majority of existing studies have looked at the degree of common perceptions within teams. While the importance of managing interactions inside the team has long been recognized, the importance of the relationship outside the team, i.e. the linkage between the team and organizational stakeholders is an area not sufficiently explored. In our model of NPD effectiveness, we include knowledge density - the degree of common perceptions between the team and stakeholders within the organization - as an explanatory variable. In our model, we look at the knowledge density in relation to the three identified factors – customer focus, goal-orientation and entrepreneurial culture. Similar to the definition of density in the network literature, we define the degree of common perceptions between actors as high knowledge density (Reagans and Zuckerman 2001; Jansen 1999; Wasserman and Faust 1994).

Knowledge Density on Customer Focus

Open communication between NPD teams and their stakeholders allows unanticipated problems to emerge and thereby enables teams to make adaptive changes (Nord and Tucker, 1987: 311) while at the same time ensuring consistency of action. The key to consistency is cross-functional coordination, which entails exchanging expertise from all functions to resolve design and manufacturing problems and testing ideas with marketing and sales (Dougherty, 1992, Souder, 1987). Especially the interface between marketing and sales and the new product development team entails development of a common customer understanding so that the newly designed product or service meets the needs of the customer. Moorman (1995), in particular, has pointed to the importance of consistent information flow between the various functions involved in NPD and the customer as a key determinant of innovation success. We therefore argue that a high degree of agreement between stakeholders on the team's customer focus is linked to the success of the NPD team.

Hypothesis 1a: Knowledge density on customer focus is positively linked to innovation success.

Knowledge Density on Entrepreneurial Culture

As NPD teams and their stakeholders communicate, the stakeholders start to develop an understanding of the team members' knowledge capacity. The consistency of perception between the stakeholders and the NPD team on whether the team has the entrepreneurial capacity to suggest new ideas which will ultimately be transformed

into products has a direct impact on their success as the team will be supported by the stakeholders in their creative efforts.

Hypothesis 2a: Knowledge density on entrepreneurial culture is positively linked to innovation success.

Knowledge Density of Goal-Orientation

Not only the precise and realistic development of team goals has a direct influence on the team's performance, but also the link between the NPD team's goals and organizational units' alignment with the team's goals has been reported to have a direct effect on performance (Leonard-Barton, 1988; Kanter, 1988; Dougherty and Hardy, 1996). By creating a common understanding between the stakeholders of the NPD team and the team's goal, the different functions are in a better position to contribute to the success of the team. This enables the team to obtain information and resources and legitimizes their activities. In short, new product development teams that understand their role within the organization and that work with other units that understand their role have a higher chance of innovation success (Dougherty and Hardy, 1996).

Hypothesis 3a: Knowledge density on goal-orientation is positively linked to innovation success.

Insert Figure 1

Methods

Research Site and Data Collection

The research was conducted in a multinational chemical corporation. In 2000, at the time of data collection, the company had annual sales of \$23 billion and employed over 40,000 people. Its products covered a wide range of markets that are vital to human progress, including food, transportation, health and medicine, personal and home care, and building and construction. The company operated across North America, Europe and Asia. One-site sampling schemes have been used widely in innovation research as broad contextual factors that are known to influence the innovative ability can be controlled (Tsai and Ghoshal, 1998).

As the leadership of this large chemical corporation recognized that it had to offset stagnant revenues by entering new and faster growing markets, it started a program to establish new product development teams for the purpose of growth, i.e. semi-autonomous, multifunctional teams housed within the company. Initially, 60 projects were identified as potential prospects for new growth. After receiving initial funding, the projects were regularly evaluated using a stage-gate process consisting of five stages: concept shaping, concept analysis, validation, development and implementation. At the end of each stage, a growth board consisting of business

directors evaluated the results – either terminating the project or providing additional funding.

Our data were gathered through an internet-based 360° team feedback questionnaire during the course of 2000/2001. Twenty-nine new product development teams as well as organizational members working with the team upstream, downstream and the boss(es) completed the survey. Upstream consisted of organizational members from marketing & sales. Downstream consisted of organizational members from R&D and production. Bosses were individuals the team reported to.

Unit and Level of Analysis

All the data generated for each of our variables were measured at the individual level yet the survey items were written to capture not individual attributes but attributes of the team as a whole. Each member of the team provided his or her own perceptions of the team's capability. We then aggregated responses from organizational members upstream, downstream, bosses and the team into unit-level measures for each of the constructs, an approach previously employed by other scholars (Earley, 1999; Feltz and Lirgg, 1998). This approach is consistent with calls for survey items that truly refer to the level of interest (Klein et al., 1994; Rousseau, 1985) and there is evidence that team-referenced wording of items helps within group agreement and promotes between group variability (Klein et al., 2001).

Measures of Innovation

To identify the determinants of innovation of new product development teams, we used selected items of the 360° Denison team leadership development survey. This survey is based on the validated Denison culture survey (Choo, 2000). The measure for customer focus was defined as driven to clearly understand the present and future needs of the customer, seeking ongoing input from the customer and ensuring that all employees are driven by a concern to satisfy the customer. The variable was measured using an eight-item scale assessing the new product development team's understanding and reaction to customer's future needs. Higher scores indicate higher levels of understanding of customer needs.

The measure for entrepreneurial culture was defined by a new product development team's anticipation of future changes by continually creating adaptive and innovative ways to meet changing needs. The survey comprised items such as encourages creative thinking or generates innovative ideas and solutions to problems. This variable was measured using an eight item scale assessing the degree to which the new product development teams exhibits an entrepreneurial culture. Higher scores indicate higher levels of entrepreneurial culture.

The measure for goal-orientation was defined as encouraging accountability in setting and accomplishing goals. The survey comprised items such as sets clear goals that are ambitious, but realistic, or provides clear directions and priorities for employees,

establishes high standards of performance. This variable was measured using an eight item scale assessing the degree to which the new product development team had a clear set of goals and objectives that provided everyone with a clear direction in their work. Higher scores indicate clearer goals.

All three variables were measured using an eight item scale assessing the degree to which the new product development teams had a high level of customer understanding, had an entrepreneurial culture and had clear goals. The items were based on a Likert type scale which had seven response options from 1 “strongly disagree” to 7 “strongly agree”.

Knowledge Density

To measure knowledge density between the team and its stakeholders within the new product development organization, we used the interrater agreement measure proposed by Lindell et al., 1999. Interrater agreement measures „the extent to which different judges tend to make exactly the same judgements about the rated subject“ (Tinsley and Weiss, 1975). It thereby measures the degree to which different stakeholders agree with each other. Since the rating represents a perceptual measures, interrater agreement measures the degree of convergence of perceptions between team members and its stakeholders. This is in contrast to interrater reliability, which measures „the degree to which the ratings of different judges are proportional when expressed as deviations from their means“ (Tinsley & Weiss 1975). While Webber et

al. (1999) mention that interrater reliability and interrater agreement can both be used to measure mental models, we used interrater agreement as it measures consensus between judges rather than consistency of responses. Interrater agreement compares the mean standard deviation of all raters across all items given a maximum dissens across all raters (Lindell & Brandt & Whitney 1999).

Innovation Success

The success of the new product development team was evaluated using two measures: a (1) termination measure and a (2) perceptual measure of the team's effectiveness. The termination measure was created by identifying the teams that were still in existence and received corporate funding after a period of 24 months. Out of the 31 teams, 19 were terminated. In addition, we asked the outside stakeholders working with the team to rate the team on five items reflecting team effectiveness indicators.

Results

Table 1 shows the means, standard deviations and correlations of all variables.

Insert Table 1

To test the hypotheses, we run four regression models of the six independent variables on the two measures of success: (1) team effectiveness and (2) team funding. Table 2 shows four regression models. Model 1 tests the three main hypotheses on team

effectiveness. Model 2 tests all hypotheses on team effectiveness. Model 3 tests the three innovation determinants on team funding. Model 4 tests all hypotheses on team funding. Hypothesis 1 states that an NPD team's customer focus is positively linked to innovation success which was not confirmed in any of the models. Hypothesis 2 states that an NPD team's entrepreneurial culture is positively linked to innovation success, which was confirmed in all models. Hypothesis 3 states that an NPD team's goal orientation is positively linked to innovation success, which was not confirmed. Neither was hypothesis 1a stating that an NPD team's knowledge density on customer focus is positively linked to innovation success. Hypothesis 2a stating that an NPD team's knowledge density on entrepreneurial culture is positively linked to innovation success was confirmed using the funding criteria but could not be confirmed on the basis of team effectiveness. Hypothesis 3a stating that an NPD team's knowledge density of goal-orientation is linked to innovation success was confirmed using the team effectiveness criteria but could not be confirmed based on funding.

Insert Table 2

Discussion and Conclusion

One of the innovation determinants – the existence of an entrepreneurial culture – was clearly confirmed as a variable linked to innovation success. This confirms a recent argument (Ernst, 2002), which points towards the importance of an entrepreneurial culture within an innovation team. Two other important hypotheses that support the existence of a dense knowledge between the innovation team and its stakeholders have also received support somewhat confirming prior research that has linked

convergent perceptions within the team and success (Mathieu et al. 2000; Druskat and Pescosolido, 2002). In contrast to previous research, these findings point towards the importance of common perceptions, knowledge density, across the team. While dense knowledge on goal-orientation between the team and its stakeholders is linked to team effectiveness, dense knowledge on an entrepreneurial culture is linked to funding. This seems to suggest that the existence of congruent perceptions between the team and its stakeholder on the team's goal-orientation, dense knowledge across the team, is more likely to lead to an effective team while congruent perceptions on the team's entrepreneurial culture is more likely to lead to continuous funding. Stakeholders and the team seem to attribute the ability to find creative solutions an important indicator of innovation warranting corporate funds despite potential deviations from the original business plan.

A possible reason for the lack of significance between knowledge density on customer focus and success may be the stage of the product development teams. Data on teams was gathered in an early product development stage during which most teams were still in the concept analysis or validation stage. During this stage, finding innovative solutions to technical questions were potentially more important than being customer focused. Other reasons for the lack of significance could be the limited number of observations since the unit of analysis was the team.

The findings on innovation success have enabled us to confirm the existing literature on innovation and highlight upon the importance of knowledge density in the networks of innovation actors. Based on our findings, a team's entrepreneurial culture

can be considered a necessary condition for innovation success, but insufficient for continuous funding. In order to receive continuous funding, knowledge density between the team and its stakeholders on the entrepreneurial culture of the team is necessary. Knowledge density on goal-orientation between the NPD team and different functional constituents within the organization appears to have a greater influence on the effectiveness of teams. Apparently, a team can function well, yet if it does not receive any strategic support by organizational stakeholders it will be terminated. These findings are similar to Dougherty and Hardy's (1996) arguments that sustained innovation does not occur if the new product development team can not solve the "innovation-to-organization problems". The knowledge flow between different organizational constituents and the team itself has to be sustained in order for the organization to see their value. Teams that have a great idea but are not able to act upon the idea by letting their knowledge flow to different functional areas within the organization are more likely to be terminated.

Organizational constituents need to believe in a team's ability to find creative solutions in order to receive continued funding. Since changes in goals in the course of the new product development occur frequently, the ability to adapt to these changes by repeatedly finding solutions as seen by the organizational constituents is crucial.

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Figure 1

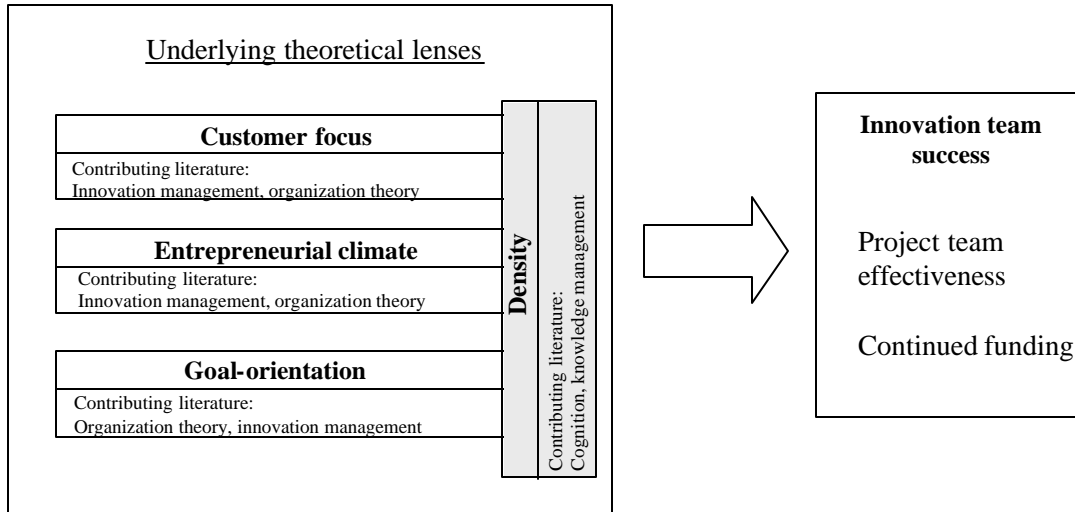


Table 1

	Variable	Mean	s.d.	1	2	3	4	5	6	7
1.	Total team	15.71	7.50							
2.	Customer focus	5.58	.62	-.08						
3.	Entre. Culture	5.16	.50	-.31	.51 **					
4.	Goal-orientation	5.35	.40	-.17	.54 **	.67 **				
5.	Density on customer focus	.97	.014	-.36 *	.53 **	.44 *	.29			
6.	Density on entre. Culture	.94	.027	-.07	-.08	.11	.18	.23		
7.	Density on goal. orient.	.97	.020	-.42 *	.14	.12	.18	.24	.29	
8.	Team effectiveness	4.76	.78	-.08	.24	.55 **	.40 *	.11	.43 *	.48 **

** Significant at 0.01 level

* Significant at 0.05 level

Table 2

	Team effectiveness & innovation factors		Team effectiveness & innovation factors plus knowledge density		Funding & innovation factors		Funding & innovation factors plus knowledge density	
	B	Std. Err.	B	Std. Err.	B	Std. Err.	B	Std. Err.
Total team	0.79	0.02	0.24	0.03	2.00	0.09	2.23	0.19
Customer focus	0.13	0.37	-0.04	0.43	0.90	0.98	0.01	1.60
Entrepreneurial culture	0.60 **	0.52	0.56 **	0.45	3.94 **	1.68	2.76 **	2.74
Goal orientation	0.13	0.68	0.93	0.60	1.80	1.45	3.14 †	2.42
Knowledge density on customer focus			-0.23	17.80			2.11 †	55.74
Knowledge density on entre. culture			0.26	10.10			2.91 **	49.84
Knowledge density on goal orient.			0.45 **	12.00			1.45	56.37
R-Square (or Cox & Snell R-Square)	0.34		0.59		0.26		0.49	
F-Statistic	2.50 **		3.50 **		1.60 **		1.60 **	

*** Significant at 0.01 level

** Significant at 0.05 level

† Significant at 0.1 level