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The product development learning process and its relation to performance indicators

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Abstract

Many companies have introduced Knowledge Management systems in product development and innovation processes to control their information and knowledge flow throughout the product lifecycle. Such systems enhance relationship between product features, geometries, interfaces, functions etc, and articulated knowledge by those who design, develop and decide upon the actual product. The innovation and product development process is constrained by ever increasing ambitions with regards to time-to-market, cost and product and process complexity. The latter is a response to the demand for tailoring products to individuals in the B2C market and niches in the B2B segment. Complexity also increases according to product responsibility along both the value chain and product lifecycle. One approach to handle stringent time and budget constraints, as well as multifaceted complexity, is to increase the knowledge base of the firm. In this article, we investigate the extent to which critical knowledge capabilities are aligned to performance indicators as time, cost and quality. A survey is conducted in the Norwegian manufacturing industry to determine knowledge practices from the construct of a generic model as basis. The survey was answered by 306 respondents from 50 companies, providing the opinion of individuals as to where they place their current practices and capabilities on the knowledge maturity scale for each question, including a supplemental set of performance and productivity related assessment items. Results indicate that there seems to be significant relation between performance and formalization of the knowledge creating process, and specifically the later stages of the learning process.

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1. Introduction

Increasing pressure to develop products of higher quality, with added functionality, at a lower cost, and in shorter time frames unquestionably brings about some dichotomies. The examples of high quality vs. low cost, less resources and time vs. higher performance, and increased robustness vs. lower weight all illustrate well known contradictions which become more and more important to optimize. Only companies that can manage such conflicting objectives and in an adaptive manner consistently and timely bring new and innovative products to market will be regarded as long-term partners. Advances in information and communication technology, cross functional teams, overlapping processes, platform and module thinking, standardization of processes, project management techniques and knowledge management systems have in various ways been introduced to keep up the pace of the product development process. However, implementations of such attempts have in many cases been only partial successful, suffering from lack of involvement and coordination. In this regard, Utterback [1] claimed that the main challenge is to develop the ability to innovate products, processes, and the organization, seeing them dependent of each other as a whole. A common denominator of products, processes and organization is knowledge, meaning how companies identify knowledge gaps, search for relevant information, make mutual understanding, extract and prioritize, and convert information into usable knowledge demonstrated into added value products. A firms competiveness can be understood from how market needs and wants are converted into desirable products by combining customization at product level and standardization at manufacturing and value chain level. This focus on knowledge-based activities implicitly means innovation at all levels is the key determinant of competitiveness. Given the growing importance of knowledge work, more attention will probably be directed towards making knowledge work more productive and knowledge workers more effective [2]. The challenge is how to build and maintain an organization where knowledge and innovative action are valued.

From a philosophical point of view, epistemology is the theory of knowledge, what it is and the extent of how much we know [3]. A common definition of knowledge, provided by Plato, is [3]; "*true justified belief*", meaning that one has to believe in what is claimed to be true by a trustworthy and reliable source or method. However, there are many competing theories. For instance Nonaka et al. [4] focused on the "*justified*" rather than the "*true*" aspect because truthfulness is regarded as a static and nonhuman view of knowledge. The reason for a belief is also questioned by numerous examples, demonstrating the possible irrational component of a so-called good reason for belief. This discussion is outside the scope of this study, leaving the common definition as plausible for now. More practically, knowledge can be said to make up the expertise and skills acquired through experience and education. Thus, learning can be approached as a process of synthesizing different types of information, leading to the production and expansion of existing knowledge and skill bases, where the output or new knowledge from such a process often refers to a relatively permanent change in behavior as a result of maturation, practice, or experience [5]. This definition is also theoretically questionable in the sense that learning does not necessarily change behavior but rather changes the ways in which people understand, experience, or conceptualize the world [6].

In this paper we seek to study how a set of knowledge components are related to key performance indicators at both project and company level. Thus, the focal research question is: ***how strong is the cause and effect relationship respectively between knowledge components and the organizational performance?***

2. Theory

2.1. Product development

Kennedy [7] defined product development as; "*Product development is the collective activities, or system, that a company uses to convert its technology and ideas into a stream of products that meet the needs of customers and the strategic goals of the company*." Clark and Wheelwright [8] used similar wording: "*The aim of any product or process development project is to take an idea from concept to reality by converging to a specific product that can meet a market need in an economical, manufacturable form*." Seen together these definitions emphasize that product development

is a collective concern at the same time as the output from the process shall satisfy the customer, manufacturing, and the company in terms of return on investment. Clark and Wheelwright [8] also concluded that product development can create competitive advantage in at least three areas: market position, resource utilization, and organizational renewal. However, the ability to achieve and maintain these advantages is not a given; for instance Dougherty and Hardy [9] noted that many organizations have difficulty with sustained product development success. Product development capability [10], the ability to use and integrate existing organizational and inter-organizational competences, is seen as fundamental to introducing a successful new product. It is argued that success is especially challenged by technology changes and global competition, meaning that product development capability must contain features beyond competence utilization. For instance, Barney [11] emphasized that such capability must be valuable, rare, and imperfectly imitable.

2.2. Knowledge.

Knowledge is important as a value stream and competitive factor for all companies; in fact, Kennedy et. al. [12] refers to product development as a "*world of knowledge, rather than a world of tasks*". Companies that lack systems, processes and culture for generating, capturing and standardizing knowledge for later re-use will suffer from dilution of market value when losing people (downsizing)—and not the opposite in an instant perspective, as commonly seen in the stock market. Collective knowledge generation and ability for learning are the only permanent advantages as markets, technologies and competitors change over time.

A product development process is initiated with the intention of producing something new, whether it is an incremental change to an existing feature or it involves fundamentally rethinking the way things traditionally are done. Consequently, both extremes, and therefore the product development process, involve some degree of learning, or as stated by Jensen, "*In a way all organizations are learning organizations. If they were not, they would not be able to survive in a changing environment*" [13]. So far, agreement is found in the main body of learning theory. But how the process of learning is perceived by different authors is very different. As stated by Fiol and Lyles; "*no theory or model of organizational learning is widely accepted*" [14]. But there are some common agreement upon the different phases of a learning process, where for instance Pawlowsky summarized these four phases from the learning literature [15]:

- The identification of information that seems relevant to learning
- The exchange and diffusion of knowledge
- The integration of knowledge into existing knowledge systems
- The transformation of the new knowledge into action and the application of the knowledge to organizational routines so it can affect organizational behavior

2.2.1. Identification

The first learning phase, defined as identification of information, acquisition or observation, is about how relevant information is identified for the creation of new knowledge. This information can be derived from learning by doing, learning from customers, by copying, problem solving, opportunity taking, and by learning from mistakes [16]. Information which stimulates learning is often triggered by recognition of a crisis [14, 17], which is based on the assumption that existing organizational routines must be unlearned in order to legitimize new information and knowledge [18]. Zhang et al. also pointed to critical incidents as triggers for learning, such as financial crisis, key staff exit, acquiring new customers, innovating new products, and mergers [19]. Dodgson recognized that organizational learning is triggered both by environmental change and by internal factors in an iterative manner [20]. Environmental changes that challenge the organization are often emphasized as the main trigger for learning and search for new information [21], but also the motivation to improve our way of working, seen as an internal factor, should be considered as an important criterion for information generation [22]. It is also important to note that just seeing a difference leads only to creation of information, while both seeing a difference and pointing it out may lead to creation of knowledge [13]. This is because information is viewed as an explicit representation of knowledge, not knowledge in itself [23].

2.2.2. Diffusion

Diffusion of knowledge is about exchange and distribution of knowledge from the individual to the

collective level, or at the collective level itself. March and Olsen argued that individual behavior is influenced by different patterns of interaction with other organizational members, emphasizing level of trust and integration as two important factors for effective information sharing [24]. In an atmosphere of trust, individuals will be more likely to perceive what other members of the organization or group perceive [25]. Hence, this assumption does not say anything about the common perception as intentional for the company. Schein pointed out that organizations are composed of sub-cultures often having different goals and languages [26], meaning that organizational learning will be impeded if these sub-cultures don't understand each other's terminology, metaphors or stories. Trust is also important in making information readable for others [27]. Enabling translation is highly correlated with individuals' motivation to share their hard-won knowledge, something which is culturally conditioned rather than technology dependent (knowledge management systems).

Translation or transferability also concerns the ease of with which a type of knowledge can be transferred from one party to another. These knowledge types are often referred to as explicit and tacit, where the former is regarded as relatively easy to codify and transfer whereas the latter is more personal and difficult to articulate and codify [28]. Other obstacles to diffusion are formal structure, dysfunctional workflow and distance [27]. Hierarchical organizations with long vertical information chains are said to be counterproductive to information and knowledge flow [29].

2.2.3. Integration

The integration and modification phase describes how knowledge is kept, stored and secured within the organization, and how the existing knowledge base is altered, modified and renewed [27]. Thus, this phase poses fundamental questions about organizations' ability to unlearn or modify dominant mental models. It also raises questions about the incentives for experimental behavior and if there is some sort of threshold for organizational learning. The latter points to the learning event itself, both the magnitude of a failure or a crisis leading to action and the organizational impact of such action measured in terms of both breadth and depth. The influence of history on the organization can be positive as well as negative [26], depending on the rate of technological change. Accumulated knowledge forms an organization's identity and can be a source of future competitiveness, but if that knowledge becomes obsolete it can lead to inertia since organizations tend to conserve what exists [30]. Accumulated knowledge can therefore slow learning processes, or as stated by Hedberg and Wolff; "*History becomes a constraint that prohibits seeing*" [31]. This dilemma implies that learning requires both change and stability in the relationship between the organization and its environment. Too much turbulence will make it difficult for the learning system to map and store anything [31], while a high degree of stability will offer few opportunities for learning. In both extremes a formal knowledge management system will provide little help in acting as the organization's memory. This because a high rate of knowledge turnover will make knowledge less valuable to store, whereas in a stable environment the organization's behavior is more routinized in which the knowledge is less valuable to store. March has also described this knowledge dilemma, which he differentiated between exploitation and exploration [32].

Table 1. Knowledge components.

Index	Question
Vk1	The company has a structured approach to identify knowledge gaps in product development projects
Vk2	The company always develops several design concepts/alternatives in the early stages of product development, using a "survival of the fittest" approach to develop the final solution
Vk3	Valuable insight and new information is often discovered by physical testing
Vk4	The company is actively seeking information and knowledge from outside to broaden the knowledge base
Vk5	Informal knowledge sharing (for instance face-to-face communication) is widely used in our company
Vk6	The company emphasizes formal knowledge sharing through medium as data bases, project meetings, visualization boards/rooms, lessons learned etc
Vk7	Negative experiences, in terms of test- and product failures, unplanned loop-backs etc, are utilized as a valuable contribution to the existing stock of knowledge
Vk8	New and relevant information is translated and articulated in a way that eases understanding for others

Vk9	The organization is willing to explore new knowledge to develop new and innovative ideas
Vk10	Knowledge is, as far as it is possible, captured and documented in formal knowledge systems
Vk11	In our company we have dedicated knowledge owners related to critical product characteristics
Vk12	Our company has a structured process to maximize the benefits from its body of knowledge

2.2.4. Transformation

The notion *"bounded rationality,"* coined by Simon [21], refers to the limitations of the human mind when it comes to formulating and solving complex problems. These limitations to prediction of a full range of possible actions and outcomes serve as an argument for a trial and error approach. Alchian [33] found that trial and error learning may be effective in an uncertain environment, saying that learning is partially influenced by chance. Reinertsen, who has described the "*Design Factory*" in relation to systems theory, said that events that are less probable contain more information than expected events [34]. Translating this information processing view to a learning approach indicates that degree of learning increases with degree of uncertainty. A small change in probability or risk generates information, and maximum information content occurs when there is a 50% failure rate. Weick [35] suggested a somewhat higher failure rate to create understanding by stating, "*There is a delicate tradeoff between dangerous action which produces understanding and safe inaction which produces confusion.*" However, harvesting from the previous stages in the learning circle is demonstrated through the process of synthesizing information towards usable and valuable knowledge built into the actual product.

From these four theoretical stages of learning, identification, diffusion, integration and transformation, 12 questions and statements, knowledge components, are outlined and asked the respondents through the survey (Table 1).

2.3. Performance indicators

Godener and Söderquist asserted that performance measurement of R&D and new product development activities is gaining increased importance because the effectiveness and efficiency of these activities determine not only a company's competitive advantage, but its very survival [36]. This is supported by Pawar and Driva [37], who stated that survival of a company is obtained through effectively managing and measuring the product development process and keeping a focus on reduced time to market, increased quality and reduced costs. Reasons for the increased focus on product development performance, according to Kerssens-van Drongelen et al. [38], are new factors or changes observed in R&D environments, like faster changing customer requirements, intensified competition, splintered mass markets, growth of scientific and engineering capabilities, increased breadth of technologies in products, development of global networks and virtual laboratories, focus on HES (Health, Environment and Safety) and increased pressure on R&D departments to be accountable to business units. In addition, rapid advances in information and communication technologies, globalization and shortened product life cycles are highlighted as challenges in new product development [36]. Another important reason to keep track of the product development process is the total life cycle cost of a product.

There are trade-offs made every day among metrics such as time to market, customer satisfaction, defect reduction, platform reuse, core-competence alignment, reduced product complexity, enhanced variety, service quality, and the more than eighty variables that have been identified in the product development literature as affecting success [39]. Trade-offs among different measures are also mentioned by Narahari et al. [40], who argue that the interdisciplinary nature of product development activities involves challenges at various project stages, dynamics of technology, customer preferences, competition, pressures to bring the product to market quickly and organizational realities.

Driva et al. [41] found that existing measurement tools are primarily directed towards the strategic level, with minimal involvement from designers and developers. Product development and design have traditionally been managed by project budgets and schedules, meaning that engineers do not recognize the economic cause and effect of their decisions at the company level [42]. This decupling of strategy and operational goals was also noticed by Tipping et al. [43]. They asserted that the project management orientation is micro in character, and often separated from short- and long-term economic objectives. In line with these findings, Griffin and Page [44] recognized the need to measure new product development at both the project level and the corporate/program level. But

they emphasized a bottom-up approach in determining performance measures, indicating that corporate success actually depends on project strategy. A slightly different approach is suggested by Cooper and Kleinschmidt [45], who emphasized that tough go/no-go decisions must be made throughout each development effort to ensure that resources are being allocated appropriately. This means that decisions can only be managed at the company level since the individual projects have to be compared against overall requirements, targets and available resources.

From this base of knowledge on performance indicators related to product development, four questions are outlined as shown in Table 2.

Table 2. Performance components.

Index	Question
Vp1	Customers are generally satisfied with the true value realized in our new products
Vp2	Product development projects are launched on time
Vp3	Product development projects are launched at budget
Vp4	During the last three years our product portfolio have been extended by introducing (new to us) type of products in the marketplace

3. Method

3.1. Background and selection criteria

A wide set of Norwegian manufacturing companies were chosen to participate in a descriptive survey to gain preliminary insight into the status of product development practices. To target these companies a profile including a set of criteria was developed before inviting potential respondents to participate in this study. The criteria are listed below:

- Minimum 50 employees per satellite (local unit)
- Develops and delivers mainly physical products
- Organization chart shows product development and/or engineering functions
- Delivers products to end-user (B2C), customer's purchasing department, OEM or system integrator (B2B)
- R&D department/hub in Norway (may be owned by foreign company)
- Ensure companies from different industries

Companies were contacted either by managing director or head of R&D to determine if the company was interested in participating in the survey. Then, an e-mail was sent to provide information on the research project, its purpose and structure as well as how the data would be stored and used. A web-based survey using the program Opinio developed by Object Planet AS was used. An e-mail with a link to the web-based survey was issued to each of the contacts. Two reminders were issued, respectively, four and ten days after the first submission to the contact people who did not respond or complete the questionnaire. Non-probabilistic sample design was used as it was important to obtain information relevant to and available from only certain groups (i.e. personnel involved in product development and design). The subjects in the sample were product development and design engineers, quality engineers, process development engineers, project managers and functional managers. The sample size in each firm was based on firm characteristics as well as size of product development departments. The estimated time to complete the survey was approximately 30 minutes, which turned out to be a little too long since several of the respondents had to do the survey in several steps to be able to complete.

3.2. Structure of survey

The survey was structured in eight parts in which the introductory part included six questions dealing with general information about the respondent and the NPD environment. The answers had from two to ten alternatives with only one possible alternative, except for the one requesting role/function of the respondent. Each of the next six parts included twelve statements associated with the main components in the model. Here each statement reflected a specific characteristic, including strategy, practices, behaviors, methods or tools, which collectively covered the domain of each component. The statements were assessed on a Likert-scale from 1 (strongly disagree) to 5 (fully agree). The Likert scale is widely applied to measure subjective meanings, preferences, opinions, emotions and attitudes within the field of social science, and was therefore chosen as appropriate for measuring companies' current performance with respect to LPD. McDonald found that most survey respondents prefer a five-point rating scale because the number of options is adequate and that it is easy to use [46]. The adopted scale provides the respondents with the opportunity of

indicating neutrality, even though the respondents may see the middle response as the easy way out.

The eight and last part includes nine questions related to NPD-performance, determining how the company perceive themselves in order to conduct NPD projects in time, on budget, with the right quality and product performance etc. Here it should be kept in mind that the response represents a subjective perception made by each individual, although several characteristics obviously would have just one 'correct' answer for each company; e.g., 'Our new product introductions made during the three last years have met profitability goals'. Although there is some factor bias associated with the approach, the overall purpose is to study NPD performance at team level rather than at business level. In the latter case, there is other bias, typically associated with external factors such as technology, market, business, competitors, etc.

3.3. Data

The survey was offered to 147 companies, whereof 50 responded positively, giving a response rate of 34%. From these 50 companies in total 306 respondents completed the survey. More men (83 %) than women (17 %) participated in the study, which is believed typical for this type of functional responsibilities in the manufacturing industry. 75 % of the respondents had more than 5 years of experience in NPD, with 28 % more than 15 years of experience. More than 85 % of the respondents have BSc degree or higher, and 5 % held a PhD. Approximately 80 % of the companies have more than 5 people that work in NPD at the specific site, and the most common size of the NPD department was between 6-15 people.

Most of the respondents worked (partly) in product development/engineering (53%), while 27 % worked in project management and 25 % in design. Other functional areas were quality, process development (manufacturing), coordination, market, purchasing, production and management. Some people had multiple responsibilities, particularly in the smaller companies.

3.4. Analysis

Each of the 12 knowledge components, Vk1, Vk2, Vk3, ..., was compared against an indicator describing new product development performance, vP1, Vp2, Vp3, ... These were indexed both through a factor analysis giving a Cronbach's alpha value of 0.71 and by summarizing its values for each respondent (Index = vi1+vi2+Vi3+Vi4). Cronbach's alpha is used to calculate how well each individual item in the scale correlates with the sum of the remaining items. When Cronbach's alpha is sufficiently high for a group of items, it is reasonable to treat them as an indicator instead of in terms of individual items. The threshold-value for a reliable measure is widely discussed; for example both Kline [47] and Halvorsen [48] argued that alpha-values of 0.7 or higher are acceptable, and that 0.8 or higher indicates good reliability. In total 306 respondents from 50 companies answered the survey. Finally, a multiple linear regression analysis was conducted to define the relationship between the dependent variable, denoted the NPD performance indicator, and the 13 exploratory variables representing the knowledge category. Support criteria are defined at $p<0.05$.

4. Results and discussion

The twelve knowledge components shown in Table 3 represent all phases of the learning cycle, from identification of information, acquisition or observation based on knowledge gaps, to how the organization interpret and make common understanding of that information and to how information is transformed to relevant knowledge that can be mirrored in products and processes. The three first questions, Vk1-Vk3, aim at increase understanding about the identification phase. Respondents rate relatively low, an average of 2.8, the ability to have a structured approach towards identifying knowledge gaps, and they say that developing several design concepts rarely is the practice for learning. Asking about to which degree physical testing is part of identifying valuable information, the companies rate this statement as high as 4.1 in average. The interpretation of this learning stage is that companies are used to do physical testing at a limited number of concepts, but not always as structured as described routines tell them to do. However, none of these statements are significant related to the performance indicator. One explanation for finding relatively low average scores and low correlation rates can be that firms tend to have fewer resources and skills involved at early stage of product development. Thus, the organization memory belongs to a few key persons and the time lag from ideation to

realization, which can be 10-15 years in for instance the aerospace industry, may delude the history.

The diffusion phase of the learning cycle conveys how information is enriched through exchange and distribution from the individual to the collective level. Trust and level of integration, internal and external, are important factors for effective information sharing. The statements Vk4-Vk6 seek to uncover how these two factors are perceived by the respondents, where they seem to score relatively high on both interaction by externals and how informal information and knowledge sharing occur. The average score decreases, question Vk6, when asked about how they emphasize formal knowledge sharing through typical knowledge management systems. This result support that trustworthiness is more likely to happen between individuals and groups than between individuals and systems. Again, there is no significant relationships between performance and the statements belonging to the diffusion phase.

Table 3. Results.

Component	Mean	Std. dev.	p
Vk1: The company has a structured approach to identify knowledge gaps in product development projects	2.8	0.97	0.84
The company always develops several design concepts/alternatives in the early stages of product development, using a "survival of the fittest" approach to develop the final solution	3.1	1.07	0.19
Valuable insight and new information is often discovered by physical testing	4.1	0.86	0.15
The company is actively seeking information and knowledge from outside to broaden the knowledge base	3.6	0.90	0.68
Informal knowledge sharing (for instance face-to-face communication) is widely used in our company	4.1	0.81	0.15
The company emphasizes formal knowledge sharing through medium as data bases, project meetings, visualization boards/rooms, lessons learned etc	3.3	1.04	0.23
Negative experiences, in terms of test- and product failures, unplanned loop-backs etc, are utilized as a valuable contribution to the existing stock of knowledge	3.7	0.92	0.64
New and relevant information is translated and articulated in a way that eases understanding for others	3.0	0.81	0.32
The organization is willing to explore new knowledge to develop new and innovative ideas?	4.0	0.83	*0.03***
Knowledge is, as far as it is possible, captured and documented in formal knowledge systems	2.8	1.01	0.37
In our company we have dedicated knowledge owners related to critical product characteristics	3.4	1.06	*0.06**
Our company has a structured process to maximize the benefits from its body of knowledge	2.9	0.93	*0.04***

The questions Vk7-Vk9 are hypothesized to emulate how the existing knowledge base is altered, modified and renewed based on new information. One way to interpret the ability to learn and unlearn is how people view and relate negative experiences according to the existing knowledge base, where question Vk7 gives an indication of good climate for lessons learned. This result can be viewed in the light of the Nordic work life model where trust, collaboration and flat organizational structures enhance little or no negative consequences for failures. Thus, the potential for learning is relatively high. But, due to the emphasize on informal above formal knowledge sharing, it is explainable why the respondents score low and medium on the question about how new and relevant information is translated and articulated in a way that eases understanding for others. Informal knowledge sharing means that the receiver gets enriched and contextual information, but the transfer is still very personalized and thus hard to diffuse in a precise manner to larger groups and the organization as a whole. The latter question in the integration phase poses willingness to explore new knowledge to develop new and innovative ideas, where the respondents both rate their answers relatively high but also in significant relation to how they perceive

product development performance. This result can be viewed positively in terms of willingness to innovate and challenge the existing, and at the same time see this in accordance to results for both the team and the organization, but at the other hand this may increase risk in the long run given the respondents low rating on formal processes for identifying knowledge gaps, documentation and mode of knowledge transfer.

The transformation phase includes how organizations are able to convert new knowledge into products, processes and services that generate positive and expected revenue streams to the company. By asking the respondents about routines for knowledge documentation, responsibility for knowledge streams and the ability to benefit from the stock of knowledge, Vk9-Vk12, it tries to summarize the common practice of knowledge transformation. There are moderate average rates for all these three questions, from 2.8-3.4, meaning that the respondents clearly see a potential – given that these statements are important to them. An interesting part is that both product knowledge responsibility and formal processes in place for optimal use of the knowledge base relate significantly to new product development performance. An interpretation of these results may be that formalization of the knowledge process is easier to relate to tangible results. For instance drawings, user manuals, technical specifications etc. all represent the accumulated explicit knowledge of a project. These explicit forms of knowledge may also be easier to relate to the physical output because of concurrency in time. The fuzzy front end of product development means that the knowledge process is blurred and it usually involves fewer people then when the project is to be realized.

5. Conclusion

To dramatically improve the capabilities to invent, develop and produce new products, while increasing customer value, is key to sustain and increase competitiveness of companies. Grounded in knowledge theories, a model of new product development performance in relation to critical knowledge components has been developed based on a literature review. Based on survey results from Norwegian manufacturing companies, current practices relative to knowledge components have been identified. To generalize from these initial findings, and to give advice about practical application, there seems to be a pattern that product development team members relate willingness to explore new and innovative ideas and structural knowledge processes, owned by dedicated resources, to performance criteria's covering quality, time and cost. It is interesting to note that only statements from the transformation phase of the four-stage learning circle that is represented by significant relationships to performance indicators. Thus, how the respondents perceive the phases of identification, integration and diffusion are likely to be independent of perceived performance at both micro and macro level in the organization. One reasoning for this result is that we tend to be more conscious about the later stages of learning, when we intend to realize our insights into tangible outputs. We will not, based on these findings, reject the importance of accomplishing the learning cycle, but we will advise to be more aware of the process of upscaling information to valuable and useful knowledge. In practical terms this means how we manage to evaluate risk aspects and knowledge gaps in the early stages of product development, and being capable of systematically involve and develop the right competence, create a common and shared understanding and to execute based on facts.

For further research, the authors will increase the population to strengthen the data set and to conduct comparative analyses across borders and industries. The generic model will also be reviewed. Acknowledgement is given to the Norwegian Research Council supported project VALUE that made this study possible.

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