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Team learning, top management support and new product development success

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Abstract

Purpose – This paper aims to investigate the relationship between team learning, top management support (TMS) and new product development (NPD) success.

Design/methodology/approach – This is a quantitative research by nature. A questionnaire derived from previous studies and covered by 27 NPD projects in the high-tech semiconductor industry in Malaysia. Stepwise regression was adopted to test hypothesis.

Findings – Out of the four independent variables, knowledge acquisition and information interpretation were found to have a signification relationship with NPD success. The findings also confirmed that TMS is a moderator in the relationship between team learning and NPD success.

Research limitations/implications – The relationships investigated in this research deserve further investigation. Because the data analyzed were collected from the high-tech semiconductor industry in Malaysia. More studies are required before general conclusion can be drawn.

Practical implications – It is reasonable to conclude, on these findings, that NPD can be successful in the high-tech semiconductor industry with given emphasis on team learning and TMS.

Originality/value – The paper reinforces the body of knowledge relating to NPD in the high-tech semiconductor industry.

Keywords Team learning, Senior management, New products, Product development, Semi-conductors, Malaysia

Paper type Research paper

Introduction

For many industries, new product development (NPD) is now the single most important factor driving the firm's success or failure (Griffin, 1997). Companies in all industrial sectors face the challenge of coping with rapid technological changes, shorter product life cycles, and higher complexity in the business systems, characterized by a move from products developed in isolation by research and development (R&D) or marketing, towards projects carried out in a seamless global

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firm, with multifunctional teams involving internal and external parties from several countries – products which not only seek to satisfy the needs of clients but also bring them increased value – as a key factor to their competitiveness. This strategic reorientation with importance put on innovativeness and uniqueness (Kumpe and Bolwjin, 1994) requires individuals and organization to constantly create not only new or improved products and services, but also recreate themselves through learning and knowledge sharing.

High-technology product development projects require continuous collaborative efforts among group of individuals from different functional specialities who hold specific information about the market and customers that need to be shared across the organization. In order to respond the competitive challenges, organizational units have more closely coupled than in the past, often working in parallel to complete assignments spanning traditional units and functional areas. The complexities of systems and products today require integration of knowledge from diverse disciplinary and personal skills-based perspectives where creative cooperation is crucial for innovation. Innovators need to work and learn as teams in order to be successful. Despite the importance given to NPD projects, new product failure rates are still very high. Many R&D projects never result in a commercial product, and between 33 and 60 percent of all new products that reach the market place fail to generate an economic return (Page, 1991). Many large organizations have begun to recognize the importance of NPD and innovation issues, such as time-to-market; organizational learning and mass customization. Among these components, organizational learning and knowledge creation has emerged as a key strategic variable and have been found to be an important absorptive capability for innovation.

Malaysian resilience in surviving the global electronics downturn hinges on its ability to promote innovation in NPD. The evidence of a large gap in R&D activities of Malaysia, Singapore and Thailand compared to that of Europe has prompted economists to ask local manufacturers to embrace innovation (Emmanuel, 2001). Organizations are increasingly paying attention to the concept of organizational learning in order to increase its competitive advantage, innovation and effectiveness. Improving future organizational decisions through understanding of past actions – that is, through organizational learning, organizations are more likely to be successful in NPD efforts (McKee, 1992; Lucas *et al.*, 1996). This study has investigated the relationship between four dimensions of organizational learning with focus on team learning, namely knowledge acquisition (KA), information distribution (ID), information interpretation (II), organizational memory (OM) and top management support (TMS) to NPD success in high-tech projects in Malaysia.

Literature review

Organizational learning

Organizational learning has been an important issue in business management academia over the last two decades. Since then, various disciplines and perspectives of this subject have been researched, resulting in a broad and confusing variety in organization learning literature and terminology (Garvin, 1993; Fiol and Lyles, 1985). Information processing patterns, behavioral change, memory, new thinking and organizational routines are some of the wide variety of perspectives used to define this process. Interestingly, studies of some management scholars (Nicollini and Meznar, 1995;

Klimecki and Lassleben, 1998) who have worked on classifying these contrasting terminologies, indicate that most of these definitions converge to a socially shared process of acquiring knowledge (defined in some literature as social cognition). Social cognition is the acquisition, storage, transmission, manipulation and use of information in a group or organization (Larson and Christensen, 1993). Huber (1991) describes this cognitive learning process as KA, ID, II and OM. Cognitive learning modifies representations and interacts with specific visions or preferences (Cayla, 2008). Organization learning is a collective activity rather than individualistic, because people encode, interpret and recall information together rather than apart. People in organizations exchange inter-individual process and knowledge by interaction. These social exchanges produce shared cognitive products, such as memories, norms and interpretations of shared events and activities in organizations. Pentland (1995), for instance, notes that literature should treat organizations as social collectives that acquire, construct, organize, store, distribute and apply information and knowledge by social entities. Nonaka and Takeuchi (1995) and Moorman and Miner (1997) have brought to our understanding that organization learning occurs through cross-functional teams due to integration of broad base of knowledge by acquiring, processing, storing, manipulating and reducing the information and knowledge. A group of interdisciplinary researchers in the Centre for Research in Innovation Management at the University of Brighton, UK, also developed several key mechanisms for helping organizations to "learn how to learn about learning" (Levy and Brady, 1996). The mechanisms include inter-organizational learning networks, action learning, mirroring to aid action research, continuous improvement self-assessment benchmarking, etc. Essentially these learning mechanisms help develop partnerships with organizations to support mutual learning.

Team learning

Miller (1996) suggested that in addition to the above classification by scholars on organizational learning, an empirical test of socio-cognitive construct is needed. Thus, building on these prior researches (Table I), this study researches this cognitive concept at team level, focusing on NPD teams. In this study, organizational learning concept was empirically tested on NPD teams, as organizational learning happens through teams (Madhavan and Grover, 1998), teams are small representations of organizations and show a similar behavioural pattern as organizations do (Argote, 1999) and because learning is an important factor in NPD success (Ayers *et al.*, 1997). Many scholars assert that NPD team is perceived as a process of organizational learning (Nonaka and Takeuchi, 1995; Moorman and Miner, 1997).

Top management support

One of the factors with a strong impact on NPD projects is a company's commitment to, and involvement with, innovation, which starts at the highest level in the hierarchy (Bartezzaghi *et al.*, 2001). As the key interface between NPD teams members, leaders are in a critical position to encourage the application of newly learned information to current and future NPD efforts. Support provided by senior managers to NPD teams is believed to be one factor contributing to successful NPD programs (Brown and Eisenhardt, 1995; Maidique and Zirger, 1985; Cooper and Kleinschmidt, 1991). Both SAPPHO (Rothwell *et al.*, 1974) and the NewProd studies (Cooper, 1980) found that

Author	Study
Meyers and Wilemon (1989)	Studies showed the factors that facilitate team learning including: formal and informal communication, employing experienced people into teams, open communication with other teams, keeping project learning logs, clear goals, learning from experience of other people and small scale experimentation
Purser *et al.* (1992)	Identifies factors that are associated with the management and design of deliberations enable and obstruct team learning. They found KA, sharing and planning, knowledge frame of reference and knowledge handling procedures as important factors for team learning and deliberations
McKee (1992)	Demonstrated the three levels of organization learning which are associated with three types of innovation: (1) single-loop is associated with incremental innovation, (2) double-loop is associated with discontinuous innovation and meta-learning is associated with institutionalizing innovation
Brooks (1994)	Demonstrated that collective team learning occurs when team members share knowledge, combine and recombine their knowledge, gather data from outside team boundaries and disseminate new knowledge. She also found out that collective team learning occurs when power differences are either controlled or not present in the team
Kasl *et al.* (1997)	Presented a research-model of team learning in terms of processes and conditions (e.g. appreciation of teamwork, individual expression, common goals, values and beliefs)
Edmondson (1999)	Empirically found that team learning is associated with team performance; psychological safety and team efficacy is associated with team learning and team leader coaching and support impacts team psychological safety
Lynn *et al.* (2000)	Demonstrated the applicability of some individual learning models to product development teams
Järvinen and Poikela (2001)	By intersecting three different theories, the writers constructed an experiential process model of learning at work, which explains group learning in the light of social, reflective, cognitive and operational processes flowing, influencing and shaping individual, group and organizational contexts in a process of continuous learning. For example, abstract conceptualization at the individual level, combining new knowledge at the group level, and the integration of interpreted knowledge at the organizational level constitute a set of cognitive process that serve the production and exploitation of organizational knowledge
Akgün *et al.* (2002)	By studying 124 NPD projects, the writers empirically showed that learning in NPD is best conceived as a multi-dimensional structure with nine correlated but distinct constructs including: information acquisition, information implementation, information dissemination, unlearning, thinking, improvisation, memory, intelligence and sensemaking. Further demonstrated that a model-based on multi-dimensionality of team learning provides a more robust explanation of new product success than a uni-dimensional team learning model

(*continued*)

Table I.
Summary of literature review on team learning

Author	Study
Sarin and McDremott (2003)	Study examines how leadership characteristics in NPD teams affect the learning, knowledge application, and subsequently the performance of teams. Based on 229 members of 52 high-tech new product projects, the writers empirically demonstrated that team learning has a strong positive effect on the innovativeness and speed to market of the new products. Further showed democratic leadership style, initiation of goal structure by the team leader and his or her position within the organization were positively related to team learning
Ignatius *et al.* (2004)	The writers assessed the extent and effectiveness of inter-/intra-functional technological learning than occurs within and between NPD project team and functional groups. Additional to that, the writers investigate the impact of this learning process on project success, development speed and project entry timeliness
Lawrence *et al.* (2005)	By first investigating Crossan *et al.*'s (1999) framework – looking into the "4I" multilevel process of the politics of organizational learning – the authors develop a set of propositions that specify the political conditions that are likely to take place during organizational learning. They argue that power and politics helps in the transformation individual and group insights into the institutions of an organization. Finally they proposed that there are connections between specific learning processes and various forms of power within the organization

Table I.

there is a link between top leadership commitment with innovation and product development in successful innovative firms. Gupta and Wilemon (1996) reported the results of a survey on 120 technical directors from technology-based companies; they found that one key factor in successful innovation is senior management support to various technical activities. TMS is highly important in high-tech projects which are typically governed by high-technology uncertainty and high-market uncertainty environments (Reilly *et al.*, 2003). Swink (1999) found TMS to be associated with reduced NPD lead-times only in dynamic, uncertain markets, especially for a "rush" NPD project, while a UK SME survey cited TMS to be one the major reasons for delays in NPD (Owens, 2007). Souder and Song (1998) demonstrated the importance of TMS in unfamiliar markets, in contrast to highly familiar markets. Harborne and Johne (2002) emphasized an empowerment approach, together with greater involvement by top management, for successful NPD under high-market uncertainty. Mullins and Sutherland (1998) also noted that involving top functional management early and often is an effective practice in rapidly changing markets: in rapidly changing, unfamiliar markets and uncertain technology conditions, the early and active involvement of top management in assessing, developing and supporting ideas for new products may be more urgent. TMSs cross-functional teamwork by a variety of means, such as: demonstrating commitment, helping the team to overcome obstacles, making things happen, and providing encouragement to team (McDonough, 2000). Top management is responsible for helping to create a stimulating, nurturing and supportive environment for fast learning (Guns, 1996). Senior management indirectly influences the effectiveness of organizational and team learning by putting in place learning and knowledge management systems and encouraging employees to use them throughout the development project.

Gomes *et al.* (2001) studied the relationship between senior management support to NPD activities by means of a quantitative and qualitative analysis of questionnaires and interviews. The quantitative analysis showed small to medium association between senior management support to NPD and project performance in the dimensions of time, cost and product quality. The qualitative analysis suggest the weak relationship should be explained by direct and indirect effects, where direct effects involve issues such as the use of multi-functional senior teams and process champions whereas indirect effects include issues such as organizational mission and goals, and learning and knowledge management systems. On the other hand, Reilly *et al.* (2003), studied the role of TMS and team empowerment in NPD projects under market and technological uncertainty. The writers discovered that empowerment is positively associated with NPD speed under all conditions of uncertainty, but more highly correlated with overall project success when uncertainty is high than when it is low. Their study also revealed that TMS is positively associated with NPD speed and success regardless of uncertainty.

Research model

Figure 1 shows the research model employed in this study.

The model in Figure 1 is a hypothetical construction derived from literature. The dependent variable is NPD success, and the independent variables are the processes or activities of team learning, namely KA, ID, II and organization memory. This model also includes TMS, which moderates the relationship between the independent and dependent variables. Learning is a multi-faceted and multi-phased process. Knowledge or information acquisition is the first step in the socio-cognitive learning process. It is a critical component of cognition and team-learning (Lynn *et al.*, 2000) and usually occurs in three stages: knowledge assessment, knowledge sharing and knowledge assimilation (Zou and Ghauri, 2008). Information acquisition in organizations is the gathering of information about customers, market, technologies and competitors for an

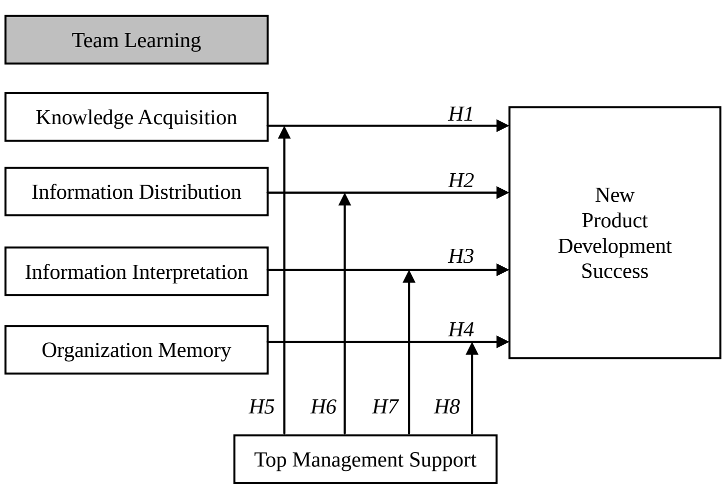

Figure 1.
Conceptual model

effective NPD process (Moorman, 1995). During development stages of a product, continuous acquisition of customers and competitors information and continuously incorporating this information into prototypes and models help teams to learn about the changing customer needs and competitive reactions (Iansiti, 1995). Ancona and Caldwell (1992) empirically found that when teams scan market and technical environments, communicate with outsiders and initiate programs with them, they perform internal activities better, and increase long-term success. Thus, this study postulated:

H1. KA in technology team's learning process positively influences NPD success.

Huber (1991) noted that ID or dissemination is a determinant of occurrence and breadth of organizational learning. Once collected, management must then disperse the information on a timely basis (Lehmann and Winer, 1997). Organizations can create knowledge and learn by combining the information, which is disseminated and shared from different units. For effective and successful NPD, sharing information among team members is vital (Slater and Narver, 1995). Information dissemination process is instrumental for making individual insights and know-how accessible to others. Consequently, information dissemination helps teams to create new knowledge and provide access to existing and tacit knowledge (West and Meyer, 1997). It helps to keep everybody up-to-date, and builds cohesion and integration within the group (Ancona and Caldwell, 1992). However, Bakker *et al.* (2006) suggest that groups share the information directly rather than using a broadcasting mode. In studying the organizational antecedents to new product success, Ayers *et al.* (1997) concluded that the transfer of information between R&D and marketing personnel was critical. They found a direct correlation between high interaction and information exchange with new product success rates. Secondly, we hypothesized:

H2. ID in technology team's learning process positively influences NPD success.

After information is acquired, making sense of that information is vital for organizational learning process. This stage of knowledge development is sometimes known as the II or shared interpretation stage. Information integration refers to the degree to which members of the team share, pay attention to, and challenge one another's information and perspectives to generate new insights about the product (Sethi, 2000). Some literatures identify this stage as "sense making" (Akgün *et al.*, 2002). It is a social process of developing a common or shared understanding by organizing information, insights and ideas in meaningful ways (Dougherty *et al.*, 2000). Slater and Narver (1995) described shared interpretation as "a consensus on the meaning of the information and its implication for that business." Thus, II in teams can be defined as the degree of consensus among project members on the meaning of the acquired information in terms of the implications for development of the product.

As members in a team with high-information integration share information more effectively, carefully attend to one another's perspectives, and freely question and challenge these perspectives and their underlying assumptions, they are more likely to achieve a common understanding among themselves and consistency across various decisions made by the team (Sethi, 2000). Developing a common understanding about the product and achieving consistency among decisions made throughout the product development process are considered critical for the development of a quality product

(Clark and Fujimoto, 1991; Garvin, 1988; Menon *et al.*, 1997). Because individuals from various functional areas often have different ideas about the product (Dougherty, 1992; Garvin, 1988), without effective information integration, these individuals generally pull the project in different directions and thereby adversely affect the success of the new product. This study thereby hypothesized that:

H3. II in technology team's learning process positively influences NPD success.

OM is the knowledge gathered through cumulative learning of the organization via its founders, managers or employees. It is said to be the most influential component of learning (Sinkula, 1994). El Sawy *et al.* (1986) identify memory as a repository of detailed past decision and their perceived results, past surprises, and the organization's responses and unwritten decisions. Once formed, OM has a tendency to "filter-out" information that does not reflect the company's norms, rules, or strategic focus. According to Moorman and Miner (1997), in a NPD team, memory is described as the storage of skills and experiences within the team about project routines and the team cultures. Two key findings of the authors are OM may positively impact the performance and creativity of new products, however on the other hand, under turbulent environment the impact of OM on new product success diminishes. For NPD teams, memory involves the storage of skills and experiences of team members, project routines, team culture (Moorman and Miner, 1997) and the absorptive capability of team (Cohen and Levinthal, 1990). Thus, we postulated:

H4. OM in technology team's learning process positively influences NPD success.

As reviewed in the literature, greater TMS keeps the project on track and prevents surprises from an autonomous team (Lynn and Akgün, 1998). Top management is responsible for helping to create a stimulating, nurturing and supportive environment for fast learning (Guns, 1996). Top management can facilitate conditions for better team learning and cognition. Thus, we proposed:

H5. TMS increases the impact of KA on NPD success.

H6. TMS increases the impact of ID on NPD success.

H7. TMS increases the impact of II on NPD success.

H8. TMS increases the impact of OM on NPD success.

Methodology

The primary source of data collection is a survey, which was administered to managerial staff in the high-tech semiconductor industry in Malaysia. A total of 27 NPD projects participated in this study. The high-tech semiconductor industry was chosen as a context because of their high level of product development activity using cross-functional NPD teams. To be included in the study, NPD projects were required to meet three main criteria. First, only intra-organizational NPD projects were to be included in order to reduce noise caused by inter-organizational factors. Second, all new product introductions were to be bound for the external market; products being developed for intra-organizational use were excluded. Third, due to the high-turnover rate in the high-tech industries, and problems associated with respondent recalls, only those NPD projects introduced within the previous 12 months were included in the study. Other criteria for qualification included:

- respondents were knowledgeable, having been a part of the NPD team; and
- respondents were willing to provide the time to complete the survey.

The sample members were middle level executives (such as department managers, project managers, technical leaders and senior-level engineers) of design and manufacturing firms, which were chosen because of the importance of their involvement in NPD projects.

A five-point scale was used for questionnaire design. Items of the questionnaire were adapted from Lynn *et al.* (1999), Gold *et al.* (2001), Ignatius *et al.* (2004) and Moorman and Miner (1997), and is presented in the Appendix. An effort was made to cut the length of the questionnaire down as far as possible given the scope of the project. Pilot studies were conducted to validate these measures prior to finalizing the questionnaire. The primary means of distributing the survey questionnaire was via e-mail. The questionnaire was distributed after pre-contracting the recipients and informing them about the pending survey in September to December 2006. A total of 89 respondents take part in the survey, yielding a response rate of 68.4 percent.

Results

Cronbach's α was chosen to analyze the degree of internal consistency among the items in a variable. α coefficient ranges in value from 0 to 1. The higher the score, the more reliable the generated scale is. Nunnaly (1978) has indicated 0.7 to be an acceptable reliability coefficient. All the variables, independent, dependent and the moderator were tested to analyze its internal consistency. All of them showed an acceptable internal consistency, with Cronbach's α ranging from 0.74 to 0.90. Table II summarizes the results obtained from the reliability analysis.

Regression analysis was performed to test the possible relationship between the social cognition construct of team learning: KA, ID, II and OM and the dependent variable of this study, NPD success.

Based on the statistical package for social sciences output summarized in Table III, KA (Sig. = 0.02) and II (Sig. = 0.03) were found to be significant at 5 percent significance or 95 percent confidence level. In contrast, ID (Sig. = 0.51) and OM (Sig. = 0.41) were found to have no significant impact on NPD success at 5 percent significance level. These four independent variables only account for 25 percent of the variation in success of NPD projects.

Variables	Number of items	Number of deleted items	Cronbach's α
Knowledge acquisition	4	0	0.84
Information distribution	4	0	0.77
Information interpretation	4	0	0.74
Organizational memory	4	0	0.90
NPD success	7	0	0.79
Top management support	6	0	0.80

Table II.
Summary of reliability analysis

Table IV illustrates the results of the hierarchical regression run when the moderating variable, TMS was taken into account. The coefficient of determination, R^2 significantly increases to 0.375 when top management is considered as a moderating variable.

From the hierarchical regression output, it was found that the moderator TMS was not significant to be considered as an independent variable however as proposed in the study model played a role as a moderator. The hypothesized relationship between ID and NPD success which was rejected in Model 1 is positively moderated by TMS in Model 3. It indicates that TMS moderates the relationship between ID and NPD success (Sig. = 0.04). Thus, from the findings above, we accepted the following hypothesis:

H1. KA in technology team's learning process positively influences NPD success.

H3. II in technology team's learning process positively influences NPD success.

H6. The impact of ID on NPD success is higher with TMS.

Discussions and implications

Knowledge acquisition

KA was found to be positive and significant among the dimensions contributing to NPD success in this study. This finding supports the assertion made by Nelson (1982)

Variables	β	Sig.
Knowledge acquisition (KnowAc)	0.30	*0.02*
Information distribution (InfoDis)	0.07	0.51
Information interpretation (InfoInt)	0.26	*0.03*
Organizational memory (OrgMem)	0.95	0.41
$R^2 = 0.25$		
Durbin-Watson = 1.80		
Dependent variable = NPD success (success)		

Table III.
Regression summary

	β	Sig.	R^2	R^2 change	F change	Sig. F change	Durbin-Watson
Variables							
Knowledge acquisition (KnowAc)	0.40	0.66					
Information distribution (InfoDis)	1.12	0.06					
Information interpretation (InfoInt)	0.93	0.20					
Organizational memory (OrgMem)	0.44	0.53					
Top management support (TMS)	1.17	0.11					
TMS × KnowAc (TMS_KnowAc)	1.09	0.52					
TMS × InfoDis (TMS_InfoDis)	1.98	*0.04*					
TMS × InfoInt (TMS_InfoInt)	1.31	0.31					
TMS × OrgMem (TMS_OrgMem)	0.59	0.60					
Model							
1			0.25	0.25	7.34	0.00	
2			0.27	0.01	1.89	0.17	
3			0.37	0.09	3.14	0.01	1.806

Table IV.
Hierarchical regression summary

that effectiveness in R&D initiatives is associated with the effective acquisition of knowledge. It is also in agreements with the findings of Akgün *et al.* (2002) that KA in teams has a positive relationship to new product success. KA is especially important in new NPD team, as existing technical knowledge about the product or technology within the team may still be limited. NPD teams are relatively new and are exponentially growing in technical knowledge and size compared to more matured teams abroad. Sinkula (1994) found that younger firms with less OM are more inclined to be open to all types of information and acquire more information compared to more established firms. TMS positively supports, however, was not shown to be a significant contributor to the relationship of KA and NPD success, although supportive and innovative culture had shown significantly positive effect on KA in Chang and Lee's (2007) research. KA in technological projects can be highly specialized, individualistic and a complex process which is on-going throughout the development project. With the added interference of market and technological uncertainty, top management should play an indirect role of empowering teams in KA efforts. Empowerment rather than TMS is most likely to produce better outcomes when project uncertainty is high (Reilly *et al.*, 2003).

Top management can facilitate and further accelerate this dimension of learning by ensuring: the right expertise are in place to assist teams acquire the needed information, the right information channels are in place to gather relevant information, and well-structured tools are built into the organization's information system to manage the abundance of information. Additionally, for effective information acquisition and implementation, management can form a knowledge team to monitor and capture this information (Akgün *et al.*, 2002). Schein (1993) suggested a "transition group" and Rothberg (1999) mentioned a "shadow team" that monitors external environments to capture information about customer and competitors, and integrates intelligence to create new learning. Akgün *et al.* (2002) added that there could be a person known as a "linking pin" (gatekeeper) between new product teams and the knowledge teams (transition group or shadow team). In this way, team members could obtain current external information.

Information distribution

ID was seen to have a positive relationship with NPD success however the relationship was not found to be significant. This result disagreed with the findings of Ignatius *et al.* (2004) which found that the influence of ID on development speed and project success to be significant. ID can play an improved role if the right organization structure is put in place. Especially, in rapid development of new products, evidence is mounting in favour of organization structures that facilitate both the quick dissemination and utilization of information (Kharbanda, 1991; Wheelwright and Clark, 1992). When organizations structures become more rigid, the rate at which information is disseminated and utilized is likely to decrease. These fairly new NPD organizations studied here are still utilizing old manufacturing organization structures which are bureaucratic in nature. These structures needs to be reassessed and restructured to de-emphasize hierarchies, while old communication channels need to be reengineered to have a more favourable impact on NPD projects. Flatter organization structures may facilitate this dimension of learning.

However, from statistical analysis, it was found that TMS positively impact to the above relationship of ID and NPD success. This result shows the positive outcome of TMS in the high-tech development project, especially in this dimension of learning. This could be due to the actuality of continuous commitment shown by senior management over the last decade to ensure seamless information systems are in place, adequate training is provided to maximize the capabilities of these systems and keeping communication channels as accessible and short as possible across teams through the advancement of information technology. The infrastructures setup in most of the premises of the surveyed NPD teams is of world class. As majority of the participants surveyed in this study have team members located at sites worldwide, we observe from the findings that senior management significantly influences teams to share project related information freely amongst virtual team members with the help of information and communication technology.

Information interpretation

II has a positive and significant relationship with NPD success. The finding is in agreement to prior research findings (Akgün *et al.*, 2002; Ignatius *et al.*, 2004). One of the trends in the development of new high-technology products is the unit structure of these products is the system character requiring the usage of multiple technologies in combination. This is similar to the trend of new semiconductor products today which consists of multiple intellectual property modules, new design methodologies, complex test structures and specialized packaging techniques. Developing such products require team members from diverse specialities to come together, to share acquired information and to gain consensus on the meaning and implications of the new information. Conversely, TMS was not shown to have a favourable moderating relationship between the variables of II and NPD success in high-tech projects. This finding is similarly viewed by some other studies. Zirger and Hartley (1996) found that projects with higher level of senior management support take more time than their competitive counterparts. Greater management attention can slow down development if senior management involvement slows problem solving, consensus building and decision-making process (Reilly *et al.*, 2003). Brooks (1994) also found that collective team learning occurs when power differences are either controlled or not present in the team. Care should be taken by senior management not to get over-involved in a project's II matters. Especially, when the product implementation cycles are relatively short, empowering project managers or team leaders to manage this dimension of learning can speedup the implementation time.

Organizational memory

OM was not proved to be a significant contributor to NPD success. In fact this dimension of team learning was negatively related to NPD success. This finding contradicts the findings of Moorman and Miner (1997) that stored information and competencies would increase a firm's NPD performance however it has a similar outcome to the research findings of Ignatius *et al.* (2004). NPD teams researched in this study are relatively new and may not have developed enough familiarity and expertise in the particular product line. Additionally, as development life cycles have become relatively shorter for new semiconductor products and as new advancements are rapidly discovered in the areas of design and manufacturing processes, existing technical knowledge of previous project learning about semiconductor processes become obsolete quickly. The absence of learning from previous product successes and failures through post-project reviews and retrospective meetings could also be another factor contributing to this negative relationship. To most technical personnel, improvement reviews may be unnecessarily unpleasant. Since employee turnover in knowledge work is fairly high, firms often lose this form of OM (Cross and Baird, 2000). This could also be another reason why the relationship of OM and NPD success in this study is relatively low as both turnover rates and job opportunities in the semiconductor industry are relatively high.

A positive relation is though seen to affect the relationship of OM and NPD success with the presence of TMS. TMS ensures continuous learning through cross functional sharing and improvement reviews. Improvement reviews provide an opportunity for evaluating and enhancing NPD processes, something generally lacking in existing NPD models (Caffyn, 1997). OM can have a more significant impact to NPD success, if improvement reviews are formalized by senior management teams. Formal reviews lead to fewer individual biases and tend to be more successful in terms of having reviewers reach shared conclusions (Lilly and Porter, 2003). As NPD teams are relatively new, senior management should sponsor training programs to develop NPD team members' proficiency in development methodologies or in a certain technology where experience is lacking. This would accelerate the teams' learning process and its collective expertise. Assessing team members' competencies and weaknesses on a regular basis, allowing them the opportunity to sharpen their technical and non-technical skills from time-to-time with internal, cross-functional and external training and development programs, and re-monitoring improvements through post-training assessment will continuously bring positive improvements to the dimension of OM.

Conclusion

Innovations are critical to companies. Without innovation a company will lose ground to its competitors who innovate better and faster. As a result, companies are continuously pursuing ways to innovate more effectively. One strategy does not fit all situations. NPD professionals have many tools in their innovation toolbox. If they use an inappropriate tool, they may get the job done successfully but it will take more time, effort and money. Depending on external as well as internal technical factors they need to know which tool to use. This study proposes the socio-cognitive dimensions of team learning as a tool to achieve success in NPD project implementation. This study further contributes to the organizational learning and knowledge management literature by presenting one of the few empirically examinations of learning and knowledge management in NPD teams. A summary of the hypothesis testing result is given in Table V.

NPD success is a challenging task due to its complexity and cost. This research provides further insights into the team learning and TMS into the NPD success. This research also presents some guidelines for project managers and organizations to focus their attention and resources in carrying out NPD project. This study has highlighted the significance of KA and II on NPD success. It also reveals the importance of TMS for such project. It is recommended that top management should provide sufficient support for NPD project.

Hypothesis	Results
H1. KA in technology team's learning process positively influences NPD success	Supported
H2. ID in technology team's learning process positively influences NPD success	Not supported
H3. II in technology team's learning process positively influences NPD success	Supported
H4. OM in technology team's learning process positively influences NPD success	Not supported
H5. TMS increases the impact of KA on NPD success	Not supported
H6. TMS increases the impact of ID on NPD success	Supported
H7. TMS increases the impact of II on NPD success	Not supported
H8. TMS increases the impact of OM on NPD success	Not supported

Table V.

In addition, this is one of the few studies that examine NPD success in developing nations. Despite these strengths, our study also has limitations. One of the limitations of this study is its generalizability. The findings of this study may be limited to the high-tech semiconductor industry in Malaysia. Another limitation is that some of the team learning factor was not included due to practical constraints such as time and cost. The survey questionnaire spans several pages and we were concerned that adding more factors would increase its length to the point where reliability of the responses would be affected or participation would be discouraged/avoided. One major limitation of this study is the small sample size but nevertheless it can be argued that this may be due to the filtering criteria that was set forth by the researches. Another plausible reason could be to the relative infancy of NPD in Malaysia. Follow-up work with large sample size is also needed to assess if the results are applicable to corporations in other developing countries.

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Appendix. Questionnaire

Section 1. Profile	This section of the questionnaire inquires information regarding you and your organization. *Please cross (X) for each question (Double-click on square-box)*
Gender:	☐ Male ☐ Female
Your present job position in the organization:	☐ Top level manager (e.g. CEO, General Manager, Managing Director) ☐ Middle level manager (e.g. Senior manager, department manager) ☐ Lower level manager (e.g. Project manager. Specialist engineer) ☐ Technical Staff (e.g. Senior engineer, junior engineer) ☐ Others, please specify ________________________
How long have you been working with the organization?	☐ < 1 year ☐ 1– 2 years ☐ 3– 5 years ☐ 6– 10 years ☐ 11– 20 years ☐ > 20 years
Education level:	☐ PhD ☐ Master's Degree ☐ Bachelor's Degree ☐ Diploma ☐ Certificate ☐ High School and below
Type of industry that best describes your organization:	☐ Semiconductors ☐ Computer Products ☐ Medical/Life Science Products ☐ Electrical Products ☐ IT Products/Services ☐ Others, please specify ________________________
Your parent organization is:	☐ Malaysian based ☐ Japanese based ☐ European based ☐ American based Others, please specify ________________________

Note: In the following sections, please answer all questions based on ONE recently implemented NPD project by your project team

(*continued*)

Section 2. NPD Background Information	This section of the questionnaire inquires information regarding the NPD project. Please cross (*X*) for each question (Double-click on square-box)
Your position in relationship to this project	☐ Team Member ☐ Team Leader ☐ Project Manager ☐ External Team Supporter ☐ Others, please specify ________________________
How long has this project been in existence?	☐ < 6 months ☐ 6– 9 months ☐ 9 months – 1 years ☐ 1 – 1.5 years ☐ 1.5 – 2 years ☐ > 2 years
Estimate the number of project member(s) into the following departments	Human Resources Finance and Accounting Sales and Marketing Engineering Research and Development (R&D) Operations Manufacturing Information Technology (IT) Facility Logistics Maintenance Quality Procurement or Purchasing Others *(please specify)* _________________________
Team members were located in	☐ Local site ☐ Within Malaysia ☐ Within Asia Pacific region ☐ Worldwide
The most regular way communication took place amongst team members	☐ Local Site meetings ☐ Electronic Mail, Electronic Messaging ☐ Telephone meetings/teleconferences ☐ Internet Teleconferences ☐ Offsite meetings Others, please specify ________________ _________
Common project information was mostly stored and shared through	☐ Hardcopy documents stored in cabinets ☐ Electronic Information stored via the Intranet ☐ Electronic Mail / Electronic Mail Archive ☐ Online electronic database ☐ Offsite meetings Others, please specify ________________________

(*continued*)

Section 3: Technological Learning in Teams

Please cross (X) for each question (Double-click on square-box).

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Knowledge Acquisition or Information acquisition is the gathering of internal and external information (i.e. customers, markets, technologies and competitors).					
1. During the development stages of the product there was an organized and efficient process of information acquisition	☐	☐	☐	☐	☐
2. Were product team members competent at acquiring information	☐	☐	☐	☐	☐
3. Was the product development team efficient in acquiring information	☐	☐	☐	☐	☐
4. Overall, the process of information acquisition during product development was productive	☐	☐	☐	☐	☐
Information Distribution is the process of dissemination of acquired information.					
The development project, 1. has processes for transferring knowledge acquired at organizational level to individuals	☐	☐	☐	☐	☐
2. has processes for disseminating knowledge throughout the development team.	☐	☐	☐	☐	☐
Normally, during product development stages, 3. information was distributed to other team members accurately and in a timely manner.	☐	☐	☐	☐	☐
4. team members did not misunderstand the actual meaning of the information distributed to them	☐	☐	☐	☐	☐

(*continued*)

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Information interpretation is a social process of developing a common or shared understanding by organizing information, insights and ideas in meaningful ways					
Project team members 1. understand the role and importance of information acquisition plays in developing the new product	☐	☐	☐	☐	☐
2. had a common agreement about how the acquired information would be used in developing the new product	☐	☐	☐	☐	☐
3. were given enough time to comprehend and familiarize themselves with the acquired information	☐	☐	☐	☐	☐
4. were able to analyze and discuss the acquired information with other team members	☐	☐	☐	☐	☐
Organizational Memory is the knowledge gathered through cumulative learning of the organization					
Prior to this NPD project, compared to other firms in our industry, my functional group had 1. a great deal of knowledge about this product	☐	☐	☐	☐	☐
2. a great deal of experience in this product	☐	☐	☐	☐	☐
3. a great deal of familiarity in this product	☐	☐	☐	☐	☐
4. invested a great deal in R&D on this product	☐	☐	☐	☐	☐

(*continued*)

Section 4: New Product Development Success
Please cross (X) for each question (Double-click on square-box).

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
New Product Development Success. This project met or exceeded:					
1. Project schedule expectations	☐	☐	☐	☐	☐
2. Project budgets	☐	☐	☐	☐	☐
3. Overall senior management's expectations	☐	☐	☐	☐	☐
4. Customer expectations	☐	☐	☐	☐	☐
5. Sales expectations	☐	☐	☐	☐	☐
6. Profit expectations	☐	☐	☐	☐	☐
7. Market share expectations	☐	☐	☐	☐	☐

Section 5: Top Management Support
Please cross (X) for each question (Double-click on square-box).

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Top Management Support can take several different forms such as demonstrating commitment, helping teams to overcome obstacles, making things happen, and providing encouragement to team.					
1. Sufficient incentives were provided by top management (TM) for the implementation of the NPD project	☐	☐	☐	☐	☐
2. The NPD project is viewed as a strategic activity by TM	☐	☐	☐	☐	☐
3. There was sufficient commitment to the implementation of the NPD project.	☐	☐	☐	☐	☐
4. Sufficient resources were provided to implementation of the NPD project.	☐	☐	☐	☐	☐
5. The general manager of the division actively supported the NPD project.	☐	☐	☐	☐	☐
6. TM identified the implementation of the NPD project as a critical priority	☐	☐	☐	☐	☐

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