The Role Of Knowledge Management In Product Development Performance: A Review

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ABSTRACT:

The advancement towards knowledge-driven competition based on innovation and product quality, have redefined the strategy space and competitive nature of many industries. However, researchers believe that although employee motivation in knowledge sharing is important, it is often neglected. Therefore, this paper aims to investigate the role of knowledge management in product development performance. In this study, findings from the literature review are used to develop a conceptual relation on how knowledge management influences product development performance. Based on the review of the extant literature, it was found that socialization and internalization play a more essential role in enhancing product development performance due to their more practical and convenient implementations in product development. Managers and engineers should work together to create more platforms that can harness socialization activities such as coffee klatches, technical sharing and team building activities. Apart from that, management should organize training programmes to internalize the explicit knowledge and actualize concepts about strategy, tactics, innovation or improvement.

Keywords: *Knowledge management, Innovation, Product development*

1. Introduction

In the development of new businesses today, initiatives that spur knowledge-based competitions amplify the importance of boundary spanning activities and tactical coalitions, which cause organizations to focus more on institutional knowledge, system improvement and knowledge management (Quah, 2001). From an innovative strategizing standpoint, companies face difficulties in organizing resources, codes and the development of accessible knowledge management resources for the maximization and sustainability of innovations (Love and Roper, 2009). Thus, the superiority of knowledge management as a new and sustainable competitive advantage for many organizations is evidently well acknowledged and requires serious attention especially when it comes to organizing project resources.

Liu et al. (2005) theorize that organizations with good knowledge management approaches will have encouraging new product development performance. They also conceive that knowledge shared within communities enable engineers to employ process enhancement and assume new measures and new products, making communities of practice (COP) a helpful formation for technology and knowledge management. Ostensibly, the capability and flexibility of knowledge management practices and applications increases the efficiency and speed of new product development in engineering projects.

Focuses on project management capabilities have urged companies to progress in terms of project management know-how, which are mostly subjective according to combined industrialist views on of project personnel knowledge requirements and competence (Crawford, 2005). Therefore, the need to improve project management potential motivates the need for knowledge management practices and initiatives in an organization as well.

On the applications of knowledge management, Gardoni and Dudezert (2005) posit that knowledge management systems (KMS) have been developed in engineering design activities to advance the productivity of these activities. Nevertheless, they found that identifying the influences of these systems in the engineering design performance is complicated. Hence, although the importance of knowledge management in the areas of product development performance is well-documented, there is still a need

for improving the applications and implementations of knowledge management in product development projects and activities.

In recent years, many countries including Malaysia have spent enormous amount of resources to build a knowledge-based society and economy as a primary national development goal (Baber, 2001). However, very few studies have been conducted on the factors that promote or impede product development performance in organizations in developing countries. Few studies have been conducted on the systemic affects of industrial practices such as knowledge management on product development performance in organizations. Hence, the main objective of this paper is to review the extant literature on the role of knowledge management in product development performance. Specifically, the factors that affect knowledge management will be reviewed and discussed. The elements of knowledge management can be sub-categorized into socialization, externalization, combination and internalization. The role of all the knowledge management elements will then be linked to product development performance.

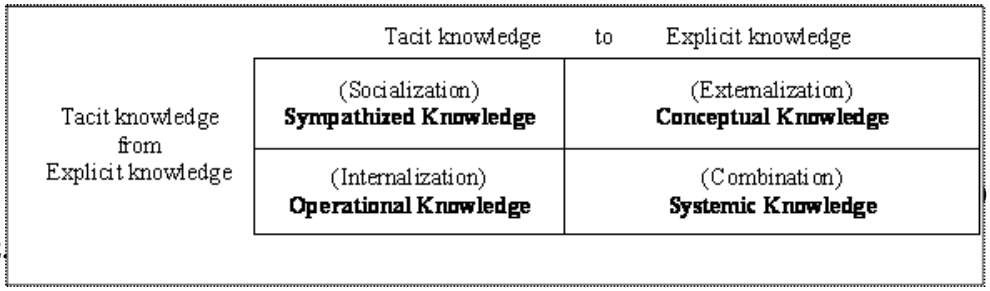
2. Literature Review

Many previous research publications that examined product development performance and the distinctiveness that impinge on such performance are simple, and demonstrate the link between product development performance and some influencing characteristics (Cho et al. 2009). Qureshi, et al. (2009) suggest that since the 'best survivor' idea most appropriately describes the current industrial situation, a superior means in evaluating product development performance will be required. Therefore, there is the need to identify the characteristics that influence product development performance in organizations.

Thamhain (2004) explains that achievement in projects comes from effective knowledge sharing among project team members in extremely complicated, difficult and hectic interactions. Thamhain (2004) further elaborates that this calls for pragmatic knowledge management to integrate technology, knowledge and elements of every project phase. According to Faniel and Majchrzak (2007), an engineer is apt in using facts sourced from supplementary areas once these facts are obtainable by summary and thorough levels so that they can further understand and use the knowledge to solve existing problems. From the aforementioned discussion, there is no denying that knowledge management could be one of the major industrial practices with the capability of enhancing product development performance in projects.

Knowledge management refers to processes in generating importance using an organization's indefinable advantages, uniting conceptions of practical artificial intelligence, computer technology, industrial re-engineering, organizational performance and other information technology related areas (Liebowitz, 1999). To this end, Lee and Chang (2006) conclude that knowledge sharing is the groundwork of continuous improvement in information technology and manufacturing processes. Since knowledge management approaches are capable of ensuring the efficiency of engineering project management, the practice of knowledge management is important for engineers who measure their performance according to their project success.

For this study, the knowledge management elements that are further discussed in the next section comprises socialization, externalization, combination and internalization (SEC!). These knowledge management variables are based on the SECI model by Nonaka and Takeuchi (1995, p. 72) in Figure 1, which broadly categorises knowledge into four conversion modes (socialization, externalization, combination and internalization) as an organization's knowledge assets are converted from tacit to explicit knowledge and vice versa. Subsequently, the literature on product development performance shall also be discussed.



2.

Socialization is the construction of new-fangled tacit knowledge through trusting in tacit knowledge resources in the course of social communication (Vaccaro et al., 2009). Socialization changes innovative tacit knowledge like collective mind-mapping representations, technological expertise plus know-how, generally taking place through training more willingly as compared to documentations (Choi and Lee, 2002). Thus, socialization presents a more subjective form of knowledge capture through the means of social communication, experience sharing and guidance or apprenticeship.

Socialization results in 'sympathized knowledge', such as common intellectual models and technological expertise (Nonaka and Takeuchi, 1995, p. 71). According to Lee and Choi (2003), socialization modifies tacit knowledge into new tacit knowledge through social relations with members. Through socialization, experiences are shared and in so doing tacit knowledge is created (Salmador and Bueno, 2007). In brief, the progress in socialization integrates tacit knowledge into a more combined and comprehensive form of tacit knowledge as a result of knowledge sharing among teams or communities from a more informal way of sharing.

Socialization methods like group conferences, multifunctional teams as well as joint workshops helps in connecting people together, by means of resultant patterns in intimate communications generating networks in inter-reliant societal relations (Lawson et al., 2009). Lawson et al. (2009) continue to explain that this improves common confidence levels and value through new product development groups. These assertions are sensible because new product development teams often consist of cross-functional team members, which rely on knowledge sharing among different fields of experience in order to progress in their projects (Lawson et al., 2009).

At the organizational level, socialization comes to effect through each communal and cultural procedures connected to the continuing organizational actions (Martın-de-Castro et al., 2008). Lin (2008) explains that workers intensify services, figures, news, commemorations, regulations as well as principles, transferring the rudiments into domestic activities and attitudes by picking up on values as well as rules from internal organizational cultures in socialization. Therefore, the intensity of implementing socialization at the organizational level is very much dependent on the social and cultural aspects of the organization itself.

Persaud (2005) reiterates that the degree of socialization in the midst of internationally discrete research and development units is decided by the intensity of cultural mix in the organization and trust among the units. According to Nonaka and Takeuchi (1995), organizational knowledge creation processes start from tacit knowledge distribution that communicates more or less with socialization, because compact and unexploited information residing within people is required for augmented distribution in an organization. Hence, since socialization acts based on the social and cultural aspects of the organization, it would only be normal for the organization to hold as many direct or indirect forms of knowledge sharing mechanisms such as meetings, technical sharings and communications in order to capitalize in capturing invaluable knowledge residing within the employees of the organization (Nonaka and Takeuchi, 1995; Persaud, 2005).

Socialization is one means through which project teams can improve collaboration throughout a project lifecycle (Oshri et al., 2007). Socialization enables workers to construct communication to liberally trade really personal or specialized knowledge (Li et al., 2009). Bolloju et al. (2002) support this idea by suggesting that through socialization, executives can obtain tacit knowledge by observation, imitation and practice. Therefore, socialization among project team members can benefit their performance in

terms of the knowledge sharing of expertise and skill sets, which could save time in investigating this particular knowledge during the project lifecycle.

With the acknowledgment that not all knowledge can effortlessly be captured, codified and kept, academics and practitioners have explored managerial characteristics regarding tacit, soft, implicit or less-structured knowledge (Kimble and Hildreth, 2005). However, tacit knowledge is often a result of implicit learning, which is context-specific, personal and difficult to communicate (Mittendorff et al., 2006). Senoo et al. (2007) explain that tacit knowledge refers to subjective knowledge, making it difficult to express through figures; for instance, philosophies, viewpoints, technological expertise as well as experiences consist of tacit knowledge.

Generally speaking, the difficulties in socialization and the key influences in reducing these difficulties are still being researched. According to Gold et al. (2001), organizations must carefully transform aspects of tacit knowledge into explicit knowledge to avoid the loss of efficiencies in production and innovation. With this in mind, the following section discusses the key aspects of the SECI model, which is externalization (Nonaka and Takeuchi, 1995).

2.2. Externalization

Externalization is a process of converting tacit knowledge into explicit notions and often occurs in the conceptual stage generated by discussion or brainstorming (Choi and Lee, 2002). Externalization results in the creation of 'conceptual knowledge' (Nonaka and Takeuchi, 1995, p. 71). In short, externalization involves the conversion of knowledge that cannot be easily codified (tacit knowledge) into knowledge that can be easily codified (explicit knowledge).

The externalization process aims at reducing an organisation's reliance on individual team members, thus making knowledge independent from individuals (Berends, et al., 2007). According to Salmador and Bueno (2007), externalization is a practice of elucidating the knowledge obtained from know-how into concepts, hypotheses, models, metaphors or analogies via communication. Hence, with externalization, the problem of having to depend on a single individual's expertise in a project team can be resolved by the conversion of these expertises into more tangible and generic forms of knowledge (Berends et al., 2007; Salmador and Bueno, 2007).

Externalization happens when the organization conveys formally its internal rules of performance or when it unequivocally sets goals or targets (Martın-de-Castro et al., 2008). Bolloju et al. (2002) state that knowledge externalization refers to the use of existing knowledge to produce organizational yields. They elaborate that it occurs once people utilize descriptions in articulating standpoints on revealing concealed and hard-to-communicate tacit knowledge. Therefore, externalization can also be driven by organizational policies or strategies in addition to the practice of the employees in codifying their knowledge and information for the benefit of the project as well as the organization.

Externalization also assists staff to convey pictorial information or thoughts as considerable conceptions and ideas that are desired for new product development and improvement (Tsai and Li, 2007). In externalization, the employment of metaphors in discussions is fundamental at a conceptual stage of a project (Li et al., 2009). In other words, externalization is beneficial to new product development and continuous quality improvement initiatives due to the convenience and easily comprehensible methods available from forming explicit knowledge.

Nevertheless, according to Vaccaro et al. (2009), the externalization process is challenging due to tight schedules. This therefore necessitates the use of manual knowledge compilation processes or other methods deemed appropriate. On the whole, even with the successful conversion of tacit knowledge to explicit knowledge, it would still not be easy for the expertise or technological knowledge to be maintained for a long period of time. Hence, another stage of development is required in the knowledge management process that involves the integration of various explicit notions to form a cluster of new and organized knowledge. These actions are referred to as combination, which is discussed in the next section.

2.3. Combination

Combination involves the establishment of innovative knowledge by substitutions and integrations in explicit knowledge possessed by employees (Bolloju et al., 2002). Vaccaro et al. (2009) suggest that the combination process results in novel explicit knowledge via the integration, classification, reclassification and synthesis of current explicit knowledge. Thus, combination initiatives are mechanized in order to efficiently manage explicit knowledge such that it is in a more systematic and structured condition to be reviewed by employees.

Nonaka and Takeuchi (1995, p. 71) posit that combination gives way to 'systemic knowledge', for instance prototypes or new constituent technologies. Combination converts explicit knowledge gathered from indoors or outdoors into further intricate and organized explicit knowledge that possibly will materialize into action and practice (Li et al., 2009). Hence, combination gives birth to new products or technologies that can benefit new product development and is more likely to produce outcomes that are more applicable to be put in practice.

Connection, reconfiguration and alternative expression of explicit elements will result in an organizational combination process (Martın-de-Castro et al., 2008). However, it may not be certain whether knowledge combination leads to improved product development or continuous improvement and marketing processes (Sapienza, et al., 2004). Combination efforts may be one level ahead of externalization processes in terms of system and control, but it may not be easy for every employee to put this into practice and hence improve the organization's product development or continuous improvement efforts in a flash. Therefore, the last mode of the SECI model known as internalization is required in order to efficiently manage the overall fine tuned knowledge that has been developed and bring it to an even more pragmatic form of use to the organization.

2.4. Internalization

Internalization facilitates the conversion of the organization's explicit knowledge into personal and team level tacit knowledge (Vaccaro et al., 2009). Bolloju et al. (2002) suggest that internalization occurs once explicit knowledge becomes tacit, whereby organization members put together collective explicit knowledge by means of previous information for updating mental representations and producing new tacit knowledge. Thus, it is apparent that internalization is a process of converting the combined and structured explicit ideas into a more action oriented form of knowledge that can be shared effectively among various levels of employees in an organization (Bolloju et al., 2002; Vaccaro et al., 2009).

Internalization produces 'operational knowledge' about managing projects, production, new product development and policy implementation (Nonaka and Takeuchi, 1995, p. 71). Once an organization goes through moments that call for decisiveness, shifting its norm of deciphering and executing, knowledge creation appears through internalization (Martın-de-Castro et al., 2008). Li et al. (2009) suggest that the internalization upholds the actualization of new product development or continuous improvement within the organization. Hence, it is evident that the final stage of the SECI model which is internalization, is the most complete stage in knowledge management because it involves a more functional and realistic outcome for organizational performance.

However, Li and Hsieh (2009) believe that knowledge stickiness (incapability in transferring knowledge) in project teams may generate negative impacts towards internalization, if deliberately transferring knowledge to supplementary firms turns out to be costly and tedious. Therefore, the level of internalization also can become more difficult and complicated if the vast knowledge and information that needs to be converted to tacit knowledge is increasingly complex.

In a nutshell, the SECI model illustrates a competitive approach in knowledge management for salvaging and containing valuable knowledge in an organization. Each conversion mode allows for the improvement of new product development made possible through enhancements in the knowledge creation process.. The following section will review the various findings and viewpoints concerning product development performance.

2.5. Product Development Performance

Knowledge from many different consultants with wide-ranging learning experience and skills is desirable to construct and create a novel product with added composite character similar to unique novel creations or systems (Schmickl and Kieser, 2008). Pheng and Chuan (2006) believe that although achievement in managing projects is centred upon procedures and the accomplishments in time, cost and quality goals, an achievement in a product concerns the outcomes in a project in addition to completing the products and the objectives of the project. Therefore, a successful product development would be one that not only was able to accomplish cost, time and quality requirements alone, but also one that was able to achieve a novel status parallel to the objectives of the whole product project.

Iyer at al. (2006) indicate that successful commercialization of new products requires the organisation to place a considerable focus in marketing and its supply chain. Olson et al. (2001) posit that novel product creations are multidisciplinary in nature and that rapid technological change and flexible manufacturing systems along with the need for global competitiveness cause cohesive and effective cross-functional teamwork to be critical for the success of new product development. Hence, one of the key factors that influence product development performance is the cooperation of cross-functional teams in order to ensure multidisciplinary involvement among all functions of the organization.

Organizations need to effectively understand and manage risks associated with developing new products since there is a high probability of new product development failure and large financial loss (Schmidt et al., 2009). Zika-Viktorsson and Ingelgard (2006) believe that working on new product development provides superior chances in improving systems as well as practices since they demand team-based knowledge creation, problem-solving and brainstorming activities, that attend to product related issues and acclimatization in schedule in addition to job measures. Improved product development performance could also mean enhanced competitive advantage for the organization, despite the fact that the probability of failure of the product may still exist.

However, high failure rates may suggest that management's knowledge of the transformation process whereby ideas are turned into successful new products is far from perfect, particularly for more innovative development projects (Bonner et al., 2002). Although the capacity to rapidly pioneer new products and assume new manufacturing processes has become a requirement for competitive advantage, the introduction of succesful new products have become exceedingly complex and require a broad variety of assets, funds and competence (Sen and Egelhoff, 2000).

In summary, an organization's management needs to intensify its efforts to better understand these transformation processes and strive to minimize the constraints of attaining a reliable product. Therefore, it would be necessary to apply a model that is geared for the direct improvement of new product development performance such as the SECI model into product development projects. Table 1 presents the summary of literature for socialization, externalization, combination, internalization and product development performance.

Table 1: Literature - Socialization, Externalization, Combination, Internalization, Product Development Performance

KM Elements	Sources
Socialization	Vaccaro et al. (2009), Choi and Lee (2002), Nonaka and Takeuchi (1995), Lee and Choi (2003), Salmador and Bueno (2007), Lawson et al. (2009), Martın-de-Castro et al. (2008), Lin (2008), Persaud (2005), Oshri et al. (2007), Li et al. (2009), Bolloju et al. (2002), Kimble and Hildreth (2005), Mittendorff et al. (2006), Senoo et al. (2007), Gold et al. (2001)
Externalization	Choi and Lee (2002), Nonaka and Takeuchi (1995), Hoegl and Schulze (2005), Berends et al. (2007), Salmador and Bueno (2007), Martın-de-Castro et al. (2008), Bolloju et al. (2002), Linderman et al. (2004), Tsai and Li (2007), Li et al. (2009), Vaccaro et al. (2009)
Combination	Bolloju et al. (2002), Vaccaro et al. (2009), Nonaka and Takeuchi (1995), Li et al. (2009), Martın-de-Castro et al. (2008), Sapienza et al. (2004)
Internalization	Vaccaro et al. (2009), Bolloju et al. (2002), Nonaka and Takeuchi (1995), Martın-de-Castro et al. (2008), Li et al. (2009), Li and Hsieh (2009)
Product development performance	Schmickl and Kieser (2008), Pheng and Chuan (2006), Iyer et al. (2006), Olson et al. (2001), Thamhain (2004), Schmidt et al. (2009), Zika-Viktorsson and Ingelgard (2006), Bonner et al. (2002), Sen and Egelhoff (2000)

3. Findings and Discussion

Based on the preceding sections, socialization and internalization mechanisms have a more profound effect on product development performance due to their more dominant and comprehensive literature support. We arrived at this conclusion by linking the literature support on socialization and externalization with the literature on product development performance to determine the relationship between the two variables.

Socialization is of great use to multifunctional teams and collaborative activities in new product development because it involves very convenient and common methods of communication that connect people and their expertise in an organization (Bolloju et al., 2002; Lawson et al., 2009; Lin, 2008; Martın-de-Castro et al., 2008; Oshri et al., 2007). These findings are relevant because product development is multidisciplinary in nature and often involves teamwork from various functions of the organization as well as all partners in the supply chain (Iyer et al., 2006; Olson et al., 2001; Thamhain, 2004). Thus, it is evident that socialization plays a very important role in integrating functions and teams for improved product development performance.

According to Gold et al. (2001), organizations must carefully transform its tacit knowledge into explicit knowledge to avoid the loss of efficiencies in production and innovation. This is because socialization often results in implicit learning, which is context-specific, subjective and difficult to express in a more comprehensible manner (Mittendorff et al., 2006; Senoo et al., 2007). Consequently, this can create more challenges in product development as it produces more knowledge barriers between team members and functions that can slow down new product development activities.

Externalization, which involves the creation of conceptual knowledge assists product development by providing a more structured and tangible form of knowledge in terms of conceptions and ideas that is more useful at the conceptual stage of the product development lifecycle (Bolloju et al., 2002; Li et al., 2009; Martın-de-Castro et al., 2008; Tsai and Li, 2007). This is very relevant in a product development context because the risks and potential failures of the products need to be understood clearly through brainstorming, problem-solving and knowledge creation activities among various team members at the beginning of the conceptual stage in new product development (Schmidt et al., 2009; Zika-Viktorsson and Ingelgard, 2006).

From the aforementioned linkages, it is evident that externalization helps more in the conceptual development in the product's overall lifecycle. However, due to the tight schedules in new product development, externalization often becomes a challenge as the conceptual knowledge created is hard to be maintained and often becomes rooted within peer-to-peer communications or manual compilations (Vaccaro et al., 2009).

The knowledge combination process helps to connect, reconfigure and organize the explicit knowledge from externalization into a new and more structured form of explicit knowledge that has a higher possibility of materializing into actions and practices (Li et al., 2009; Martın-de-Castro et al., 2008). This is more useful for product development because it requires amalgamated knowledge from various consultants and experts to be combined and prearranged for the construction of a novel product (Schmickl and Kieser, 2008). However, it still may not be certain whether knowledge combination directly leads to improved product development (Sapienza et al., 2004).

Internalization activities involves more action oriented forms of knowledge known as operational knowledge that can help facilitate the conversion of the organization's explicit knowledge into team level tacit knowledge, which upholds the actualization of new product development (Bolloju et al., 2002; Li et al., 2009; Martın-de-Castro et al., 2008; Nonaka and Takeuchi, 1995; Vaccaro et al., 2009). This, therefore, supports the idea that achieving success in product development involves more than meeting time, cost and quality goals, but also a more tangible outcome of the project such as product completion and objective fulfilment (Pheng and Chuan, 2006).

However, the introduction of new products have become exceedingly complex and require a broad variety of assets, funds and competence (Sen and Egelhoff, 2000). Similarly for internalization, due to knowledge stickiness among product development team members, deliberately transferring knowledge to supplementary firms turns out to be costly and tedious (Li and Hsieh, 2009). Therefore, as the level of internalization becomes more complicated, so will the entire process of new product development.

Table 2 presents the summary of literature supporting the role of knowledge management in product development performance. Overall, the findings indicate that although all knowledge management processes play an important role in product development performance, there are still some negative effects due to the complexity and uncertainty of the organization and projects involved.

Table 2: Literature Support on the Role of Knowledge Management in Product Development Performance

KM Elements	Literature Support		Effect on Product Development
	Knowledge Management	Product Development Performance	
Socialization	Lawson et al. (2009), Martın-de-Castro et al. (2008), Lin (2008), Oshri et al. (2007), Li et al. (2009), Bolloju et al. (2002), Gold et al. (2001)	Iyer et al. (2006), Olson et al. (2001), Thamhain (2004)	Positive
	Mittendorff et al. (2006), Senoo et al. (2007)	Bonner et al. (2002)	Negative
Externalization	Martın-de-Castro et al. (2008), Bolloju et al. (2002), Tsai and Li (2007), Li et al. (2009)	Schmidt et al. (2009), Zika-Viktorsson and Ingelgard (2006)	Positive
	Vaccaro et al. (2009)	Bonner et al. (2002)	Negative
Combination	Li et al. (2009), Martın-de-Castro et al. (2008)	Schmickl and Kieser (2008)	Positive
	Sapienza et al. (2004)	Bonner et al. (2002)	Negative
Internalization	Vaccaro et al. (2009), Bolloju et al. (2002), Nonaka and Takeuchi (1995), Martın-de-Castro et al. (2008), Li et al. (2009)	Pheng and Chuan (2006)	Positive
	Li and Hsieh (2009)	Sen and Egelhoff (2000)	Negative

4. Conclusion And Directions For Future Research

Based on the findings and discussions in the preceding section, it can be summarized that knowledge management plays a relatively important role in product development performance as far as socialization, externalization, combination and internalization processes are concerned. Also, from the literature review, it is found that socialization and internalization implementations exhibit a stronger role in enhancing product development performance.

However, since the failure rates in product development projects tend to be high, it is imperative for the organization's management to ensure careful control and attention towards the knowledge conversion processes in the organization (Bonner et al., 2002). In this case, the application of the SECI model would be an effective method to ensure tight control and monitoring of knowledge management activities in the organisation.

Managers and engineers should work together to create more platforms that can harness socialization activities such as coffee klatches, technical sharing and team building activities. This will help to enhance the socialization activities among product development teams. In addition, management should also emphasize the process of internalizing explicit knowledge that actualizes concepts about strategy, tactics, innovation or improvement. For example, training programs should be held in organizations to help employees understand the organization and themselves in the whole.

A few suggestions are proposed to further the work in this area. One of them is to conduct a qualitative or quantitative empirical study to test the sub-variables of the SECI model and determine their influence in

product development performance. Interviews or surveys may be employed to obtain insights and data from various organizations. Apart from that, it would be good if researchers are able to use secondary data from the organization's records such as sales performance, customer satisfaction or development cost to determine the knowledge management practices in product development projects.

Overall, this paper identified the important and necessary factors to enhance the practice of knowledge management in improving product development performance. In this case, socialization and internalization implementation factors are found be the more prominent elements in the SECI model that deserves attention to improve product development performance.

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