Article

Knowledge Management in the Software Industry: Creating Value Through Knowledge Application

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Abstract

The software industry being highly knowledge-centric in terms of technology, process and people has been focusing on knowledge management strategically for the past two decades. Although the processes of knowledge creation and sharing are well researched, knowledge application is not well addressed. This study identifies project knowledge application and management support for knowledge application as the dimensions of knowledge application creating value to knowledge management in the software industry. Through a structural equation modelling approach, the relationships of management support for knowledge application, project knowledge application and effective knowledge management are tested. The findings show that the management support for knowledge application has an indirect effect—higher than a direct effect—on effective knowledge management through project knowledge application. The empirical study done on data collected from 540 software professionals of 170 National Association of Software and Services Companies-listed software companies proves the significance of knowledge application through management support and projects on effective knowledge management. But the role of management support is not as strong as project knowledge, and hence the organizations could enhance their culture of management support. The dimensions of knowledge application create value for people and process in software organizations by

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developing an environment of openness, collaboration and creativity, in addition to creating better response to changing environments which will help organizations to achieve the benefits of lean-agile software and system developments at scale.

Keywords

Software industry, knowledge management, knowledge application, projects, management support

Introduction

All organizations are striving hard to achieve a competitive advantage in the concerned industry in terms of products, processes, people and technology. The effectiveness of these strategies depends on knowledge management (KM) which explains how knowledge is created, stored, transferred and applied to the products/services and processes (Alavi & Leidner, 2001; Davenport, 1994; Maier & Moseley, 2003; Nonaka & Takeuchi, 1995). The knowledge residing in the organization in the form of people, processes and practices is considered as the strategic asset that adds value to the individual and organizational outcomes. This is particularly more important to software organizations as they are highly knowledge-centric. The software industry was an early adopter of KM, and sufficient researches have also been carried out on KM in software for the past two decades. As software development is a collaborative process that needs to gather domain expertise, technological skills and process knowledge (Agerfalk & Fitzgerald, 2006; Dyba & Dingsoyr, 2008; Yanzer et al., 2014), KM became a requisite when the software organizations moved from the traditional approach to agile methodology.

As agile software development is characterized by iterative development, communication of cross-functional teams and self-organization, managing the flow of knowledge is a major concern, and a vast majority of studies focused on knowledge creation and sharing in the agile teams. But the process of knowledge application (KA) remains under-researched in this context. KA is defined as the process where the knowledge acquired from past organizational experiences and other individuals bring changes in action that could benefit the organization operationally and strategically (Brachos et al., 2007; Dalkir, 2013; Nelson & Sidney, 1982; Nesheim et al., 2011; Oluikpe, 2015). The outcome of knowledge results from application (as knowing without doing is often meaningless). But KA is not well addressed, in spite of being the logical process following knowledge creation and sharing in the KM process life cycle (Brachos et al., 2007; Dalkir, 2013; Nelson & Sidney, 1982; Nesheim et al., 2011). In the technology industry, technology exists predominantly as a part of infrastructure; the people and processes act as key resources of KA (Joshi et al., 2016; Mehta et al., 2007). Therefore, it is important to explore the significance of KA in the software industry from those perspectives.

In organizations, from an employee's perspective, KA has a significant impact on the development of skills which can enhance their performance. As far as software companies are concerned, the product/services are developed and innovated through projects. Therefore, project knowledge application (PKA) is significant for effective KM. Besides, management support and leadership could also accelerate KA by supporting innovative ideas and experiments. Motivational support can generate novel ideas and contextual solutions from employees. This could pave the way to new opportunities, learning which adds value to knowledge and insights for the organization. Though the management support in organizations is considered part of the organizational culture, the management support for KA (MSKA) refers to initiatives taken to enhance the employee learning through enterprise collaboration such as knowledge communities, both formal discussion groups and informal discussion groups that are imperative in applying knowledge based on the context with the optimum utilization of time and other organizational knowledge resources. Reviewing past literature on KM processes in the software industry, variables of KA were mostly explained in two dimensions: (a) projects and (b) management support.

The objective of this study is to analyse the impact of KA on effective KM in the software industry. The effective KM is measured by the effectiveness of other KM processes such as effective creation, storage and transfer of knowledge based on the perspectives of software professionals. The agile software development focuses more on people, and hence the perception of the software professionals who actually practice knowledge would provide a better clarity on this objective. Moreover, these objectives are expected to bring insights into how PKA and MSKA can add value to the people and processes of these software organizations in terms of KM effectiveness.

The study is conducted on National Association of Software and Services Companies (NASSCOM)-listed software companies in India. The NASSCOM is a trade association of the Indian Information Technology (IT) and Business Process Outsourcing (BPO) industry which was established in 1988 and registered under the Indian Societies Act 1860. This association has been encouraging an agile culture in the Indian software industry for the past decade. According to Singh et al. (2014), 73 per cent of NASSCOM-listed companies were either fully or partially agile. NASSCOM (2019) in their annual report emphasized to continue and strengthen focus on talent, agility, execution and impact of software development across the industry as their major objective.

Literature Review

In organizations, the knowledge that remains embedded in the organizational routines, processes, practices and norms act as a powerful resource that takes an organization competitively ahead (Davenport & Prusak, 1998; Drucker, 1966). This ideology resulted in a paradigm shift from a business economy to a knowledge economy, focusing on learning about the application and development of knowledge and knowledge management systems (KMSs) operating with many objectives, such as improving the performance of organizational systems and processes, persuading people to share (Havens & Hass, 2000), leveraging and using the uniqueness of the organization. This is done to capitalize on the mix of people, processes, services and products that define its identity and place in its competitive market (Abell & Oxbrow, 2001). These knowledge practices build and exploit the organization's intellectual capital effectively (Alavi & Leidner, 2001; Stewart & Ruckdeschel, 1998) and make knowledge more visible throughout the organization. KM is the strategic process of managing organizational knowledge resources and assets systematically through the processes such as creation, storage, sharing and application of knowledge with the support of enablers such as organizational structure, technology, leadership, people competency and networks (Bukowitz & Williams, 2000; Davenport & Prusak, 1998; Nonaka & Takeuchi, 1995; Sveiby, 1997). Strategic outcomes such as organizational performance, innovation, intellectual capital and market leadership are the denouement of KM. Though the construct was popularized during the early 1990s, researches on KMSs were pivotal in organizations for almost three decades. A vast majority of them focused on the knowledge creation and sharing, as these are critical to the latter phases of KM such as the effective application of knowledge in the right context, resulting in competitive advantage (Oluikpe, 2015).

It is crucial to ensure the effectiveness of KM which is ensured by the combined effectiveness of the four KM processes: (a) knowledge acquisition, (b) knowledge creation, (c) knowledge storage and (d) knowledge utilization (Aujirapongpan et al., 2010). By enhancing the effectiveness of these processes, an organization will have the ability to easily adapt to change. The organization has this ability because of effective KM (DeLong & Fahey, 2000). Effective KM in project-based organizations facilitates the creation and integration of knowledge by minimizing knowledge losses and fills knowledge gaps through effective knowledge sharing throughout the duration of the project (Lech, 2014). Knowledge loss can be controlled through effective knowledge storage by ensuring project documentation at different levels. KM effectiveness is important in organizations as it increases the organizational adaptability and innovativeness, which are the qualities organizations need for their survival and sustainable growth (Aujirapongpan et al., 2010).

The software industry is characterized by fast-changing technology, high employment opportunities, strategic partnerships, global markets, influence of web and Internet of Things, ever-changing client requirements, timeline-based projects and distributed employee networks (Malhotra & Majchrzak, 2004; Mehta, 2008; Purushothaman, 2015; Singh et al., 2014). These characteristics definitely make the industry highly knowledge-centric, and KM has an incredible role in the growth of a software organization as it enhances the execution and coordination of the organizational process.

In the 1990s, software companies followed the traditional approach with a planned process and comprehensive documentation. However, over the past decade, the agile methodology has become popular in the industry (Khalil & Khalil, 2019). The four core values of the agile methodology are: (a) focus on individuals and interactions, (b) working software over comprehensive documentation, (c) customer collaboration and (d) responding quickly to the ever-changing environment (Yanzer et al., 2014). The underlying theory of agile methodology in new product development was initially proposed by Takeuchi and Nonaka (1986). Later, the value of organizational knowledge assets in achieving competitive advantage was also emphasized by Nonaka and Takeuchi (1995). Agile methods encourage communication, frequent feedback and team collaboration where the tacit dimension of KM becomes important. Even though knowledge has received considerable attention in the IT sector, academic research on KM in agile software development is few. As the communication and collaboration among teams was a prerequisite, most KM researches focused on knowledge creation and sharing (Paasivaara et al., 2008). But the tacit knowledge can be developed only by action, systematically identifying solution to problems, where the role of KA in adding value to KM in software development becomes significant.

Management of projects is greatly dependent on how knowledge is created, transferred and applied effectively in projects. This in turn influences the overall effectiveness of KM that increases the speed to delivery and precision of execution (Jackson & Klobas, 2008). Knowing without doing cannot result in innovation, and this is more relevant in software projects, as the project outcome is the product of the combination of tacit knowledge which is in a state of doing (how to do) and explicit knowledge which is in a state of being (what to do) (Nonaka & Takeuchi, 1995; Oluikpe, 2015). This learning from project output would enhance organizational knowledge and innovation through effective KM. There are several aspects that contribute to successful KM in projects. They are based on the organizational resources, such as technology infrastructure and organizational structure, and knowledge resources such as people, processes and routines.

PKA is enhanced by knowledge-based practices such as team networking, rotation of individual roles, the participation of employees in diverse projects, team leader assignments, application of knowledge in client negotiations and formal and informal communities of practice (Barley et al., 2018; Herbst, 2017; Kampkotter et al., 2018; Lakshman, 2005; Nesheim et al., 2011; Singh et al., 2014; Wood, 1998; Zboralski, 2009). Negotiations with customers and clients are often discussed as sources of knowledge creation and sharing. But they are also important for employees to explore and apply their skill and knowledge suitably in negotiations. The project KM not only involves the technical contributions, but also the management techniques that could effectively exploit the knowledge and skill of the team members. Project monitoring through project meetings, regular feedback and review would greatly enhance the project progress (Valio Dominguez Gonzalez et al., 2014). Team leader assignments in software projects give opportunities to apply both technical and managerial skills (Tierney et al., 1999; Venkitachalam & Bosua, 2014). An employee who participates is diverse projects can explore various technical dimensions and apply them effectively on different contexts (Madhavan & Grover, 1998; Rindfleisch & Moorman, 2001; Song et al., 2005). Negotiation with clients on specific projects is also a platform to apply practical knowledge acquired from past projects regarding the feasibility, productivity and outcome (Balle et al., 2018; Bresnen et al., 2005; Heaton et al., 2016).

Apart from PKA, management support also contributes to KA, especially the leadership, which plays a significant role as a driver in KM implementation (Pillania, 2006). Zou and Ingram (2013) proposed a series of principles for an organization to support the knowledge network structure such as flattening of hierarchies, employee empowerment, emphasis on information exchange (formal and informal), diversified skills, continuous feedback, participatory supervision of knowledge communities and practices (Gasik, 2011; Nesheim et al., 2011; Valio Dominguez Gonzalez et al., 2014). MSKA is important in overcoming barriers such as employee unwillingness to share knowledge, complicated documentation and insufficient operational procedures (Tsai, 2014). Creating a good technical infrastructure for KA through intranet discussion groups would be a solution to overcome the barriers of knowledge access and sharing (Barley et al., 2018; Nesheim et al., 2011). The management perception of the value of the employee's participation, the quality of community management and the level of support employees receive from the line organization have direct and interactional effects on KA (Heaton et al., 2016; Nesheim et al., 2011). Encouraging suggestions and ideas during crisis and participation in client negotiation pave opportunities for the employees to creatively apply knowledge (Bresnen et al., 2005; Hatchuel et al., 2002; Heaton et al., 2016).

A detailed review on KA literature in the software industry revealed variables under two dimensions: (a) projects and (b) management support. The variables are listed in Table 1.

Table 1. Variables of Knowledge Application and Effective KM in the Software Industry

No.	Management Support for Knowledge Application
1.	The top management motivation to give suggestions on general issues (Huang & Yao, 2018; Nesheim et al., 2011)
2.	Formal meetings (Gasik, 2011; Valio Dominguez Gonzalez et al., 2014)
3.	Informal meetings (Gasik, 2011; Nesheim et al., 2011; Schönström, 2005)
4.	Freedom to give an opinion during crisis (Hatchuel et al., 2002)
5.	Support for client negotiations (Bresnen et al., 2005; Heaton et al., 2016)
6.	Intranet discussion groups (Barley et al., 2018; Nesheim et al., 2011)
No.	**Project Knowledge Application**
1.	Project monitoring (Gasik, 2011; Valio Dominguez Gonzalez et al., 2014)
2.	Practical knowledge for negotiating with customers (Bresnen et al., 2005; Heaton et al., 2016)
3.	Applying knowledge (lessons learned) in projects (Balle et al., 2018)
4.	Working with diverse projects (Madhavan & Grover, 1998; Rindfleisch & Moorman, 2001; Song et al., 2005)

(Table 1 continued)

(Table 1 continued)

No.	Management Support for Knowledge Application
5.	Temporary assignment as a team leader helps in developing leadership skills (Tierney et al., 1999; Venkitachalam & Bosua, 2014)
6.	Temporary assignment as a team leader helps in developing managerial skills (Tierney et al., 1999; Venkitachalam & Bosua, 2014)
7.	Job rotation (Barley et al., 2018; Singh et al., 2014)
No.	**Effective Knowledge Management**
1.	Effective knowledge creation (Aujirapongpan et al., 2010)
2.	Effective knowledge storage (Aujirapongpan et al., 2010; Lech, 2014)
3.	Effective knowledge sharing (Aujirapongpan et al., 2010; Lech, 2014)

Source: The authors.

Literature review culminates with the realization that the application of knowledge in the software industry is significant to ensure the effectiveness of KM. But as compared to other knowledge processes such as knowledge creation and transfer, KA is not seriously addressed from a research perspective. Hence, the key objectives of the study are as follows:

1. To identify the impact of MSKA on effective KM in the software industry.
2. To identify the mediating role of PKA in the relationship of MSKA and effective KM in the software industry.

Research Hypotheses

Management support can overcome barriers of PKA, such as complicated documentation and insufficient operational procedures, and enhance codification of tacit knowledge, creativity through knowledge networks and integration mechanisms (Grant, 1996; Heaton et al., 2016; Tsai, 2014; Venkitachalam & Bosua, 2014). It plays a significant role as the driver in effective KM implementation (Pillania, 2006; Valio Dominguez Gonzalez et al., 2014; Zou & Ingram, 2013). Hence, we hypothesize that:

H1: Management support has a significant impact on PKA.

H2: Management support significantly contributes to effective KM.

Besides, how knowledge is applied in projects influences the overall effectiveness of KM that increases the speed to delivery and precision of execution (Jackson & Klobas, 2008; Oluikpe, 2015; Tiwana, 2003). With this, we hypothesize that:

H3: PKA has a significant impact on effective KM.

Research Methodology

A questionnaire survey was conducted in NASSCOM-listed software companies in India. There are 2434 software companies listed under NASSCOM (Members Listing 2018) which included multinational companies (MNCs) as well as Indian companies. Of these, 520 (21.5%) companies exist in Karnataka. A vast majority of them are headquartered at Bangalore, the Silicon Valley of India. Hence, the survey targeted this group of companies as the sample frame.

A random sampling method was used to identify the right sample for the study. Out of these 520 companies, 270 companies focused on core software services as their primary business. This included MNCs and Indian companies. Questionnaires were distributed to software professionals working in these companies. An e-questionnaire was developed and shared in a social network platform, 'LinkedIn', where software professionals were very active. The questionnaire included questions on KA in the software industry and perception of software professionals on the effectiveness of knowledge creation, storage and transfer in their organization. All questions were measurable on a 5-point Likert scale. The 13-scale items on KA (7 items on PKA and 6 items on MSKA) and 3-scale items on effective KM were derived from past literatures which are explained in Table 1.

The software professionals were connected by searching the name of the company and designations. Individual requests were sent to professionals working in 270 software companies with designations such as software engineers, senior software engineers, software developers, test engineers and tech leads. With an average of 10 requests to each company, total of 2200 connections were activated (2600 requests sent) from which 820 professionals showed interest to contribute to study. The e-questionnaires were sent to these 820 professionals, out of which 540 completed responses were received. The responses were achieved through rigorous follow-up and regular reminders. The final sample obtained after the survey constituted 540 responses from 170 companies.

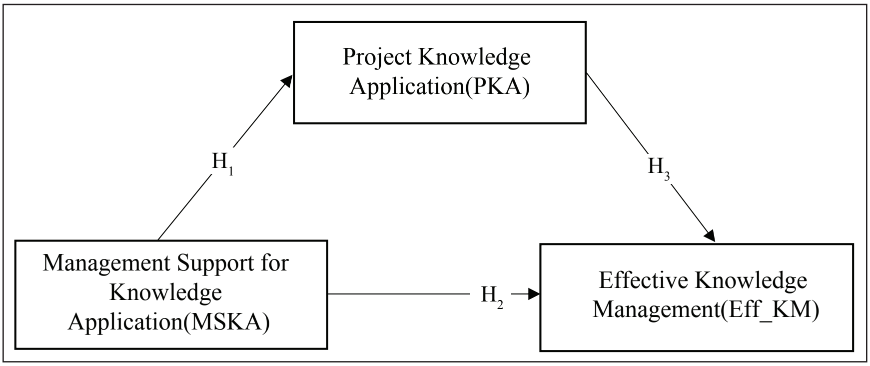

Figure 1. The Research Model

Source: Authors' conceptualization.

Table 2. Correlation Analysis: PKA

PKA Variables		[Applying Knowledge in Projects Gives Me More Confidence]	[Working with Diverse Projects Gives More Opportunities for Knowledge Application]	[Temporary Assignment as a Team Leader Helps in Applying Leadership Skills]	[Temporary Assignment as a Team Leader also Helps in Applying Managerial Knowledge]	[Job Rotation in the Organization Helps in Applying Knowledge in Multiple Areas]	[Practical Knowledge Has Helped in Negotiating with Customers]	[Project Monitoring and Control Give Opportunity to Apply Knowledge]	Mean	Standard Deviation
[Applying knowledge in projects gives me more confidence]	Correlation coefficient	1								.930
	P value	-							4.17	
[Working with diverse projects gives more opportunities for knowledge application]	Correlation coefficient	.744**	1							.863
	P value	0.00							4.09	
[Temporary assignment as a team leader helps in applying leadership skills]	Correlation coefficient	.678**	.715**	1						.967
	P value	0.00	0.00						3.90	
[Temporary assignment as a team leader also helps in applying managerial knowledge]	Correlation coefficient	.579**	.729**	.851**	1					.937
	P value	0.00	0.00	0.00					3.87	

(Table 2 continued)

(Table 2 continued)

PKA Variables		[Applying Knowledge in Projects Gives Me More Confidence]	[Working with Diverse Projects Gives More Opportunities for Knowledge Application]	[Temporary Assignment as a Team Leader Helps in Applying Leadership Skills]	[Temporary Assignment as a Team Leader also Helps in Applying Managerial Knowledge]	[Job Rotation in the Organization Helps in Applying Knowledge in Multiple Areas]	[Practical Knowledge Has Helped in Negotiating with Customers]	[Project Monitoring and Control Give Opportunity to Apply Knowledge]	Mean	Standard Deviation
[Job rotation in the organization helps in applying knowledge in multiple areas]	Correlation coefficient	.603**	.636**	.688**	.622**	1				1.054
	P value	0.00	0.00	0.00	0.00				3.78	
[Practical knowledge has helped in negotiating with customers]	Correlation coefficient	.616**	.722**	.682**	.712**	.653**	1			.920
	P value	0.00	0.00	0.00	0.00	0.00			3.89	
[Project monitoring and control give opportunity to apply knowledge]	Correlation coefficient	.628**	.609**	.614**	.608**	.543**	.636**	1		.865
	P value	0.00	0.00	0.00	0.00	0.00	0.00		3.81	

Source: The authors.

Note. ** Indicates that the correlation is significant at the .01 level (2-tailed).

Table 3. Correlation Analysis: MSKA

MSKA Variables		[We Can Apply Our Knowledge During the Client Negotiations]	[The Top Management Motivates Us to Give Suggestion on General Issues]	[We Can Express Our Views in Formal Meetings]	[I Share Ideas on Knowledge Application During Informal Meetings]	[Our Organization Gives Us Freedom to Apply Our Ideas During Crisis]	[Intranet Discussion Groups Contribute to Knowledge Application]	Mean	Standard Deviation
[We can apply our knowledge during the client negotiations]	Correlation coefficient	1							.959
	P value							3.66	
[The top management motivates us to give suggestion on general issues]	Correlation coefficient	.541**	1						1.021
	P value	0.00						3.44	
[We can express our views in formal meetings	Correlation coefficient	.650**	.690**	1					.944
	P value	0.00	0.00					3.77	
[I share ideas on knowledge application during informal meetings]	Correlation coefficient	.630**	.499**	.714**	1				.909
	P value	0.00	0.00	0.00				3.76	

(Table 3 continued)

(Table 3 continued)

MSKA Variables		[We Can Apply Our Knowledge During the Client Negotiations]	[The Top Management Motivates Us to Give Suggestion on General Issues]	[We Can Express Our Views in Formal Meetings]	[I Share Ideas on Knowledge Application During Informal Meetings]	[Our Organization Gives Us Freedom to Apply Our Ideas During Crisis]	[Intranet Discussion Groups Contribute to Knowledge Application]	Mean	Standard Deviation
[Our organization gives us freedom to apply our ideas during crisis]	Correlation coefficient	.659**	.549**	.656**	.604**	1			1.060
	P value	0.00	0.00	0.00	0.00			3.65	
[Intranet discussion groups contribute to knowledge application	Correlation coefficient	.629**	.576**	.664**	.608**	.556**	1		.917
	P value	0.00	0.00	0.00	0.00	0.00		3.77	

Source: The authors.

Note. ** Indicates that the correlation is significant at the 0.01 level (2-tailed).

Past literature has identified the variables of KA in two dimensions, namely projects and management support. Correlation analyses of PKA and MSKA variables were conducted separately. These factors were further confirmed with a measurement model using confirmatory factor analysis (CFA). The reliability and validity of these factors were also established simultaneously. Further analysis of the structural relationships between the dimensions of KA and effective KM was done using structural equation modelling (SEM). The details such as analysis of data and interpretations are explained in the following sections.

Data Analysis and Interpretation

A split sample procedure is followed in the data analysis process. Correlation analysis was conducted on a sample of 200 responses from a total sample of 540 responses. In fact, correlation analysis and reliability test were done on initial 200 responses. CFA was conducted on the remaining sample of 340 responses. Finally, SEM was executed on a full sample of 540 responses.

Correlation Analysis

Correlation analyses were done on the 7-scale items of PKA and 6-scale items of MSKA each on a sample size of 200 responses. Tables 2 and 3 explain the correlation coefficients of the PKA and MSKA variables, respectively. The mean and standard deviation of each scaled variable have also been provided in the tables. It was observed that the PKA variables were strongly correlated with *P* value of <.001. Similarly, it was observed that the correlations were highly significant for the MSKA variables with *P* value of <.001. The reliability value (Cronbach's α) of PKA was .931 and that of MSKA was .904. This was higher than the acceptable threshold of .7.

Confirmatory Factor Analysis

Now, the next step was to confirm that the observed variables were linked to the factors through hypothesis testing and then ensuring the reliability and validity of these constructs (factors). A measurement model was developed and tested for this purpose through CFA. The CFA model included one more factor, namely the effective KM, which was measured through the perceptions of software professionals on the effectiveness of creation, storage and transfer processes of KM. Effective KM acted as the endogenous variable (dependent variable) in the study. The PKA variable 'project monitoring' showed low loadings in the CFA model, and hence it was removed. The two variables of PKA on team leader assignment (temporary assignments as the team leader helped in developing leadership skills and developing managerial skills) were found strongly correlated, and hence they were transformed as a single variable 'Team Leader' by computing the average of their mean values. Similarly, the MSKA variable 'intranet discussion groups' also showed poor loadings and was removed. The final model after testing was found to be a good fit model with the adequate fit indices as reported in Table 4. The recommended values were based on the theories of Byrne and Van de Vijver (2010).

CFA was conducted to test the hypothesized relationship between the observed variables and their constructs (factors) and also to establish the reliability and validity of the constructs. The composite reliability of the constructs were 0.83, 0.83 and 0.74 for PKA, MSKA and effective KM, respectively (Table 5). This is higher than the acceptable threshold of 0.7. Construct validity is the extent to which a set of measured variables actually reflects the latent construct they are designed to measure (Hair et al., 2010). In this study, construct validity was established by establishing the face validity, convergent validity and discriminant validity.

Convergent validity was assessed by examining the factor loadings and average variance extracted (AVE) of the constructs. All the indicators had significant loadings onto the respective latent constructs ($P < .001$) with values varying between .685 and .825 (Table 5). In addition, the AVE for each construct was greater than or equal to 0.50, which further supported the convergent validity of the constructs. Fornell and Larcker (1981) state that discriminant validity can be assessed by comparing the square root of AVE with the corresponding inter-construct squared correlation estimates. The construct validity has been explained in Table 6. The square root of AVE values of all the factors was greater than the inter-construct correlations, which supports the discriminant validity of the constructs. (Square roots of AVE for each construct were .760, .752 and .745, respectively, which were higher than the inter-construct correlations, namely .74, .71 and .63.) Besides, it can also be observed that maximum shared variance and average shared variance) of all the three constructs were less than AVE. Thus, the measurement model reflected good construct validity and desirable psychometric properties.

Table 4. CFA: Model-fit Summary

Model-Fit Indices	Recommended Value	Obtained Value
Chi-square to the degree of freedom ratio (CMIN/df)	≤4.000	2.468
Goodness-of-fit index	≥0.900	.935
Adjusted goodness-of-fit index	≥0.800	.904
Normed fit index	≥0.900	.935
Comparative fit index	≥0.900	.960
Root mean square of error approximate	≤.08 and not more than .1	.066

Source: The authors.

Note. CMIN/df = chi-square to the degree-of-freedom ratio.

Table 5. CFA: Estimates, Composite Reliability and AVE

Variables		Construct	*P* Value	Estimates	Composite Reliability	AVE
Practical knowledge has helped in negotiating with customers	←	PKA	***	0.78	0.83	0.577
Job rotation in organisation help in applying knowledge in multiple areas	←	PKA	***	0.718		
Applying knowledge in projects gives me more confidence	←	PKA	***	0.761		
Working with diverse projects gives more opportunities for knowledge application	←	PKA	***	0.818		
Team leader	←	PKA	***	0.773		
I share ideas on knowledge application during informal meetings	←	MSKA	***	0.738	0.83	0.565
We can apply our knowledge during the client negotiations	←	MSKA	***	0.685		
Our organization gives us freedom to apply our ideas during crisis	←	MSKA	***	0.76		
The top management motivates us to give suggestion on general issues	←	MSKA	***	0.746		
We can express our views informal meetings	←	MSKA	***	0.825		
Effective knowledge transfer	←	Eff_KM	***	0.768	0.74	0.555
Effective knowledge storage	←	Eff_KM	***	0.737		
Effective knowledge creation	←	Eff_KM	***	0.73		

Source: The authors.

Notes. AVE = average variance extracted; PKA = project knowledge application; MSKA = management support for knowledge application.

*** Indicates high significance with $P < .001$.

Table 6. Construct Validity

	AVE	Square Root of AVE	MSV	ASV	PKA	MSKA	Eff_KM
PKA	0.577	0.76	0.548	0.472	1		
MSKA	0.565	0.752	0.548	0.526	0.74	1	
Eff_KM	0.555	0.745	0.504	0.451	0.63	0.71	1

Source: The authors.

Notes. AVE average variance extracted; MSV = maximum shared variance; AVE = average shared variance; PKA = project knowledge application; MSKA = management support for knowledge application; Eff_KM = effective knowledge management.

Table 7. SEM: Fit Indices

Model Fit Indices	Recommended Value	Obtained Value
Chi-square to the degree-of-freedom ratio	≤4.000	3.154
The goodness-of-fit index	≥0.900	.945
Adjusted goodness-of-fit index	≥0.800	.904
Normed fit index	≥0.900	.950
Comparative fit index	≥0.900	.965
Root mean square of error approximate	<.08 and <.1	.063

Source: The authors.

Structural Equation Model

A structural model was developed to test the hypotheses. The model fit indices were observed to be within the prescribed limits. Table 7 illustrates the fit indices of the structural model constituting the relationships between MSKA, PKA and effective KM (Eff._KM) in the software industry.

The structural relationships are indicated as one-sided arrows in Figure 2 (hypothesized paths between the constructs). The *P* values for the hypothesized relationships were all highly significant ($P < .001$). This indicates that management support had a significant impact on project KA (H_1 holds true). MSKA also had a significant role in effective KM (H_2 holds true) and project knowledge also, in turn, had a significant impact on effective KM (H_3 also holds true). The standardized beta coefficients for the regression relationships are also shown in Figure 2.

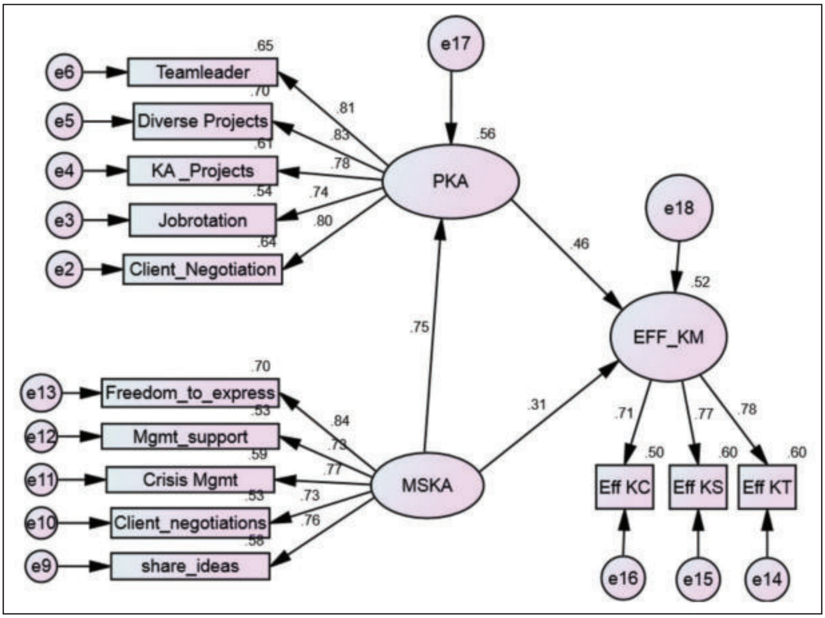

Figure 2. Structural Model

Source: The authors.

Table 8. Direct and Indirect Mediation Effects

Hypothesized Paths			Standardized Direct Effects	Standardized Indirect Effects	Standardized Total Effects
PKA	←	MSKA	0.747	0.00	0.747
Eff_KM	←	MSKA	0.312	0.33	0.646
Eff_KM	←	PKA	0.457	0.00	0.457

Source: The authors.

Notes. PKA = project knowledge application; MSKA = management support for knowledge application; Eff_KM = effective knowledge management.

Mediation Effect

The model signifies the existence of project KA in a mediation role between management support and effective KM, and this was further tested using mediation analysis. Table 8 shows that the standardized total effect and direct effect of MSKA on effective KM vary. This is a clear indication that PKA had a significant mediation role between MSKA and effective KM. As the relationship between MSKA and effective KM is significant, *PKA has a partial mediation effect* in the model. This is an obvious indication of the significance of projects in KA and further on organizational KM in general.

Discussions

Knowledge-based economies and knowledge assets as competitive advantage have become increasingly more important because the 'value' is more frequently found in the intangible than in the tangible things (Yanzer et al., 2014). These intangible things reside in the people and process of an organization. Considering the core values of the agile software methodology such as focus on individual and interactions, working software, customer collaboration and response to change, the value creation of KA for effective KM in the software industry can be explained in two perspectives: people and process.

This study was done focusing on these two aspects by identifying the scope of the KA process in software companies from the perspective of the people who are actually practising it (software professionals). Value creation through KA for software professionals contributes to skill development and empowerment. This can be well explained on the basis of the variables of PKA and MSKA. From the PKA dimension, the team leader assignment can enhance the leadership and managerial skills of an individual. Besides, the team leadership plays a significant role in agile teams in communicating, motivating and idea sharing. Responding to the changing business environment and client requirement is enabled through participation in diverse projects and job rotations. These aspects of organizational support were explained by Zou and Ingram (2013) in the knowledge network structure theory. The informal communications among the project teams create openness where a software professional gets opportunity to share ideas and apply his/her knowledge from lesson learned. The customer collaboration creates opportunities for software professionals to practically apply the knowledge on various scenarios based on the client requirements. From the perspective of the MSKA dimension, the value added to people is in the form of support for creativity and innovation. A culture of openness and experimentation supported by the management can boost creativity and confidence which in turn can lead to innovations. The participatory supervision of knowledge communities by management can also enhance the collaborative knowledge network (Valio Dominguez Gonzalez et al., 2014). This dimension of MSKA can empower employees to apply their knowledge effectively in the right context.

From the process perspective, the research model tested and proved clearly explains how the KA process creates value for effective KM. Both the projects and management are significant in adding value to KM in the software industry. Though projects and management support were identified as the dimensions of KA in the software industry, that can contribute to effective KM. MSKA can also enhance KA in projects. This has been explained as the role of human touch in managing projects in the knowledge-intense industry where the corporate databases on past projects and client requirements are shared to the project team, which enables them to exploit the knowledge and apply it effectively (Thornton & McCracken, 2005). It was evident from the result of the analysis that the management support was primarily focused on projects as it has a significant impact on project KA rather than effective KM. Effective KM was measured in the study based on the perception of employees on the effectiveness of KM processes such as creation, storage and transfer of knowledge in their organizations. Theoretically, it had been proved that KA can result in knowledge reconstruction or redefinition, which could be stored and transferred further for all the future technology endeavours to add further value to knowledge assets. Continuous improvements within the team, knowledge-based culture and encouraging direct communication will help organizations to achieve the benefits of lean–agile software and system developments at scale.

Barley et al. (2018) critically reviewed past researches on KM and identified the dominance on knowledge integration rather than differentiation. The current scenario of better technology and agile methodologies considers software professionals as change agents and knowledge as a differentiator, resulting in competitive advantage (Chawla & Joshi, 2012). Though the study had started from an integration viewpoint based on past literature, it further concludes by identifying the dimensions of KA in the software industry and how it can differentiate contributing to effective KM. The study had concluded by differentiating the KA dimensions in such a way that the professionals and management can focus on them to enrich the process to make KM more effective in future.

Conclusion

Past researches had indicated the importance of projects as a platform for application and reconstruction of knowledge in high-tech industries. However, this study measured and tested the impact of PKA on KM. This is a significant contribution as KA was neglected as a value-creation process in software organizations, especially in agile development, where creativity and innovation are imperative. The study also revealed the role of management support in KA. Though the management support is proven as the major dimension, it is obvious that the existing KM paradigm has not given an equal importance to MSKA, compared to projects. The study also proved the mediating role of KA in projects in order to measure the impact of management support on KA and effective KM in the software industry. As the study has differentiated the KA process by identifying the significant areas, it would give the industry an insight into how to revamp the KM practices in such a way that the they can add value to KM in software organizations. The study limits in measuring the effective KM as the perception of software professionals on the processes of creation, storage and transfer in their organizations rather than exploring further to the effectiveness of these processes. As these processes were already well researched, this study prioritized to measure and test variables of KA. The insights into effective KM in the software industry by creating value through KA contribute to the value created for the people and process in the industry.

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