A study of business knowledge requirements for software projects

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Abstract

Purpose – This paper aims to explore the expertise level required in various kinds of business knowledge such as regulatory, domain, strategic, operation process and, business process to execute globally distributed software projects for development, re-engineering and maintenance projects in the Indian outsourcing software industry.

Design/methodology/approach – This study adopted a questionnaire survey method to collect the expert responses for a knowledge management framework which is suggested in the literature for software development work. The questionnaire survey findings were verified by expert interviews.

Findings – The research shows that there is a lot of similarity between re-engineering and maintenance projects for different kinds of business knowledge expertise requirements for execution. The development projects require higher expertise in all the business knowledge for execution.

Research limitations/implications – The research work studies the business knowledge required for the execution of development, re-engineering and maintenance projects in Indian outsourcing software projects. However, the project's characteristics can vary drastically for a single kind of project. So the study cannot be generalized and instead should be used as a tool for learning.

Practical implications – The research findings can be used by software project managers to get insight into project planning, which can help the division of work between the onsite, offshore team and individual work allocation.

Originality/value – The research is novel as there are very few previous attempts to find the business expertise needed to execute various kinds of software projects in the Indian outsourcing industry.

Keywords Business knowledge types, Software projects, Indian outsourcing software projects, New business or process or operations models, Process design, Service design, Knowledge-based systems, Knowledge management, Both

Paper type Research paper

1. Introduction

Effective software solution requires the integration of organizational business knowledge in the domain of technology (Tiwana, 2004a). Software systems are accumulations of business knowledge distributed among various stakeholders in the organization (Baetjer, 1998). Transfer of business knowledge from business users to software developers is essential to develop business software. Information technology work is immensely popular as candidates for outsourcing to save cost and focus on the core competency of the organization (Lacity *et al.*, 2008; Willcocks, 2011). A critical success factor of software development in a globally distributed environment is the effective transfer of business knowledge between offshore and onsite locations (Kobitzsch *et al.*, 2001). Knowledge transfer difficulty is multiplied in the outsourcing environment due to factors related to quality management, project management, language, infrastructure issues and time zone issues (Kobitzsch *et al.*, 2001). There is the loss of communication richness, co-ordination breakdown, geographic dispersion and loss of team cohesiveness (Battin *et al.*, 2001) in global teams. The technology can be learned at a specific location without interaction with other teams from different locations in a global

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development environment. Business knowledge development requires interaction among onsite software developers, business users and offshore software development teams in a global environment. So it is very critical to develop an understanding of various kinds of business knowledge required for software project development especially in the global environment. A dominant percentage of global software outsourcing tasks is carried out by India due to its English-speaking technically qualified manpower available at a cheaper cost compared to their western counterpart (Raman and Chadee, 2011; Peterson and Gott, 2011). This research work makes an attempt toward an understanding of the requirement of different kinds of business knowledge for various software work such as re-engineering, development and maintenance projects in the outsourcing software industry of India.

Mishra and Mahanty (2015) suggested, on the basis of the literature survey, a knowledge-based framework of software development. Their findings were verified by the opinions of experts from India, who are involved in serving global clients in different capacities through multinational organizations. Five different categories of business knowledge were considered, namely, regulatory, strategic, domain, operation process and business process knowledge in the knowledge-based framework. The experts suggested that different kinds of projects require a different combination of business knowledge in the execution process. The communication overhead in various phases of software development is determined by the business knowledge required for execution. Other than their work, we did not find any research which focuses on business knowledge required for different kinds of software projects in the Indian outsourcing software environment. This research work verifies the knowledge management framework suggested by Mishra and Mahanty (2015) and explores the requirements of business and technical knowledge expertise for development, maintenance and re-engineering software projects through a questionnaire survey conducted among the experts of the Indian outsourcing software industry.

This research work tries to answers the following questions below in the Indian outsourcing software industry.

- Comparison of technical and business knowledge (regulatory, domain, strategic, operation process and business process) expertise requirements for executing re-engineering, development and maintenance software projects and
- Assessment of communication time required between various stakeholders in the global development team at the various phases of the software development process such as high-level design (HLL), low-level design (LLD) and system testing (ST) phases for smooth working.

The rest of the paper is organized as follows. In Section 2, we have discussed the relevant literature. The research methodology is explained in Section 3. Section 4 has elaborated the survey results of the questionnaire survey for knowledge requirements in software development. Section 5 discusses the implication of the study. This paper is concluded in Section 6.

2. Literature review

The literature review for the research work has been broadly classified into three categories as software development: integration of business and technical knowledge; global software development: need of knowledge management and global development and knowledge-based theory.

2.1 Software development: integration of business and technical knowledge

The software development process is dependent on business knowledge (Rus and Lindvall, 2002; Robillard, 1999; Walz *et al.*, 1993; Adelson and Soloway, 1985; DeSouza *et al.*, 2006a;

Haamann and Basten, 2019). Business knowledge is combined with technical knowledge to create using software products (Rus and Lindvall, 2002). Business knowledge includes knowledge about business activities, rules, stakeholder needs and overall business objectives. Technical knowledge comprises the pattern of design, best practices, estimation models, design constraints, development tools, languages of programming, code testing and debugging procedure, etc. Tiwana (2004b) found that the black-box approach to software development helps in an outsourcing environment – the vendor organization need not have all the business knowledge and the client organization need not require in-depth technical knowledge to work in a contract. However, lack of domain knowledge consumes a lot of time for software developers to be productive in a team and it can lead to quality and productivity issues (Curtis, 1988). The term domain and domain analysis was coined by Neighbors (1989). Draco was the term coined to define a systematic approach to domain engineering. Afterward, the software reuse and domain engineering were used extensively by the researchers (Kang *et al.*, 2002; Atkinson, 2002; Frakes and Kang, 2005). A good software solution is an effective combination of stakeholder's perspective, technical skills, special expertise and focused business objective for a practical, appropriate and coherent solution (Walz *et al.*, 1993; Rus and Lindvall, 2002).

2.2 Global software development: needs of knowledge management

There is a need to manage the outsourcing lifecycle for better management of global software development (Beulen *et al.*, 2011), which includes processes such as the development of strategy, selection of strategy, relationship building (Berry, 2006). Global software development requires knowledge transfer between offshore and onsite locations to bridge application, domain and technical knowledge gap. The knowledge transfer delay and blockage of knowledge at one location are few knowledge management issues in distributed software development (Desouza and Evaristo, 2006b; Nurdiani *et al.*, 2011; Kotlarsky and Oshri, 2005; Krancher and Dibbern, 2020). The effectiveness of the vendor depends on efficiency in the absorption of business knowledge in the outsourcing environment (Cohen and Levinthal, 1990; Lee, 2001; Dibbern *et al.*, 2008). The knowledge transfer in an outsourcing environment can be structured or unstructured (Chen *et al.*, 2013). The formal planned way of knowledge transfer such as classroom training constitutes a structured process. The spontaneous knowledge transfer in an informal setting constitutes an unstructured process. So both unstructured and structured communication is essential for the smooth functioning of a global software team (Yan, 2004; Carmel, 1999). The knowledge transfer process can be influenced by the nature of knowledge, client-vendor relationship and ability of the client for knowledge dissemination (Easterby-Smith *et al.*, 2008). The client-vendor relationship can be influenced by the dispatching ability of the organization (Park, 2011). There can hindrance in knowledge transfer from client organization to vendor due to various distances such as cultural, temporal, historical, linguistics, institutional and geographic (Levina and Vaast, 2008; Carmel and Abbott, 2007; Sooraj and Mohapatra, 2008; Lacity and Rottman, 2009; Carmel, 1999).

The literature suggests various ways to mitigate the knowledge transfer risks between the onsite and offshore and onsite teams. Effective relationship management is essential to transfer business knowledge specific to client organization in a distributed global team (Youngdahl and Ramaswamy, 2008; Leornardi and Bailey, 2008; Beulen *et al.*, 2005). There is a need for a personal co-ordination mechanism for knowledge transfer constrained due to linguistics, cultural and geographic differences. Both formal and informal mechanisms can be used for effective knowledge transfer irrespective of difficulties due to time zone difference and geographic distance (Leornardi and Bailey, 2008; Im *et al.*, 2005). There are researchers who worked on media richness capabilities for smooth knowledge transfer (DeLuca and Valacich, 2006), but it cannot be a substitute for person-to-person informal interaction for transfer of the tacit knowledge (Oshri *et al.*, 2007; Mattarelli and Gupta, 2009;). The teams at the onsite and offshore locations should be encouraged to interact informally for effective software development in a global environment (Kotlarsky and Oshri, 2005). The cost-benefit of offshoring can be realized with effective business knowledge flow to the offshore location (Oshri *et al.*, 2007).

2.3 Global software development and knowledge-based theory

The organization needs to create, manage and use knowledge from inside and outside their boundaries to sustain in the long term (Nonaka and Takeuchi, 1995; Spender, 1996; Grover and Davenport, 2001; Grant, 1996; Demsetz, 1991). The knowledge can be classified as explicit (codified) or tacit (difficult to document and needs an informal setting to learn) knowledge (Nonaka, 1994; Hansen, 1999; Lagerström and Andersson, 2003; Lane and Lubatkin, 1998; Polanyi, 1966; Kogut and Zander, 1992). Carlile (2002, 2004) defined knowledge boundaries at a semantic, syntactic and pragmatic levels to categorize the knowledge by specialization and novelty. The system performance has been studied by researchers by use of knowledge boundaries (Patnayakuni *et al.*, 2007). The knowledge-based theory can be used to explain knowledge transfer from onsite to offshore locations (Nonaka, 1994; Grant, 1996; Hedlund, 1994; Williams, 2011; Kogut and Zander, 1992). Mishra and Mahanty (2014, 2016 and 2019) applied the knowledge management framework to construct software development models to calculate cost and schedule of re-engineering, development and maintenance projects through system dynamics models.

Transfer of business knowledge is critical for the success of the software development process in a distributed environment. The offshore software development is dependent on smooth business knowledge transfer from onsite location (Khan *et al.*, 2009). Yuan *et al.* (2009) argued that coordination and communication are needed for both explicit and implicit knowledge sharing and mutual trust and project commitment are essential for effective knowledge transfer.

Although there is a discussion in the literature about the importance of business knowledge in software development and issues of knowledge transfer in outsourcing environment, a research gap exists in finding out specific kinds of business knowledge required for the execution of various types of global software projects. The gap is wide particularly in the context of Indian outsourcing software projects. This research work makes an effort to fill this gap.

3. Research methodology

We conducted a questionnaire survey to find out the expert opinion for business knowledge (Regulatory, Domain, Business Process, Strategic and Operation Process) requirements at various phases of the software development lifecycle based on the knowledge-management framework created by Mishra and Mahanty (2015) to understand the working of the Indian software industry. Their research was very qualitative in nature based on the opinion of a small group of experts from the Indian software industry, which can be considered as a major shortcoming in the verification and validation process. The model requires verification from a bigger group of experts through quantitative analysis. We decided to undertake a questionnaire survey to collect a large number of responses regarding the knowledge required for different kinds of software projects which is not possible in the expert interview process. These research works try to fill this gap in the previous research work to verify the findings of their work by quantitative analysis through a questionnaire survey. The results were discussed with experts from the Indian software outsourcing industry to develop insight into the working of software teams.

The framework of knowledge management created by Mishra and Mahanty (2015) from literature was used for the creation of the questionnaire. Figure 1 provides the referenced knowledge management framework adopted from Mishra and Mahanty (2015). The questionnaire is attached in Appendix. Mishra and Mahanty (2015) followed unstructured interviews and the Delphi approach to develop their framework, so a questionnaire study was essential to confirm the findings.

3.1 Survey design

The questionnaire study was conducted among senior professionals in the Indian software outsourcing industry having at least seven years of experience. A pilot study was conducted initially with 12 software professionals to check the reliability and validity of the questionnaire. The response rate was 16% for the main questionnaire survey (64 responses were received out of 400 participants).

The questionnaires were sent to the respondents by email. Apart from that, the researcher met a number of the respondents personally to encourage their time to fill up the questionnaire. In total, 40 responses were obtained in the first round. The rest of the responses (24 in number) were obtained after the questionnaires were sent again. The similarities of both the samples were tested by the ranksum test.

After all the 64 responses were obtained, they were organized according to their thematic similarity. The themes that emerged in this process were not chosen beforehand.

3.2 The questionnaire

The questionnaire was based on different kinds of business knowledge types and technical knowledge requirements for execution of maintenance, re-engineering and development projects using the knowledge requirement framework for software development as suggested by Mishra and Mahanty (2015). The questions were asked on the requirements of technology and business knowledge, business knowledge expertise needs for various kinds and the requirement of communication time with the business users. The respondents were also asked to quantify the time requirements for knowledge transfer in various phases of the software development process. The respondents were requested to provide the amount of time devoted by the software developers in communicating with the business users to

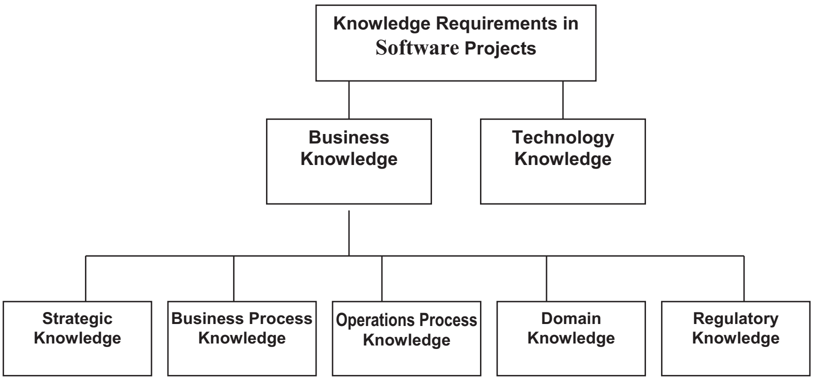

Figure 1. Knowledge requirement hierarchy in software development (adopted from Mishra and Mahanty (2015))

absorb business knowledge for the smooth functioning of maintenance, re-engineering and development projects. The questionnaire is provided in Appendix.

Responses were sought for three phases of software development, namely, high-level design (HLD), low-level design (LLD), system testing (ST) and implementation testing. System analysis was not considered as a separate phase as it is difficult to separate the system analysis phase from the high-level design phases in Indian outsourcing software projects due to the relatively small size of projects. Similarly, implementation testing is usually conducted at an on-site location by the customer employees. The software development team does not play a very critical role in implementation testing.

4. Survey results

Questionnaire study results are presented in the following sections:

- Requirement of technology knowledge,
- Requirement of business knowledge as a whole and
- Requirement of different types of business knowledge (regulatory, domain, strategic, operation process and business process knowledge).

Such knowledge requirements are presented for software project types, namely, development projects, maintenance projects and re-engineering projects. The respondents rated the knowledge requirement on a five-pointer scale which was: "1 – low, 2 – below average, 3 – average, 4 – More than average and 5 – high."

Analysis of the survey results is carried out by comparing different types of projects for a particular type of knowledge required for execution. Such comparisons are carried out by plotting the number of responses against a particular knowledge required for a different kind of projects, using Thurstone's Case V Model of comparative judgment (Green and Tull, 1973) and also by carrying out ranksum test with a significance level of 0.05. The coefficient of agreement between respondents was measured by the use of Kendall's coefficient of concordance.

4.1 Requirement of technology knowledge

The study results show that the complexity of technical knowledge required is high for development projects followed by re-engineering and maintenance projects. In total, 58 of 64 respondents suggested that highly developed or higher than average technology knowledge is required for the execution of development projects. In total, 46 respondents felt that re-engineering projects can be executed with higher than average technology knowledge. Also, 46 respondents suggested that maintenance projects can be managed by average or below average technology knowledge.

The relative ranking calculations are carried out by using Thurstone's Case V Model of comparative judgment (Green and Tull, 1973). The responses for the requirement of technical knowledge were ranked between development, reengineering and maintenance projects with respect to the use of Independent-sum-of-actions (ISA) mode of production. The first step in the calculation of relative ranking is the creation of a requirement proportion matrix obtained from the responses of the respondents. The matrix appears in Table 1 below.

It can be observed from Table 1, that 66.4% of the respondents opined that development projects require a higher level of technical knowledge in comparison to reengineering projects. From the data of Table 1, another table (Table 2) is constructed that summarizes Z values appropriate for each preference proportion. Z values are standard variates that are associated with a given proportion. Z values are areas under a normal curve that a given proportion occupies. Kendall's coefficient of concordance was measured at 69.82%, which is satisfactory for our test.

Figure 2 gives Thustone's interval scale values for all three projects with respect to the requirements of technology knowledge. The number of responses plot is given in Figure 3. The findings show that the mean of the three projects are different whereas the spread is similar.

The hypothesis test results (Table 3) showed that development projects need a higher level of technical knowledge than re-engineering projects. Also reengineering projects need higher technology knowledge in comparison to maintenance projects. The maintenance projects do not need extensive technology as they deal with minor modifications of application systems. The experts agreed with the findings of the survey.

4.2 Requirement of business knowledge

The study result shows that the complexity of business knowledge required is high for development projects followed by re-engineering and maintenance projects. In total, 51 out of 64 respondents suggested that higher than average or highly developed knowledge is required to execute a development project. In total, 36 respondents felt that re-engineering projects can be managed by average knowledge. In total, 55 respondents suggested that the maintenance projects need average and below-average business knowledge for execution. Figure 4 gives the interval scale values for all the three projects with respect to business knowledge requirement using Thurstone's Case V Model of comparative judgment (Green and Tull, 1973) with Kendall's coefficient of concordance value of 65%. The development project is at a higher distance for business knowledge need than maintenance projects and re-engineering projects. The responses plot is given in Figure 5. The findings show that the mean of the three projects are different whereas the spread is similar.

Table 4 shows the results of ranksum tests comparing development vs reengineering and maintenance vs reengineering projects with respect to their requirement of business knowledge with a significance value of 0.05. The results suggest that higher expertise in business knowledge is required for development projects followed by re-engineering and maintenance projects.

Projects	Development (%)	Re-engineering (%)	Maintenance (%)
Development	0	33.6	11.7
Re-engineering	66.4	0	22.7
Maintenance	88.3	77.3	0

Table 1. Requirement of technology knowledge for project execution

4.3 Software development and needs of various type of business knowledge

As stated earlier, five types of business knowledge, namely, domain knowledge, regulatory knowledge, strategic knowledge, business process knowledge and operation process knowledge are required for the smooth execution of software projects. The projects which require higher communication effort from business users are less suitable for outsourcing. The survey results showed that software developers spend a very high percentage of their working time communicating with business users. It can be as high as 90% of the total working time in the high-level design phase of development projects. The relative importance of various business knowledge requirements for different software project types is shown with the help of Thurstone's interval scale in Table 5. Kendall's coefficient of concordance was higher than 60% for all three kinds of projects, which is a good value for the confidence measure.

The respondents opined that the application domain knowledge holds the most relative importance for the development projects, closely followed by business process knowledge, strategic knowledge and operation process knowledge. For the re-engineering projects,

Figure 2.
Interval scale for different projects on technology knowledge requirement

Maintenance (0) **Re-Engineering (0.54)** **Development (1.187)**

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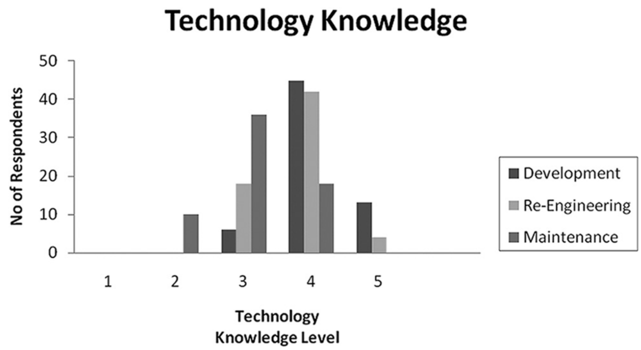

Figure 3.
No. of response plot for technology knowledge requirement

Table 3.
Ranksum test results on project type comparison on technology knowledge

Project type comparison	Ranksum test null hypothesis rejected if $Z > Z_{val}$ for $p = 0.05$	Findings
Development vs re-engineering	$Z = -3.2$; $Z_{val} = -1.96$ Null hypothesis rejected	Development projects need higher expertise in technology knowledge
Re-engineering vs maintenance	$Z = -5.3$; $Z_{val} = -1.96$ Null hypothesis rejected	Re-engineering projects need higher expertise in technology knowledge

operation process knowledge is relatively most important, which is closely followed by application domain knowledge, business process knowledge and strategic knowledge. For the maintenance projects, operation process knowledge requirements are the most important relatively, followed by business process knowledge, application domain knowledge and strategic knowledge. Regulatory knowledge carries the least relative importance among all the knowledge types in three types of software projects. It is to be remembered here that the interval scales, as depicted in Table 5, shows the relative importance of various knowledge requirements for a particular project type. The values are not comparable across project types.

The ranksum test was undertaken for inter-comparison of the projects (Table 6) with respect to different business knowledge requirements. The F-Test result for communication time is given in Table 7. The F-Test was used for hypothesis testing with a 95% confidence interval. The hypothesis testing is done in pairs between development projects, maintenance projects and re-engineering projects. The critical value for degrees of freedom (1,127) is 3.92. So we reject the null hypothesis if the calculated F value is more than 3.92. Table 8 provides the mean communication time for the transfer of business knowledge at various phases of the software development process.

Figure 4. Interval scale for different projects on business knowledge requirements

Maintenance (0) **Re-Engineering (0.277)** **Development (1.214)**

|--------------|------------------------------------|-------------------

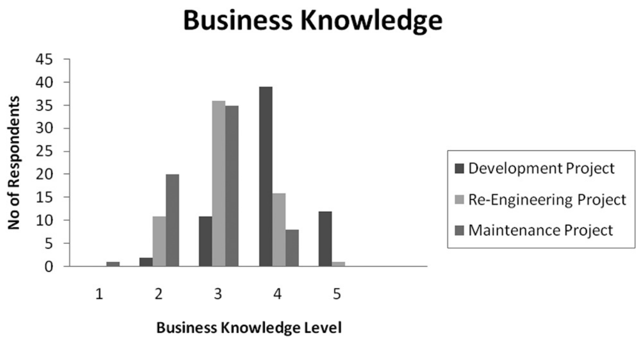

Figure 5. No. of response plot for business knowledge requirement

Table 4. Ranksum test results on project type comparison on business knowledge requirement

Project type comparison	Ranksum test null hypothesis rejected if $Z > Z_{val}$ for $p = 0.05$	Findings
Development vs re-engineering	$Z = -6.07$; $Z_{val} = -1.96$ Null hypothesis rejected	Development projects need higher expertise in business knowledge
Re-engineering vs maintenance	$Z = -2.26$; $Z_{val} = -1.96$ Null hypothesis rejected	Re-engineering projects need higher expertise in business knowledge

Domain Knowledge	Regulatory Knowledge	Strategic Knowledge	Business Process	Operation Process
0.688	0.000	0.502	0.554	0.478

(a)

Domain Knowledge	Regulatory Knowledge	Strategic Knowledge	Business Process	Operation Process
0.572	0.000	0.386	0.528	0.634

(b)

Domain Knowledge	Regulatory Knowledge	Strategic Knowledge	Business Process	Operation Process
0.764	0.000	0.262	0.864	1.010

(c)

Notes: (a) Development project; (b) reengineering Project ; (c) maintenance Project

Table 5.
Interval scales for the relative importance of various business knowledge types

The maintenance projects do not have specific SA, HLD, LLD and ST Phases. In contrast to the re-engineering and development projects, the major effort in maintenance projects is expended in a smooth transfer of the work to the offshore location without causing trouble to the work schedule. A phase-wise approach is adopted to transfer the maintenance work to an offshore location. As per Mishra and Mahanty (2015), the maintenance project knowledge transfer to an offshore location can be divided into four phases given below. The business knowledge transfer can be different in various phases of maintenance work transfer to an offshore location.

- First phase (knowledge transfer phase): The classroom sessions are conducted by the onsite team to train the offshore team members. All the maintenance tickets are worked on by the onsite team and there is no work accomplished at the offshore location.
- Second phase (little work offshore and more work onsite): The offshore team starts working on live maintenance tickets with help of the onsite team. However, the responsibility of work stays with the onsite team.
- Third phase (more work offshore and little work onsite): Most of the maintenance tickets are transferred to the offshore location. A skeletal team is maintained at the onsite team for difficult situations.
- Fourth phase (steady-state): All the work in the maintenance system is carried at the offshore location and the onsite team does not exist. The offshore team directly communicates with business users to understand the requirement to work on tickets.

4.3.1 Domain knowledge requirements. The domain knowledge is concerned with the application domain of the software product such as banking and insurance. The survey shows that development projects need more detailed domain knowledge than re-engineering and maintenance projects to create a useful information technology product for the organization.

Knowledge type	Project type comparison	Ranksum test null hypothesis rejected if $Z > Z_{val}$ for $p = 0.05$	Findings
Domain knowledge	Development vs re-engineering	$Z = -5.0$; $Z_{val} = -1.96$ Null hypothesis rejected	Development projects need higher expertise in application domain knowledge
	Re-engineering vs maintenance	$Z = -1.6$; $Z_{val} = -1.96$ Null hypothesis could not be rejected	Maintenance and re-engineering projects need the same application domain knowledge
Regulatory knowledge	Development vs re-engineering	$Z = -4.97$; $Z_{val} = -1.96$ Null hypothesis rejected	Development projects need higher expertise in regulatory knowledge
	Re-engineering vs maintenance	$Z = -0.46$; $Z_{val} = -1.96$ Null hypothesis could not be rejected	Maintenance and re-engineering projects need the same regulatory knowledge
Strategic knowledge	Development vs re-engineering	$Z = -2.15$; $Z_{val} = -1.96$ Null hypothesis rejected	Development projects need higher expertise in strategic knowledge
	Re-engineering vs maintenance	$Z = -2.44$; $Z_{val} = -1.96$ Null hypothesis rejected	Re-engineering projects need higher expertise in strategic knowledge
Business process knowledge	Development vs Re-engineering	$Z = -4.54$; $Z_{val} = -1.96$ Null hypothesis rejected	Development projects need higher expertise in business process knowledge
	Re-engineering vs maintenance	$Z = = -0.87$; $Z_{val} = -$ 1.96 Null hypothesis could not be rejected	Maintenance and re-engineering projects need the same business process knowledge
Operation process knowledge	Development vs re-engineering	$Z = -2.31$; $Z_{val} = -1.96$ Null hypothesis rejected	Development projects need higher expertise in operation process knowledge
	Re-engineering vs maintenance	$Z = -0.01$; $Z_{val} = -1.96$ Null hypothesis could not be rejected	

Table 6. Ranksum test results on project type comparison for various business knowledge requirements

The survey suggests that communication time for domain knowledge is higher in a development project in comparison to re-engineering projects at high-level design and low-level design phase similar to expert opinion as suggested by Mishra and Mahanty (2015). Although the ranksum test suggested that re-engineering projects need the same expertise level in the domain level in comparison to maintenance projects, the F-Test on communication time showed that maintenance projects require higher communication time in the second quarter compared to the low-level design phase of re-engineering project for transfer of domain knowledge. The experts suggested that the offshore team spend the first two quarters for training rather than working on a live system in maintenance projects. So it shows higher communication time for the second quarter.

4.3.2 Regulatory knowledge requirement. The survey shows that the development projects need more detailed regulatory knowledge than re-engineering and maintenance projects. The regulatory knowledge requirement is similar in re-engineering and maintenance projects. The experts suggested that all the team members need not be knowledgeable about the regulations in the application domain as the project team leader would help the team in complying with the regulatory requirement in consultation with the

Knowledge type	Project type comparison	Null hypothesis	Phase	Calculated F value	Null hypothesis rejected
Domain knowledge	Development vs re-engineering	Development and reengineering projects need the same communication time for domain knowledge	HLD LLD ST	5.52 5.56 1.02	Yes Yes No
	Re-engineering vs maintenance	Maintenance and re-engineering projects need the same communication time for domain knowledge	HLD (1st Q) LLD (2nd Q) ST (3rd Q)	0.21 8.23 0.33	No Yes No
Regulatory knowledge	Development vs re-engineering	Development and re-engineering projects need the same communication time for regulatory knowledge	HLD LLD ST	0.02 0.78 0.49	No No No
	Re-engineering vs maintenance	Maintenance and reengineering projects need the same communication time for regulatory knowledge	HLD (1st Q) LLD (2nd Q) ST (3rd Q)	0.7 0.73 2.02	No No No
Strategic knowledge	Development vs re-engineering	Development and re-engineering projects need the same communication time for strategic knowledge	HLD LLD ST	4.78 1.54 0.1	Yes No No
	Re-engineering vs maintenance	Maintenance and re-engineering projects need the same communication time for strategic knowledge	HLD (1st Q) LLD (2nd Q) ST (3rd Q)	0.78 0.02 1.07	No No No
Business process knowledge	Development vs re-engineering	Development and re-engineering projects need the same communication time for business process knowledge	HLD LLD ST	8.86 1.82 1.33	Yes No No
	Re-engineering vs maintenance	Maintenance and re-engineering projects need the same communication time for business process knowledge	HLD (1st Q) LLD (2nd Q) ST (3rd Q)	0.26 2.41 0.2	No No No
Operation process knowledge	Development vs re-engineering	Development and re-engineering projects need the same communication time for operation process knowledge	HLD LLD ST	1.82 1.89 0.2	No No No

(*continued*)

Table 7.

Table 7.
F-test result for communication time

Knowledge type	Project type comparison	Null hypothesis	Phase	Calculated F value	Null hypothesis rejected
	Re-engineering vs maintenance	The maintenance project and re-engineering projects need the same communication time for operation process knowledge	HLD (1st Q)	2.22	No
			LLD (2nd Q)	4.81	Yes
			ST (3rd Q)	0.98	No

Table 7.

Project type	Software phases	Mean communication time in an hour per 8-h day for various business knowledge: Domain	Regulatory	Strategic	Business process	Operation process
Development project	High-level design	1.45	0.69	1.03	1.70	1.27
	Low-level design	0.62	0.44	0.48	1.07	1.14
	Software testing	0.53	0.35	0.40	0.96	0.86
Re-engineering project	High-level design	1.11	0.68	0.80	1.30	1.10
	Low-level design	0.45	0.39	0.40	0.87	0.94
	Software testing	0.45	0.39	0.38	0.76	0.80
Maintenance project	1st quarter	1.05	0.62	0.72	1.23	1.31
	2nd quarter	0.69	0.44	0.41	1.08	1.25
	3rd quarter	0.50	0.30	0.29	0.83	0.93
	4th quarter	0.42	0.25	0.22	0.79	0.75

Table 8. Mean of communication time for various business knowledge types in a day

business user. The suggestion was similar to expert opinion as explained by Mishra and Mahanty (2015). The F-Test also did not show the difference between maintenance, development and re-engineering projects in this regard. The experts suggested that it is very difficult to separate regulatory knowledge from domain knowledge for a practical purpose.

4.3.3 Strategic knowledge. The strategic knowledge is related to the organizational requirement of the software product. The survey results showed that development projects need a higher level of strategic knowledge compared to re-engineering or maintenance projects. This is due to fact that development projects create a new product, which should be useful for the organization to achieve its overall organizational goal. The re-engineering projects, on the other hand, create the same functional product with new technology. In this case, the project team needs to be aware of the strategic aspect of the project to be re-engineered. As the maintenance projects are only concerned with minor modification of an application system, the requirement of strategic knowledge is less.

The development projects need a high level of communication effort to gather strategic knowledge in the high-level design phase. Although the ranksum tests showed that re-engineering projects need more strategic knowledge than maintenance projects, the survey suggested that there is not much need for communication efforts in either re-engineering or maintenance projects to gather strategic knowledge. This is because software engineers can gather strategic knowledge from already developed project manuals in such projects.

The experts also suggested that strategic knowledge requirements can vary drastically from project to project. For example, a data warehousing software project would need significantly more strategic knowledge in comparison to a project developing online transaction processing software. This is because the data warehousing software need to create a number of reports which help the top management in providing an intelligent decision support system. The project requiring higher expertise in strategic knowledge is difficult to outsource as it requires higher interaction with senior management in the organization.

4.3.4 Business process knowledge. Business process knowledge is related to the overall business architecture of the software product. The survey results showed that development projects need a higher level of business process knowledge compared to re-engineering or maintenance projects. Again such requirements of business process knowledge are more in the phase of high-level design in development projects. The survey suggested that, for re-engineering and maintenance projects, business process knowledge can be gathered from the existing application system. Thus, the process of acquiring business process knowledge is comparatively less challenging in such projects.

4.3.5 Operation process knowledge. The research findings for the operational process knowledge are similar to that of business process knowledge. Development projects need higher operations process knowledge in comparison to the other two types of projects. Operations process knowledge requirements are very similar in re-engineering and maintenance projects. Because operations process knowledge is readily available, acquiring such knowledge is easy for such projects. The F-Test shows higher communication time in maintenance projects in the second quarter compared to the low-level design phase of re-engineering projects. This is due to the training need for offshore resources in the initial quarters of maintenance projects.

5. Discussion and implications

Various kinds of software projects require a varying amount of business and technology knowledge. The knowledge requirements in a software project guide the project execution-style and also the development process. It is, therefore, important for a project manager to study the business and technology knowledge requirements in detail for various phases of the software for effective management of the project.

The development projects require a high level of expertise in domain knowledge. A project manager managing a development project should, therefore, ensure that a high level of domain knowledge is acquired by the project team. The project manager should hire persons for the development team, who can provide domain knowledge to the team members. The build-up of other kinds of business knowledge is also dependent on the level of domain knowledge acquired. With a low level of expertise in domain knowledge, a development team will also suffer in acquiring other kinds of business knowledge. The strategic, business process and operations process knowledge can be provided by the customer organization and people associated with these functionalities. So there should be high interaction between onsite and offshore teams for knowledge flow. The project manager should ensure a high level of interaction of the development team with various stakeholders of the project. The interaction can be achieved by the use of technology, onsite-offshore travel and other informal methods. The optimal process and execution-style can vary for different projects considering the knowledge level of the team and different external and internal constraints.

The reengineering and maintenance projects exhibit similar characteristics for various kinds of knowledge requirements. The business process and operations process knowledge assume greater significance compared to the domain and strategic knowledge. The expertise level required for strategic knowledge is rather low. So the project manager can start the project execution after the development team has acquired an initial level of the domain and strategic knowledge. The requirement of interaction with the onsite team is also low for strategic knowledge build-up in reengineering and maintenance projects. The self-learning process can be initiated in the project team after only an initial build-up of domain, business process and operations process knowledge. The current live application can be a learning tool. Generally, only a handful of modules require greater effort in a maintenance project. So a project manager should ensure that operations process knowledge of these critical modules is available in the team. The repetitive nature of maintenance projects helps the developers to gradually build up the knowledge required for improving productivity.

We did not observe the communication time pattern in various phases of software development for development, re-engineering and maintenance projects as suggested by Mishra and Mahanty (2015). For example, the experts opined that the communication requirement for operation process knowledge will achieve the highest intensity in the LLD phase of a development project. However, the questionnaire study showed that communication effort for operation process knowledge is highest in the HLD phase. The experts suggested a few of the reasons for the difference in findings. The development projects executed in the Indian industry are very small in nature. It is difficult to differentiate communication time between various kinds of business knowledge in a real-life scenario. Also, there is greater stress on documentation for software project execution in an outsourcing environment and the work is executed at the onsite location where communication need is higher in the team. These factors may because of the difference in the questionnaire study.

6. Conclusion

The literature discusses the importance of business knowledge in software development (Tiwana, 2004a, 2004b; Haamann and Basten, 2019) and knowledge transfer issues in global software development (Krancher and Dibbern, 2020). Except for Mishra and Mahanty (2019), there is no effort to find out the requirement of various kinds of business knowledge for different projects. We tried to address the limitation of their study to identify the requirements of technology and business knowledge for carrying out different types of outsourcing software projects in the context of India with the help of a detailed questionnaire study among software practitioners. The success of developing software projects depends on the transfer of technology and business knowledge from business users to the team members. The development projects require higher expertise in technology and various kinds of business knowledge such as strategic, business process, operation process, regulatory and domain knowledge for effective execution. So development projects are not very popular candidates for outsourcing and are executed at onsite locations. The re-engineering and maintenance projects, on the other hand, require significantly less amount of technology and business knowledge.

The research findings could be very useful in the study of the working of the software firms in global software development. An overall understanding of the technology and business knowledge needs would lead to the selection of appropriate project personnel, formation of the software team and the communication requirements. The business user team should provide proper business knowledge to the software development team. The software project managers should ensure rich communication of the required knowledge among the software project team members. Similarly, the establishment of appropriate communication channels between the team members and the business users is vital for the successful implementation of the software project.

The current research work can be extended to apply the knowledge management framework to other global operations such as BPO, KPO and business analytics. which are very popular candidates in the outsourcing environment. This is especially important in a post-COVID world where remote teams will be the norm and the dissemination of knowledge across remote teams and geographies will be a challenge for software development. The evaluation of various kinds of business knowledge can be undertaken for these processes before the outsourcing decision is formalized. The team structure, work division and workflow pattern to the offshore location can be formalized based on business knowledge need at an onsite and offshore location.

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Appendix

QUESTIONNAIRE

Please Assume Application Software Development, Re-Engineering and Maintenance for all questions. We are not considering other kinds of software work like server maintenance, network support, infrastructure management, call center, BPO, KPO and consulting work etc.

1. The software development process involves integration of business knowledge and technology knowledge. The business knowledge involves information about business domain and the technology knowledge involves knowledge about capability of technology involved in the application development.

   Please rate significance of each type of knowledge for various kinds of software development. Here significance means that amount of knowledge necessary to perform the job.

   1 - Little knowledge, 2 – Below average knowledge,
   3 – Average knowledge, 4 – Better than average knowledge,
   5 – Highly developed Knowledge.

   Significance of Business and Technology Knowledge

	Development Project	Re-Engineering Project	Maintenance Project
Business Knowledge			
Technology Knowledge			

   Remarks:

2. The business knowledge is comprise five distinct types of knowledge, which are:

   Strategic Knowledge: The strategic knowledge defines the organizational problems to be solved and their organizational solutions. Basically it is the bird's eye view of the application system. It gives uses of application system at higher level.

   Example – Let us take an example of report generation application in an insurance company. The strategic knowledge defines the use of the application, its relationship with other applications like claim processing and its importance to overall business goal.

   Domain Knowledge: It compromises the domain knowledge of the application system. The examples are being insurance, finance etc.

   Business Process Knowledge: The business process layer describes the business processes architecture at the conceptual and the organizational levels. So it is the higher level knowledge of business application. **This can be taken as knowledge one level below strategic level.**

   Example – Here we are considering an example of claim processing application for an insurance company. The overall flow of application starting from customer claim, the linkages with rules and regulation of the organization, verification process for authenticity of claim, clearing of money constitute business process knowledge.

   Operation Process Knowledge: This is the day to day activities performed by end user to fulfill organizational business goal. So it can be taken as business process at lower level. So it constitutes of very detailed knowledge of a small process. It also comprise of processes, software and hardware tool used by the customer.

   Example – The verification of authenticity of the claim in claim processing is an example of operational process knowledge.

   Regulatory Knowledge: This knowledge is required to fulfill governmental rules and regulations in a specific country. Some noted examples are HIPPA for healthcare industry and Sarbanes Oxley for financial industry etc.

   How much business knowledge of various kinds is necessary to perform the software development? Please rate the importance of each type of knowledge for various projects?

Figure A1.
Questionnaire survey

(*continued*)

1 - Little knowledge, **2 – Below average knowledge,**
3 – Average knowledge, **4 – Better than average knowledge,**
5 – Highly developed Knowledge.

Importance of various kinds of business knowledge in software projects

	Development Project	Re-Engineering Project	Maintenance Project
Strategic Knowledge			
Domain Knowledge			
Business Process Knowledge			
Operational Process Knowledge			
Regulatory Knowledge			

Remarks:

3. How many **hours of communication are necessary everyday with business** user during various phases of software development cycle? **Please give a number range in hours. Please assume co-located team for the question. Please assume that total number of working hours in a day is 8. So total hour in a one phase of the project cannot exceed 8. Please fill your response in next page.**

Hours spend in communication in co-located team

DEVELOPMENT PROJECT

	System Analysis, High Level Design	Low Level Design, Coding & Unit Testing	System Testing
Strategic Knowledge			
Domain Knowledge			
Business Process Knowledge			
Operation Process Knowledge			
Regulatory Knowledge			

RE-ENGINEERING PROJECT

	System Analysis, High Level Design	Low Level Design, Coding & Unit Testing	System Testing
Strategic Knowledge			
Domain Knowledge			
Business Process Knowledge			
Operation Process Knowledge			
Regulatory Knowledge			

MAINTENANCE PROJECT

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Strategic Knowledge				
Domain Knowledge				
Business Process Knowledge				
Operation Process Knowledge				
Regulatory Knowledge				

Remarks:

Figure A1.