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Knowledge transfer challenges and mitigation strategies in global software development – A systematic literature review and industrial validation

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Abstract *Context:* In this article we considered knowledge transfer (KT) in global software development (GSD) from two perspectives, state-of-the-art and state-of-the-practice, in order to identify what are the challenges that hamper the success of KT in global software teams, as well as to find out what are the mitigation strategies that can be used to overcome such challenges. *Objectives:* The overall aim of this work is to provide a body of knowledge for enabling successful KT in GSD settings. This is achieved by an in-depth understanding of KT challenges and mitigation strategies, both from the perspective of literature and industry. It also identifies the similarities and differences in challenges and strategies gathered from literature studies and industrial experts. *Methods:* In order to fulfill the aim of the research, we collected data through a Systematic Literature Review (SLR) and conducted interviews with industrial experts. Through the SLR we found 35 primary studies relevant to our objectives. We also conducted eight interviews of experienced industrial professionals from eight different multinational companies world-wide. For analyzing the data we used grounded theory and cross-case analysis. *Results:* In total, 60 different challenges and 79 unique mitigation strategies are identified from both SLR and interview results. The challenges and mitigation strategies are grouped into three core categories of personnel, project and technology factors, thus giving rise to a conceptualization called as 2PT factors. There are greater numbers of challenges and mitigation strategies in the project and personnel factors, highlighting the complex interplay of project-related and human-intensive issues in GSD projects, while the technology factor plays the role as facilitator in transferring knowledge. The study also maps the mitigation strategies to challenges, which can guide practitioners in their selection of strategies to use for overcoming KT challenges in GSD. *Conclusions:* We conclude that effective management of project and personnel factors, facilitated by technological factors, are crucial for a successful transfer of knowledge in GSD projects. Thus in future, the researchers and practitioners need to focus on the 2PT factors for ensuring effective KT in GSD settings.

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1 Introduction

Global Software Development (GSD) is being widely adopted by software organizations worldwide (Carmel and Abbott, 2007; Damian and Moitra, 2006). There are two main reasons for this adoption. First, software projects are growing bigger which ultimately increases the work and personnel requirements (Salger et al, 2010). Secondly there are growing pressures on organizations' maintenance costs and limited availability of skilled onshore employees (Chua and Pan, 2008). By acquiring the GSD phenomenon, software organizations are reducing their costs by replacing expensive onshore employees with offshore resources. In some organizations, this replacements is 65% of their onshore presence (Chua and Pan, 2008). While promising, GSD is faced by a number of challenges. These challenges span to economic, technical, organizational and cultural dimensions due to differences in time zones, languages and geographical locations (Damian and Moitra, 2006).

In GSD, development of software systems involve active collaboration, i.e., software engineers need to understand and communicate over a common system. A successful GSD project is marked by a common understanding among its participants (Keller et al, 2002). An essential element of developing a common understanding is to share knowledge at all stages of software development (Desouza et al, 2006). This is a difficult task as coordinating and integrating multiple knowledge sources (often under time, resource and budgetary constraints) increases complexity (Desouza et al, 2006). Without effective knowledge management practices, success in GSD will be difficult. Managing knowledge in GSD has therefore attracted research interest in recent times (Section 2). There are challenges to overcome in all three facets of knowledge in GSD: acquisition, synthesis and transfer. This paper focusses on knowledge transfer (KT) challenges in GSD and presents solutions to overcome delays or blockages of KT.

Argote and Ingram (Argote and Ingram, 2000) define KT in organizations as "*the process through which one unit (e.g., group, department, or division) is affected by the experience of another*". KT in essence is the sharing of one's ideas, insights, solutions, experiences with another individual (Turban and Volonino, 2010).

Related work shows that KT faces various challenges in GSD. Carmel and Beulen (Carmel and Beulen, 2005) argues that one of the major reasons for failed offshore outsourcing projects in the first few years is unsuccessful KT. Tiwana (Tiwana, 2004) admits that some of the knowledge is so complex and context-dependent that it is difficult to transfer across the client-vendor interface. Reed and Knight (Reed and Knight, 2010) argues that insufficient KT is a risk to virtual team projects. Bender and Fish (Bender and Fish, 2000) argues that ineffective KT leads to an ineffective development and retention of expertise. In order to overcome such challenges in KT, literature offers several models, methods, approaches and some algorithms. However, the challenges in KT proposed by one author differs from another and there is no broad coverage of all challenges related to KT. Also, as mentioned in (Gregory et al, 2009; Gang and Bosen, 2010), few studies focus on *both* vendor and client side challenges and mitigation strategies for KT. Therefore in order to provide a comprehensive coverage of KT challenges and solutions, both from the perspectives of literature and industry, we set out to answer the following research questions in this paper:

RQ 1: What are the challenges faced and the mitigation strategies for effective KT in GSD settings as reported in literature?

RQ 2: What are the challenges faced and the mitigation strategies for effective KT in GSD settings from an industrial perspective?

RQ 3: What can we learn in terms of comparing the literature and the industrial perspectives regarding challenges and mitigation strategies for effective KT in GSD settings?

The results of our study show that the challenges and the mitigation strategies for KT in GSD can be grouped into three core factors of personnel, project and technology. Moreover the study comes up with a map of challenges and mitigation strategies to guide practitioners in the selection of strategies when faced with KT challenges. The rest of the paper is organized as follows: Section 2 presents the related work and Section 3 presents the methodology used in the study. Sections 4 and 5 present the SLR and interview results respectively while the results are compared in Section 6. Threats to validity are presented in Section 7 and the paper is concluded in Section 8.

2 Related Work

In this Section we start with the definition of knowledge and then briefly discuss KT in knowledge management. Section 2.3 discusses the importance of KT in GSD projects as given in literature.

2.1 Knowledge

Literature offers many different definitions for knowledge. In information technology, knowledge is differentiated from data and information. Data can be termed as a collection of facts, measurements and statistics. Husemann and Goodman (Husemann and Goodman, 1999) define data as objective facts describing an event without any judgment, perspective or context. When data is analyzed to add understanding, relevance, meaning and purpose, information is created. Drucker (Drucker, 1988) terms information as data enhanced with relevance and purpose. Knowledge is then the transformation and enrichment of information by personal experience, beliefs and values that add decision-making and actionable strengths. Knowledge, in essence, is information in action (O'Dell and Grayson, 1998).

Two dimensions of knowledge – tacit vs. explicit and individual vs. collective – are widely used. Tacit knowledge is difficult to communicate and articulate. It is highly personal. Explicit knowledge can be articulated in words and numbers and can be shared in the form of data, scientific formulas and specifications (Nonaka, 1994). Individual knowledge is created by and exists in individuals while collective knowledge is created by the collective actions of a group and is composed of cultural norms that exist as a result of working together (Nonaka, 1994; De Long and Fahey, 2000). Based on the combinations of the two dimensions of knowledge, Lam (Lam, 2000) proposed four types of knowledge:

- Embrained Knowledge: Individual - Explicit (e.g. theoretical knowledge).
- Embodied Knowledge: Individual - Tacit (e.g. practical experience).
- Encoded Knowledge: Collective - Explicit (e.g. written rules, procedures).
- Embedded Knowledge: Collective - Tacit (e.g. routines, norms).

2.2 Knowledge management and knowledge transfer

Knowledge management includes the creation, valuation, mapping and indexing, transport, storage, distribution and sharing of knowledge (Coleman, 1999). Among these knowledge management processes, knowledge transfer is especially crucial in the context of globalization and global work assignments and is the focus of this study.

In addition to the definition of KT given by Argote and Ingram (Argote and Ingram, 2000) (Section 1), Davenport and Prusak (Davenport and Prusak, 1998) define KT as:

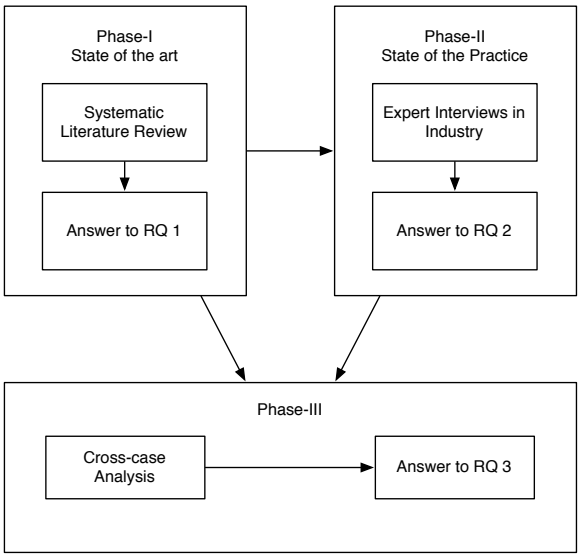
$$\text{Transfer} = \text{Transmission} + \text{Absorption} + \text{Use} \tag{1}$$

Thus KT involves not only the transfer of knowledge but the transferred knowledge is most likely to be used. Reed and Knight. (Reed and Knight, 2010) define KT as a "unidirectional exchange" of knowledge, generally with a clear idea, geared towards a specific receiver and is done with a specific purpose in mind. KT processes are commonly classified into structured and unstructured knowledge transfer. Structured KT is a process of transferring knowledge through formal means and in a planned manner. In contrast, unstructured KT takes place informally and without prior planning (Chen and McQueen, 2010).

2.3 Knowledge transfer in GSD

The important role of KT in GSD is increasingly being emphasized in literature. De Souza et al. (Desouza et al, 2006) argued that delays or blockages of KT is a common knowledge management problem in GSD. The same argument is shared by Kotlarsky and Oshri (Kotlarsky and Oshri, 2005) and Nurdiani et al. (Nurdiani et al, 2011). Herbsleb and Moitara (Herbsleb and Moitra, 2001) pointed out that without effective sharing of information, projects might suffer from coordination problems leading to unsuccessful collaborations. According to Kobitzsch et al. (Kobitzsch et al, 2001), KT issues in outsourced projects fall within planning, programming and project management categories. Emam et al. (Hossain et al,

Fig. 1: Research design of the study.



2009) showed that a number of studies have highlighted collaboration issues as a challenging factor in using Scrum in GSD. KT has also been shown as one of the challenges for distributed software project management (da Silva et al, 2010) while effective knowledge exchange is found to be one of the critical success factors for offshore software development by Khan et al. (Khan et al, 2009).

Betz et al. (Betz et al, 2010) conducted a literature review and expert interviews to highlight some of the issues of KT in offshore outsourced projects. Their study, however, did not cover issues in all collaboration modes in GSD, i.e., offshore insourcing, offshore outsourcing, onshore insourcing and onshore outsourcing. Similarly, Noll et al. (Noll et al, 2011) conducted a literature review on collaboration issues and solutions in GSD but did not focus explicitly on knowledge transfer issues.

3 Methodology

In this section, we describe the research methodology used in our study.

3.1 Research design

The research design of this study consist of three phases:

Phase-I: In this phase we conducted a Systematic Literature Review (SLR), following the guidelines by Kitchenham and Charters (Kitchenham and Charters, 2007). Using an SLR, we extracted KT challenges and mitigation strategies in GSD from existing research papers. In order to analyze the extracted data, we followed the Grounded Theory (GT) approach proposed in (Strauss and Corbin, 1997; Corbin and Strauss, 1990a; Adolph et al, 2011; Strauss and Corbin, 1998). Phase-I of this study helped us answer RQ 1.

Phase-II: Based on the results obtained from Phase-I, we conducted semi-structured interviews with experts. The data thus obtained was again analyzed using GT approach. Phase-II of this study helped us answer RQ 2.

Phase-III: After collecting the data from SLR and expert interviews, a cross-case analysis method (Eisenhardt, 1989) was used to identify the gaps and similarities in the data. This helped us answer RQ 3 and to come up with a mapping of challenges and mitigation strategies from both literature and industrial perspectives.

The research design of the study is shown in Figure 1.

3.2 Phase-I: Systematic literature review (SLR)

According to Kitchenham and Charters (Kitchenham and Charters, 2007), "a systematic literature review is a means of evaluating and interpreting all available research relevant to a particular research question, topic area, or phenomenon of interest". The main phases of an SLR are (Kitchenham and Charters, 2007):

Planning the SLR – In this phase we define the SLR protocol which includes defining the rationale of the SLR, research questions and strategies for searching literature, selecting primary studies, assessing the quality of studies, extraction of relevant data and synthesizing the extracted data.

Conducting the SLR – After planning the review protocol, the actual conduct of the SLR can begin which includes performing the following set of activities: identification of research, study selection, study quality assessment, data extraction and data synthesis.

3.2.1 The need for this SLR

The need for this SLR arises from the requirement of summarizing all existing information about KT challenges and mitigation strategies in GSD in a thorough and unbiased manner. This is significant due to the important role of KT in global software assignments (Section 2.3).

3.2.2 Research question for our SLR

Our SLR addresses the following research question:

RQ 1: What are the challenges faced and the mitigation strategies for effective KT in GSD settings as reported in literature?

It is suggested to use PICOC (Population, Intervention, Comparison, Outcome and Context) criteria to structure research questions for a SLR (Petticrew and Roberts., 2005). However only population, intervention and outcome are relevant for our research question:

Population: Global software development and associated synonyms.

Intervention: Knowledge transfer and associated synonyms.

Outcome: Challenges and mitigation strategies for KT in GSD.

3.2.3 Generating a search strategy

The search string for finding relevant studies was constructed by joining the terms for population, intervention and outcome with an AND operator. The synonyms for each population, intervention and outcome were joined using an OR operator. We also used the wild card operator ($*$) where required. Due to the length of our search string, we had to realign a few keywords for the IEEEXplore digital library. Therefore we had to come up with two search strings which were semantically same. The search strings are shown in Table 1.

The following electronic databases were used in our search for relevant studies:

1. IEEEXplore.
2. Engineering Village (Compendex & Inspec).
3. ScienceDirect.
4. ISI Web of Science.
5. ACM Digital Library.
6. Wiley Inter Journal Science.
7. Springer Link.

Zotero (a freely available bibliography management tool[1]) was used to record search results from each database and to remove duplicates. The starting year of our search was 1999 as it is argued that GSD gained momentum only in the beginning of the 21st century (Friedman, 2007; Šmite et al, 2010).

[1] http://www.zotero.org/

Search string 1	Database
(("global software development" OR "collaborative software development" OR "global software engineering" OR "distributed Software development" OR "distributed software engineering" OR "offshore software development" OR "offshore software engineering" OR "geographically distributed software development" OR offshor* OR "software outsourcing" OR "software outsource" OR "globally distributed software development" OR "offshore outsourcing" OR "Dispersed teams" OR "distributed teams" OR "virtual teams" OR "globally distributed work" OR "global software teams" OR outsour*) AND ("knowledge transfer" OR "knowledge shift" OR "knowledge exchange" OR "knowledge distribution" OR "tacit knowledge" OR "explicit knowledge" OR "knowledge transfer process" OR "knowledge flow" OR "organizational knowledge transfer" OR "knowledge acquisition")) AND (risk* OR challenge* OR tool* OR method* OR Problem* OR challeng* OR barrier* OR "best practices" OR model* OR techniq* OR strateg* OR approach* OR process* OR solution* OR obstacle* OR "risk analysis" OR effect* OR "risk factors" OR selection* OR mechanism* OR assesment* OR "evaluation process" OR practice* OR mitigat*)	Compendex/Inspec, ScienceDirect, ISI Web of Science, ACM Digital Library, Wiley Inter Journal Science, Springer Link
Search string 2	Database
(("global" OR "distributed" OR "collaborative" OR "offshore" OR outsourc* OR "geographically distributed" OR "virtual" OR "dispersed" OR "offshore software") AND (software development OR software engineering OR team)) AND (("knowledge" OR "tacit knowledge" OR "explicit knowledge") AND (transfer OR "information" OR distribution OR flow OR acquisition)) AND (risk* OR challenge* OR tool* OR method* OR Problems OR challenges OR barriers OR "best practices" OR models OR techniques OR strategies OR approaches OR process OR solutions OR obstacles OR selections OR mechanisms OR assessment OR practice OR mitigation OR "risk factors" OR "evaluation process")	IEEEXplore

Table 1: Search strings for the SLR.

3.2.4 Study selection criteria

After formulating a search string, explicit inclusion and exclusion criteria were established to make sure that we only have relevant studies for further analysis. We included studies that:

- were available in full-text.
- were published between year January 1999 and March 2011.
- were written in English.
- were peer-reviewed.
- were within the domain of GSD.
- discuss KT challenges and/or mitigation strategies.

We excluded studies that:

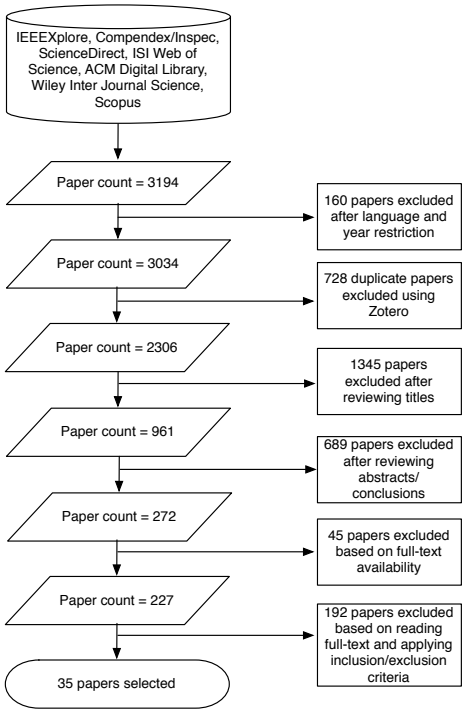
- were related to KT but not related to GSD.
- were not available in full-text.
- were not related to our RQ.
- were outside the time span of our search.

The study selection was done using a tollgate approach, as in (Afzal et al, 2009). After searching in all 7 databases, we got a set of 3194 studies. After including only English language papers and restricting the year of publishing between January 1999 and March 2011, we were left with 3034 studies. Out of these 3034 studies, 728 were duplicates and were removed using Zotero. For the remaining 2306 studies, 1345 studies were excluded based on title review and 689 studies were further excluded after reading the abstracts and conclusions. 45 studies were excluded because of non-availability of full-text. Finally after reading the full text of remaining papers and applying the inclusion/exclusion criteria, 35 papers were selected. Table 2 and Figure 2 shows the number of articles that were refined in each stage of our selection criteria for different databases.

#	Databases	Papers found	English language / Time span	Title review	Abstract / Conclusions review	Availability of full-text	Reading full-text/applying inclusion, exclusion criteria
1	IEEEXplore	1401	1401	421	59	53	6
2	Compendex/Inspec	325	274	119	47	32	10
3	ScienceDirect	547	498	165	28	22	4
4	ISI Web of Science	63	63	27	19	18	0
5	ACM Digital Library	163	163	73	31	29	4
6	Wiley Inter Journal Science	97	93	36	17	14	3
7	Scopus	598	542	120	71	59	6
	Total	3194	3034	961	272	227	35

Table 2: Number of papers refined during each stage of study selection.

Fig. 2: Study selection process.



3.2.5 Study quality assessment

The purpose of quality assessment is to make a decision regarding the overall quality of the selected papers. This helps further scoping of the literature review. We developed the following quality assessment criteria to evaluate selected papers:

1. Is the topic addressed in the research paper relevant to our SLR?
2. Is there any description of KT risks or challenges in GSD in the research paper?
3. Is the research methodology clearly specified in the paper?
4. Are the results of the research paper relevant for our SLR?
5. Has the approach been validated on a certain scale (either in academia or/and industry)?

We assessed the quality of a paper as either high, medium or low depending upon its score on each of the above mentioned quality assessment criteria. If the paper satisfied a criterion, it was given a score of 1. If the paper partially satisfied a criterion, it was given a score of 0.5. If it did not satisfy the criterion, it was given a score of 0. We considered the paper's quality as high if it scored above or equal to 3, medium if it scored between 1 and less than 3, low if it scored below 1. The results of applying the quality assessment criteria is given in Table 3. It is to be noted that no further paper was excluded from

the set of 35 papers obtained at the end of study selection phase. Thus the primary studies of our SLR comprised of 35 papers (listed in Appendix B).

Paper	QC1	QC2	QC3	QC4	QC5	Total
P1	1	1	1	0	0	3
P2	0.5	0	1	1	1	3.5
P3	1	1	1	1	1	5
P4	1	0.5	1	0.5	0.5	3.5
P5	1	0.5	0.5	1	0.5	3.5
P6	1	1	0.5	0.5	0.5	3.5
P7	1	1	1	1	1	5
P8	1	1	1	1	0	4
P9	1	1	1	1	1	5
P10	1	1	1	0	0	3
P11	1	0.5	0.5	0.5	0.5	3
P12	1	1	1	1	1	5
P13	0.5	0.5	0	0.5	0	1.5
P14	1	1	1	1	1	5
P15	1	1	1	1	1	5
P16	1	1	1	0.5	0.5	4
P17	1	0.5	1	1	0.5	4
P18	1	1	1	1	0.5	4.5
P19	1	1	1	1	1	5
P20	1	1	1	1	0	4
P21	1	1	1	1	1	5
P22	1	1	1	1	1	5
P23	1	1	1	1	1	5
P24	1	1	1	1	1	5
P25	1	1	1	1	1	5
P26	1	1	1	1	1	5
P27	1	1	0.5	0.5	0.5	3.5
P28	1	1	1	0.5	0.5	4
P29	1	1	1	1	1	5
P30	1	0.5	0.5	0.5	0.5	3
P31	0.5	1	1	0.5	0.5	3.5
P32	1	1	1	1	1	5
P33	0.5	0.5	0	0.5	0.5	2
P34	1	1	1	1	1	5
P35	1	0.5	0.5	0.5	0.5	3

Table 3: Score of each paper on quality assessment criteria. Column 'Paper' contains labels to the original papers to be found in Appendix B. QC is short for Quality Criterion.

3.2.6 Data extraction for SLR

Out of our 35 primary studies, 22 were journals and 13 were from conferences. The data extraction was divided into general information and specific information. The general information consisted of publication venue, date of data extraction, title of the paper and name of the publication database. The specific information extracted consisted of challenges/issues in KT in GSD, proposed mitigation strategies (if any), validity threats, type of research method used and extent of validation.

3.2.7 Data synthesis for SLR

Data synthesis for an SLR includes summarizing and combining the results of the included primary studies (Kitchenham and Charters, 2007). Our synthesis is mainly descriptive (qualitative). We followed the Grounded Theory (GT) approach as proposed by Strauss and Corbin (Strauss and Corbin, 1998, 1990). The intent of GT is to generate or discover a theory that explains a process, action or interaction on a topic (Creswell, 1998). The theory is grounded in data from participants who have experienced the process. The theory generation process in GT involves coding strategies, i.e., breaking down of raw data into distinct units of meaning. The researcher begins with *open coding* which is concerned

with identifying, naming, categorizing and describing the events found in the text, i.e., the researcher structures categories of information about the incident being studied from the initial data gathered. All open codes have as much as close meaning to the raw data as possible (Strauss and Corbin, 1997; Corbin and Strauss, 1990b). From this, *axial coding* emerges which involves gathering of open codes together, i.e., constraining of similar open codes in to respective axial codes. This type of coding is useful to shorten the process rather than looking for entire relations (Strauss and Corbin, 1997; Corbin and Strauss, 1990b). The axial codes are also referred to as *concepts*. The final step in the coding is *selective coding* in which a core category is chosen and all concepts are related to that core category. The basic aim is to develop a single action around which everything else is covered. The theory developed in the end can take several forms, such as a narrative statement, a visual picture, or a series of hypotheses or propositions (Creswell, 1998).

There were several reasons that motivated us to choose GT as the data analysis method:

1. GT suits the overall goal of our data analysis, i.e., we want to look for patterns and trends in the qualitative data which takes advantage from well-defined coding strategies in GT.
2. Strauss and Corbin (Strauss and Corbin, 1990, 1998) propose systematic and structured procedures for conducting GT.
3. There is a lack of an integrated theory in literature as to how companies deal with KT issues in GSD. The theory generation process of GT offered the greatest promise to move towards building such a theory.
4. KT in GSD is a human intensive activity. GT is known for its application to human behavior (Martin and Turner, 1986).

The following example illustrates how open, axial and selective coding strategies were framed. The example contains excerpts from two primary studies of our SLR (P6 and P21). We denote them as Data X and Data Y.

Data X: *[. . .] during knowledge transfer process one of the key problems identified was the participant's willingness to say yes to everything even when they did not understand what had been presented. A respondent in this research stated "I asked where people worked and these two guys worked in technology X and I thought they were experts in technology X they had worked there for the last two years. It turned out they knew very little about it [. . .]"* [P6].

Data Y: *"[. . .] In this article, a major challenge to KT can exist because knowledge source may fear the loss of control or ownership, so knowledge sender may be reluctant to devote time and resources to the transfer of knowledge [. . .]"* [P21].

From Data X it is clear that the participant's behavior exhibits only superficial KT. We gave such a challenge an open code: "Willingness to say 'Yes' even when there is no knowledge gained". Data Y show another challenge in KT, i.e., the sender is reluctant to transfer knowledge. We gave it an open code: "Sender reluctant to transfer knowledge". Since both of these open codes relate to personal behaviors, they were given an axial code of "personal attributes". Finally personal attribute subsumed in the selective code of "Personnel factors".

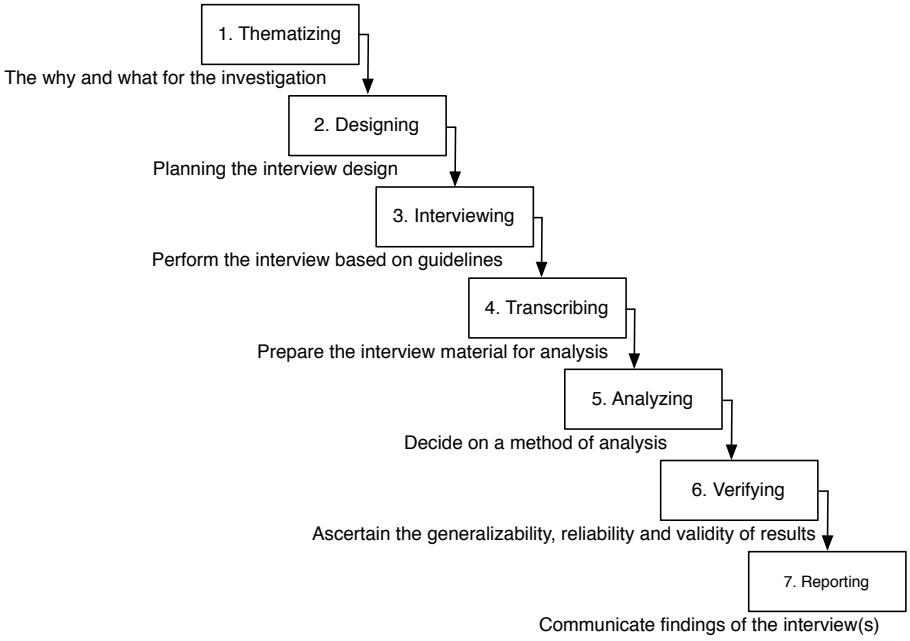
3.3 Phase-II: Interviews

The Phase-II of our study included conducting expert interviews to cover state-of-practice with respect to KT issues in GSD. This helped us answer RQ 2. We resorted to conducting semi-structured interviews as it gives freedom to the researcher to pose both open-ended and closed-ended questions. Moreover semi-structured interviews pose no limit on how much data is to be collected for analysis (Kvale, 1996). The interview questions were prepared taking guidance from the results of Phase-I of our study.

According to Kvale (Kvale, 1996), there are seven stages of an interview investigation (Figure 3):

1. Thematizing: Thematizing involves formulating the purpose of the investigation and to clarify the concept/topic to be investigated before starting the interviews. The purpose of our interview was to gather as much information as possible regarding KT issues faced by experts working in actual software projects and different practical strategies to deal with such issues. Before start of the interviews, the interviewees were contacted via email invitations. They were informed about the purpose of the interview and the concept under investigation, i.e., KT issues and mitigation strategies in GSD.

Fig. 3: Interview stages (Kvale, 1996).



2. Designing: The interviews have to be planned and designed to obtain intended knowledge. This involves taking into consideration all seven stages of conducting an interview. By following Kvale's guidelines (Kvale, 1996), an appropriate interview design was reached. Semi-structured questions were prepared by taking help from SLR results. The list of questions prepared appear in Appendix A. The interviewees were selected based on the following criteria:

- The persons should be experienced in software development and software project management. We targeted persons with the roles of project manager, project lead, technical lead and senior software engineer for our interviews.
- The persons should have experience working with globally distributed teams. Our interviewees had experience working both onsite and offsite for multiple projects.
- The interviewees should be based in diverse locations around the globe for potentially informative and rich feedback. Our interviewees were based in six countries: India, United States, United Kingdom, Netherlands, Germany and Ireland.
- The interviewees should have experience working with diverse application domains and technologies. Our interviewees had rich experience of working with a range of application domains, e.g., healthcare systems, financial services and energy systems. They also worked in a variety of technologies, e.g., Oracle, SAP, Java and .NET.

Before the start of the interviews, informed consent was taken from all the interviewees. The participation was entirely voluntary and the interviewees were assured of privacy and confidentiality. There were no perceived risks associated with interviews.

3. Interviewing: Interviewing is the actual conduct of an interview with a reflective approach to the knowledge sought (Kvale, 1996). A total of 8 interviews were conducted. 4 of them were conducted using Skype[2] while 4 of them were conducted using phone calls. The interviews were conducted on weekends to suit interviewees' availability. Before starting the interview, the interviewees were reiterated with a brief explanation about the topic, format of questions asked and the aim of the interview. On average, each interview lasted about an hour. Some basic instructions as in (Gubrium and Holstein, 2002) were followed while conducting the interview:

- The interviewer should listen more and talk less.

[2] www.skype.com

– The answers should be recorded carefully without thinking about the next question to be asked.
– The interviewer should clarify any ambiguities that may arise during the interview.

Table 3.3 summarizes the background information about the interviewees.

Organization location	Certification	Application domain and/or technologies used	Interviewee role	Years of experience
Netherlands	CMMI Level 5 & ISO 14001	Oracle, Database administration, SAP	SAP project manager	14
India	CMMI Level 5	IT services	Senior system analyst	8
USA	CMMI Level 3 & ISO 9001:2008, 27001:2005	Java, .NET	Project leader	9
Germany	CMMI Level 5	healthcare systems, financial services, energy systems	Project manager	10
India	CMMI Level 5	Business outsourcing solutions	Senior test engineer	6
Ireland	CMMI Level 5	Consulting and integrated solutions	Team leader	9
UK	CMMI Level 5	Business outsourcing solutions	Senior project manager	18
India	CMMI Level 5	Enterprise data management, consulting, analytics, business intelligence and data warehousing	Senior software engineer	8

Table 4: Information about the interviewees and their organizations.

4. Transcribing: In transcribing, interview material is prepared for analysis, typically by transcribing from oral speech to written text (Kvale, 1996). For the interviews done through Skype, we used MX Skype Recorder[3] to record the interviews. After ending the interviews, two of the authors listened to the recorded conversation individually and transcribed in written text. At the end, the notes were compared to consolidate any differences or missed conversation. Incase some ambiguity remained, the conversation was played one more time. For telephonic interviews, one of the authors supervised the interview while the other author took notes and wrote key points immediately.

After we finished transcribing the interviews, the written notes were sent to the interviewees for validation and for them to provide any further comments and feedback. The validation also accompanied some additional questions for the interviewees that emerged during the course of the interview sessions.

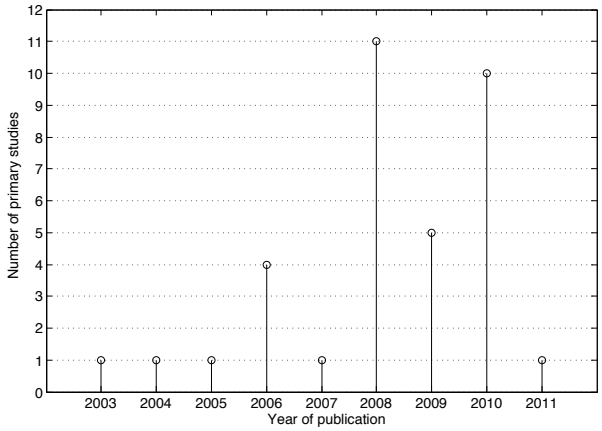
5. Analyzing: Analyzing involves using an appropriate data analysis method based on the purpose and topic of investigation and on the nature of the interview material. We used GT to analyze the interview data as it suited the design of our study as well as complemented the analysis done in the Phase-I of this study.

6. Verifying: Verifying includes ascertaining the generalizability, reliability and validity of interview findings. According to Prechelt and Oezbek (Prechelt and Oezbek, 2011), GT study cannot claim generalization to any specific domain because the data selection in GT is driven by the needs of the analysis (theoretical sampling) rather than by representativeness (random sampling). However the diverse backgrounds of our interviewees (Table 3.3) adds some value to our sample. Reliability is concerned with how consistent our results are and is discussed further in interview data analysis. Validity refers to whether an interview study investigates what is intended to be investigated. Following Kvale's systematic process (Kvale, 1996) adds to our confidence that our results are inline with the purpose of the interview.

7. Reporting: Reporting involves communicating the findings of the study and the methods applied in a readable form. Section 5 reports on the findings of our interviews.

[3] www.skyperec.com

Fig. 4: Year-wise distribution of primary studies.



3.4 Phase-III: Cross-case analysis

The Phase-III of our study used cross-case analysis to find commonalities and dissimilarities in challenges and mitigation strategies of KT in GSD settings, collected from both SLR and interviews. This helped us answer our RQ 3. Cross-case analysis enable the comparison of different cases against predefined categories, in search of similarities and commonalities, or classifies the data according to data sources. According to Seaman (Seaman, 1999), when the data can be divided into cases, cross-case analysis is applicable. This is true in our case where the primary studies in the SLR and the unique context of every interviewee represent data from a number of cases or settings. Eisenhardt (Eisenhardt, 1989) argues that while searching for patterns using a cross-case analysis, the chances of finding a reliable and accurate theory are improved. Eisenhardt (Eisenhardt, 1989) suggests three useful tactics for cross-case analysis:

1. The cases can be partitioned into categories based on some common denominator. Then within-group similarities coupled with intergroup differences can be examined.
2. A pair of cases can be selected with similarities and differences between each pairs listed down.
3. The data can be divided by data source (e.g., interviews, SLR) to get insights from different types of data collection.

Our cross-case analysis method progressed as follows. Once the GT was applied on SLR and interview results, we started comparing the open codes. We first compared the total number of open codes belonging to both challenges and mitigation strategies as identified from both SLR and interviews. We identified common challenges and mitigation strategies. We then compared the numbers belonging to each of the 2PT factors to analyze if some factors are more representative. The cross-case analysis finished with a mapping between the challenges and mitigation strategies.

4 SLR results

Before discussing the data analysis for our SLR, some basic statistics about the primary studies were calculated. Figure 4 shows the year-wise distribution of the 35 primary studies. It can be seen that the years 2008–2010 show an increase in the publication of KT studies in the context of GSD (26 studies) while the years 2003–2007 saw little research published on the topic (7 studies). This is perhaps not surprising since the annual international conference on global software engineering[4] started only in the year 2006. Since our search was limited to March, 2011 therefore we only have one primary study in 2011.

Out of the 35 primary studies, Figure 5 shows the distribution of studies with respect to the research methodology. 17 studies report case-studies, 5 report industrial experience reports, 5 report surveys and 3 report literature reviews. Two studies report both a case study and a literature review while, finally, one study reports both a case study and a survey.

[4] www.icgse.org

Fig. 5: Research method wise distribution of primary studies.

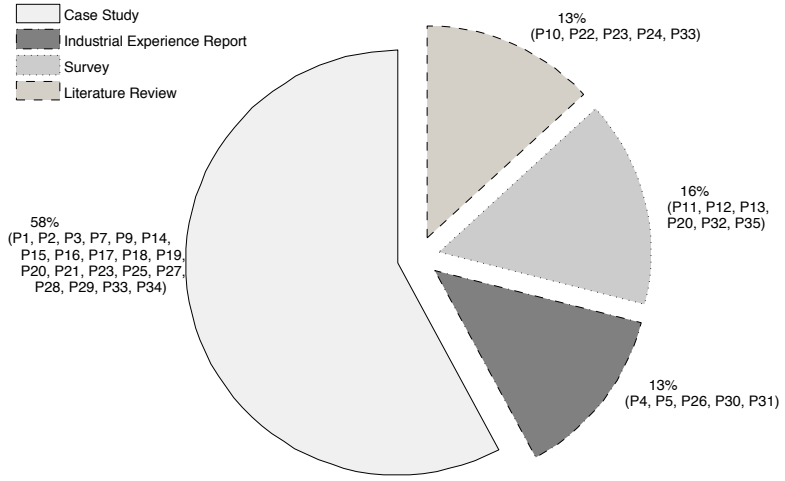
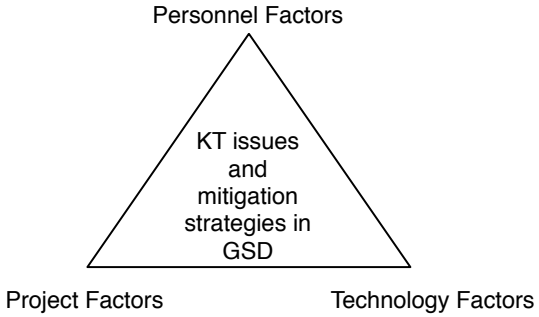


Fig. 6: Personnel, project and technology (2PT) factors for KT in GSD.



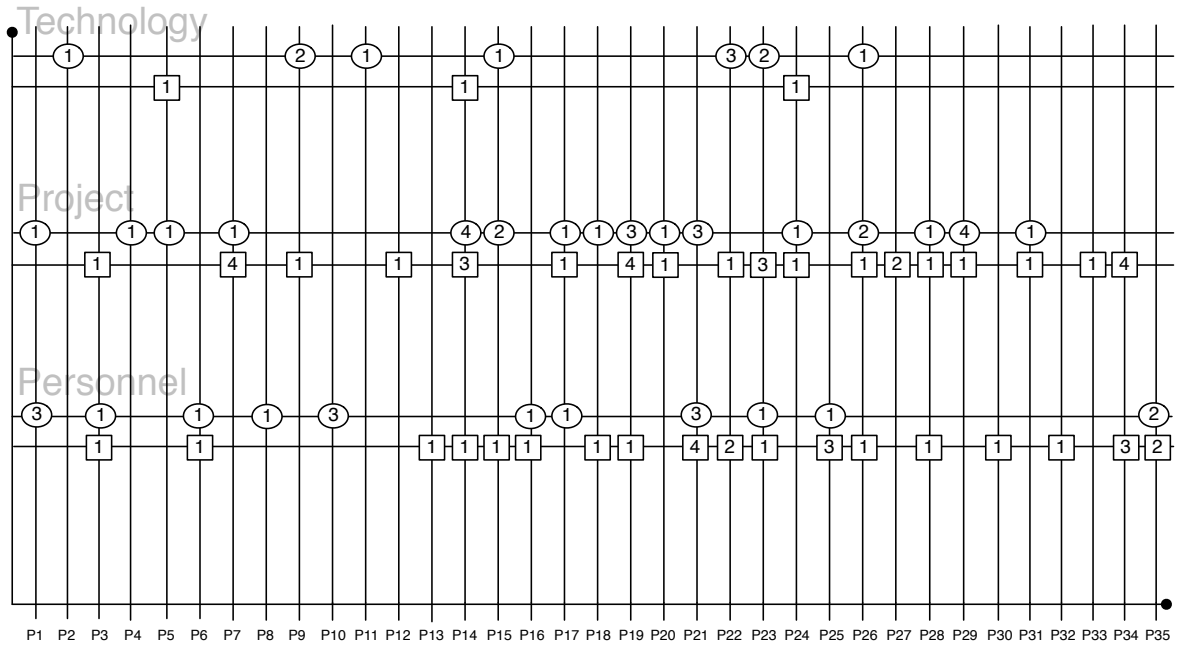
The analysis of the primary studies in our SLR showed that KT challenges and the mitigation strategies in GSD belonged to three core categories. We call these core categories as 2PT factors (Figure 6):

- Personnel factors.
- Project factors.
- Technology factors.

Personnel factors reflect the characteristics of individual employees who are involved in global software development. These factors take into account human related challenges and individual capabilities of employees. These factors are also related to human talents and their skills. *Project factors* take into account project related KT issues, e.g., issues related to project requirements, project budget, project delivery timing, project resources and milestones. Other characteristics of project factors include project management and organization, quality of software developed and monitoring of an ongoing project. Lastly, *technology factors* include all those factors that relate to use of tools and technologies for KT in GSD.

Figure 7 presents a mapping between the 2PT factors and the primary studies (P1 to P35). In this figure, there are two symbols at the intersection of the factor vertical axis and the primary study horizontal axis. The box symbol represents the number of challenges while the circle symbol represents the number of mitigation strategies.

Fig. 7: Mapping between primary studies and the 2PT factors for KT challenges and mitigation strategies in GSD found through SLR. The box represents number of challenges while the circle represents number of mitigation strategies.



Personnel factors			
Codes	ID	SLR - Challenges	Primary study
Language barriers	C1	Lack of English language skills	P25
	C2	Misinterpretation of conversation style	P28
	C3	Misunderstandings due to language	P22, P23
	C4	Inability to translate code comments and project documentation	P21
	C5	Lack of a common language	P25
Cultural differences	C6	Impact of national culture	P25
	C7	Lack of understanding of cultural differences	P22
	C8	Inexperience of the project members for interaction	P21
	C9	Additional cost in KT	P34
Trust	C10	Lack of trust between client and vendor	P3, P13, P32, P35
	C11	Reliance on a typical SRS document	P26
	C12	Lack of timely reporting of project status	P19
Personal attributes	C13	Aligning KT process with changing experience levels	P15
	C14	Willingness to say 'Yes' even when there is no knowledge gained	P6
	C15	Sender reluctant to transfer knowledge	P21
	C16	Shortcomings in client's IT human capability	P35
	C17	Lack of experience in application domain	P34
Staffing	C18	Frequent readjustment to variants of methods and process modes	P30
	C19	Loss of tacit knowledge due to replacement of onshore staff with offshore staff	P14
	C20	Rescheduling activities and knowledge gap due to changes in staff	P18
	C21	High rate of skilled employee turnover	P16, P21, P34

Table 5: SLR challenges - Personnel factors.

4.1 KT challenges in GSD - Personnel factors

Our data analysis of SLR grouped personnel factors for KT challenges in GSD into following codes: language barriers, cultural differences, trust, personal attributes and staffing. Below is a description of primary studies within each of these codes while Table 5 presents a summary.

Language barriers: One of the significant challenges of KT in GSD is difference in speaking languages. The authors in P21 describe how German language source code comments and project documentation were difficult to understand by a vendor based in India. The authors in P25 argue that people cannot share knowledge if they do not share a common language. The ability to share a common language is thus important for success in KT. Lack of a common language between client and vendor can increase chances

of lack of understanding and trust. Authors in P22 note that the team members might not be confident of their English language skills, therefore they may prefer instant messaging or email over telephone or video conferencing. People lacking in English language skills thus hesitate in transferring knowledge in globally distributed teams. Authors in P23 further elaborate a number of language barriers for KT, i.e., mismatch in preferred language for conversation, improper verbal communication, different dialects, and sometimes explaining their point in their native language leads to extra problems. Misinterpretation of conversation style is further highlighted as a barrier to KT by authors in P28.

Cultural differences: Building a common culture in GSD is highlighted as a big challenge in KT by authors in P25. Language barriers, as highlighted above, are one outcome of cultural differences, as noted by authors in P22. The authors further highlight issues in KT due to lack of cultural understanding, i.e., culture influences interpretation of communication, cultural norms can lead to conflicting approaches for problem solving. The authors in P21 shows how inexperience with working in different cultures can hinder client-vendor interaction. The authors in P34 observed that there were extra costs involved in KT due to cultural distances. There were situations when the offshore team was reluctant to ask questions and clarify issues. Also the offshore team required enhanced support during KT due to their different learning approaches and strict adherence to prescribed standards for documentation.

Trust: Trust is seen as an essential enabler for KT. Authors in P3 emphasize that trust plays a significant role during KT, especially because it is partially tacit. The authors argue that when the knowledge source is not perceived as trustworthy, the extent of knowledge transferred in reduced. Authors in P13 found a strong relationship between trust and knowledge sharing for distributed teams. Authors in P32 further show that mutual trust is important for knowledge sharing and outsourcing success. Authors in P35 found that trust affects cooperative learning in an IT outsourcing context, which in turn influences KT.

Due to lack of tacit knowledge incorporation and changes in requirements, reliance on a typical SRS document for transferring correct and complete functional requirements in GSD projects is not enough. Authors in P26 show how development of specification patterns for SRS in GSD projects help develop trust among client, onshore and offshore team members. Authors in P19 mention that sometimes vendors do not like to report when they are going to deliver the project. They are going to miss their project deadline but they do not intimate the push back dates to clients. This leads to misunderstanding between both parties and cause lack of trust between onsite and offshore team members.

Personal attributes: Authors in P35 showed that KT is significantly associated with the client's IT human capability. They argue that IT personnel in a client firm should have a cooperative relationship with vendors to acquire knowledge from vendors in an outsourcing situation. Authors in P15 argue that different strategies for KT are useful for different experience levels of knowledge recipients, e.g., novices face difficulties in structured KT process due to low absorptive and retentive capacities, a large knowledge gap and cultural and communication difficulties. Authors in P6 identify one more problem while transferring knowledge from client to vendor: participant's willingness to say yes to everything even when they did not understand what had been presented. Such a behavior manifests only an artificial KT. Authors in P21 point to another major barrier to KT, i.e., the knowledge source may fear the loss of control or ownership, may not be adequately rewarded for KT or may be reluctant to devote time and resources for KT. Authors in P34 also describe a case when the lack of vendor's experience in the application domain led to higher KT costs.

Staffing: One of the challenges of KT is that the project suffers from changes in staff. Authors in P14 mention that the retrenchment of onshore staff to be replaced by offshore staff results in loss of tacit, hard-to-transfer software process knowledge. Authors in P18 highlight another challenge for KT in GSD. Sometimes staff members leave or join in the middle or towards the end of the project. This requires re-scheduling of activities and overloading of other team members to meet deadlines. Moreover the knowledge gap left takes additional time to overcome by team members. Authors in P30 highlight that in GSD, offshore development teams have to repeatedly readjust their methods and process models to variants used by respective business units. Authors in P16 found that supplier turnover was a problem in KT because when supplier employees left, they took the hard-earned, client-specific knowledge with them. Similarly authors in P21 and P34 note that a challenge for KT in GSD is the high rate of personnel turnover at the vendor side that causes disruptions in KT.

Project factors			
Codes	ID	SLR - Challenges	Primary study
Inadequate infrastructure	C22	Lack of adequate facilities available	P27
Problems in requirements engineering & documentation	C23	Lack of requirements specification understanding	P9, P12, P23, P26, P28
	C24	Ineffective SRS reviews	P31
	C25	Access to relevant documentation	P17
Temporal distance	C26	Limited opportunities for synchronous meeting	P7, P22, P27
	C27	Tacit knowledge harder to access from a distance	P14
	C28	Delay in catching-up time and reporting time for team members	P7
	C29	Delay in handover of work at the end or beginning of a shift	P7
	C30	Increased artefacts transfer time	P7
Changing vendor	C31	Loss of experiential knowledge	P29
Additional costs	C32	Additional costs due to modifications in specifications	P34
	C33	High levels of client-specification knowledge	P34
	C34	Additional cost due to traveling	P14, P23, P34
	C35	Testing of supplier employee's knowledge	P19
	C36	Ensuring knowledge renewal	P19
	C37	Ensuring client knows suppliers' knowledge	P19
	C38	Poor planning for KT	P23
	C39	Increase in effort due to repetition in KT	P34
Meeting project deadlines	C40	More time required in KT upfront	P19
	C41	Cutting down KT due to aggressive deadlines	P14
Coping with novelty	C42	Novelty of project knowledge	P24
Communication challenges	C43	Infrequent and inadequate communication between team members	P3, P20
	C44	Delays due to centralized communication flow	P33

Table 6: SLR challenges - Project factors.

4.2 KT challenges in GSD - Project factors

Our data analysis of SLR grouped project factors for KT challenges in GSD into the following codes: infrastructure, requirement specification, temporal distance, changing vendor, extra costs, project deadlines, novelty, community of practice and communication. Below is a description of primary studies within each of these codes while Table 6 presents a summary.

Inadequate infrastructure: Provision of a sustainable infrastructure is one of the basic elements in a successful GSD project. Authors in P27 argue that the issue of infrastructure has to be considered at an early stage during the selection of an outsourcing location. Some elements of an infrastructure include dependable electricity supply and alternate power sources, adequate telecommunication infrastructure including dependable internet connection and bandwidth. The authors observed that inadequate remote telecommunication system impacted on routine communication and particularly had a negative impact on training and KT.

Problems in requirements engineering and documentation: Understanding of requirements specification is a major challenge in GSD projects, especially during KT from provider to recipient(s). Authors in P12 note that for standardized products that are based on clear specifications, KT seems to be more straightforward and scheduling tasks is also easier. Authors in P9 highlight that one particular challenge in GSD is to transfer knowledge about customer requirements from onsite to offshore team. The offshore team should be able to understand correctly customer requirements as documented by the onsite team. Authors in P23 further highlight that one of the KT challenges in GSD is that the specification is not understood by the offshore team members. This happens due to limited communication between onshore and offshore teams and also the onsite team members do not know how detailed the specification documents need to be. Authors in P26 give a number of specification patterns for GSD projects. Among them, one of the pattern addresses the challenge that SRS must be understandable both, by the client and the offshore developer(s). Lack of understanding of requirements between client and offshore developers will hamper the progress of offshore team to design and will make development inefficient. Authors in P28 admit that in GSD, misunderstandings in requirements easily arise and it is necessary that sufficient understanding of specifications is reached on the vendor side before the technical specification of the system begins. Authors in P31 further highlight a challenge in KT in GSD, i.e., the customer reviews of the requirements specification might be weak, therefore the teams have difficulty evaluating whether a SRS is correct. Authors in P17 point out that while maintaining updated documentation is an important part of a project, newcomers generally find it more important to experiment with the system than to have up-to-date and complete documentation. Nevertheless, newcomers need to have ways to find and access relevant documentation.

Temporal distance: Temporal distance refers to a barrier in KT due to timezone differences when teams are distributed across the globe. Authors in P22 point out that the main problem with developers working in different timezones is that synchronous meetings can be done only for fewer hours a day. This means that problem resolution and answers to queries take longer time. Authors in P27 also highlighted a similar challenge when they describe a situation where inexperienced team members on one location did not get enough knowledge transferred from more experienced team members located on another location due to lack of synchronous meetings. This affected the operational efficiency of the team. Authors in P7 mention the KT overheads due to distributed sites in GSD projects. These overheads are due to lack of synchronous meetings, delays in hand-over of work at the end or beginning of a shift, delays in artefacts' transfer time and delays in daily KT tasks such as reporting time and catching-up time. Authors in P4 further argue that tacit knowledge is locally specific and is therefore harder to gain access from a distance. Authors in P14, P23 and P34 describe situations where additional costs were incurred due to the necessity of the client to travel to the vendor site for supporting actual development and testing by providing detailed design instructions.

Changing vendor: Authors in P29 argue that moving from an old vendor relationship to a new vendor relationship brings additional challenges. A long-term relationship in outsourcing with previous vendor means that much daily operational knowledge is left with the previous vendor. The client's knowledge loss becomes a problem of KT, as the client no longer holds all the information that the new vendor critically needs to involve in services with the client.

Additional costs: Authors in P34 argue that offshore outsourcing brings about the challenge of integrating application domain knowledge (usually residing at the client side) with technical understanding (usually the responsibility of the vendor). The authors further point out that there are additional costs in modifying or complementing specifications throughout the service delivery phase. The authors also argue that higher the required client-specific knowledge in offshore software project, the higher are the client's cost for KT. This is because the client effort for transferring knowledge to an external vendor is particularly high if the required knowledge to perform tasks is highly client-specific. One other challenge reported by the authors is that due to high turnover rates, the client may be required to transfer the same knowledge to the replacement staff many times. This of course adds to increased effort. Authors in P23 mention additional costs in KT due to poor project planning for knowledge creation and acquisition. This results in project budgets being underestimated and frequent escalation of issues to senior management. Authors in P19 describe a situation where project managers had to ensure that the KT was successful by testing the supplier employee's knowledge by taking some oral quiz questions. Also the project managers had to ensure knowledge renewal activities at the supplier end to overcome knowledge gaps created by high turnover rates. Project managers also had to ensure that knowledge is also transferred from the supplier to the client end regarding new applications and technologies. These all activities entail additional cost and effort. Authors in P19 mention a case when project managers had to ensure that KT was successful by testing the supplier employee knowledge by taking oral quizzes. Also as unexpected turnover of supplier employees affected KT, the project managers had to ensure knowledge renewal, i.e., they had to preserve the knowledge transferred. The project managers also had to ensure that the client knows about the supplier's knowledge about the new technologies and applications. This was required so that the client can have a better control over the project in the absence of the supplier.

Meeting project deadlines: Authors in P19 argue that when a project included offshore employees, intense KT had to be planned upfront by the project managers. This was required to minimize the knowledge gap as early as possible. Another challenge in KT is that sometimes too aggressive deadlines were set by IT leaders, therefore project managers were forced to cutdown KT.

Coping with novelty: Authors in P24 argue that project novelty increases the difficulties of KT. In outsourced projects, the project knowledge might be incomplete or new due to dynamic and diverse nature of client's requirements. This requires the team members to interact ore frequently to exchange knowledge.

Technology factors			
Codes	ID	SLR - Challenges	Primary study
Challenges with tool support	C45	Lack of knowledge on tool selection criteria and usage	P5
Challenges with a transactive memory system (TMS)	C46	Unavailability of up-to-date documentation	P14
	C47	Low knowledge codifiability	P24

Table 7: SLR challenges - Technology factors.

Communication challenges: It is intuitive to argue that KT has to be facilitated by frequent communication between the remote team members. Infrequent communication between the client and the vendor creates barriers to KT. Authors in P3 found that for an individual to be perceived as an effective KT agent, he or she should extensively participate in electronic conversations. Authors in P20 show that virtual team projects exhibit more risk due to insufficient KT than co-located projects. The reason is that the implicit knowledge transfer is compromised in virtual projects which normally gets transferred using fact-face communications and meetings. Authors in P33 mention centralized communication flow as another challenge for KT. A common scenario is that the technical architects are located onsite and an offshore coordinator, typically a local development manager, is tasked with monitoring the team and the quality of work. The architects provided knowledge transfer flows from onsite location to offshore team members through offshore coordinator. Due to this dependency on a centralized source, delays occur and team members have to wait for important information to be shared.

4.3 KT challenges in GSD - Technology factors

Our data analysis of SLR grouped technology factors for KT challenges in GSD into the following codes: Challenges with tool support and challenges with a transactive memory system (TMS) . Below is a description of primary studies within each of these codes while Table 7 presents a summary.

Challenges with tool support: In a virtual work environment as in GSD, the KT has to be facilitated by the use of different tools. The authors in P5 focus on the role of tools to keep a global technical workforce up-to-date and linked with just-in-time access to product knowledge and peers. A key challenge is then how to leverage on such a tool support for an effective KT and to know what tools to select for use in varying contexts.

Challenges with a transactive memory system (TMS): A transactive memory system (TMS) is a combination of individual memory systems and communication between individuals. It is a system for encoding, storing and retrieving information in groups (Wegner, 1987). The communication between individuals take place through either codified (e.g., databases, explicit) or personalized (e.g., personal memory, tacit) directories. Tacit knowledge is codified at low levels since it is hard to articulate or express. Authors in P24 argue that the higher the codifiability of project knowledge, the easier is to transfer the knowledge. Moreover, authors in P14 highlights the importance of having access to documentation that is up-to-date with the latest changes.

4.4 KT mitigation strategies in GSD - Personnel factors

Our data analysis of SLR grouped personnel factors for KT mitigation strategies in GSD into following codes: cultural bridges, staffing, promoting trust and personal attributes. Below is a description of primary studies within each of these codes while Table 8 presents a summary.

Cultural bridges: Cultural differences are a known barrier to KT. However these differences can be minimized. Authors in P1 argue that persons belonging to individualistic societies are likely to withhold information while those coming from collectivist cultures will transfer more knowledge. Collectivist cultures believe that success comes with sharing knowledge and involvement of team members in most aspects of their work. Authors in P23 and P21 suggest conducting cultural workshops to narrow down the cultural differences. The cultural workshops are meant to improve socialization among team members and to trigger informal communication. Authors in P21 present a number of other ways to develop

Personnel factors			
Codes	ID	SLR - Strategies	Primary study
Developing cultural bridges	S1	High collectivist cultures transfer more knowledge	P1
	S2	Onsite visits and replay sessions	P21
	S3	Conduct cultural workshops	P21, P23
Staffing	S4	Stimulate individual motivation	P21
	S5	Implement mentoring and shadowing	P6, P16
	S6	Credible knowledge sender	P1, P3, P35
Promoting trust	S7	Reinforce communication with client	P10
	S8	Promote high quality client relationship	P10
	S9	Understand the language and business culture of clients	P10
	S10	Travel to client location for establishing friendly ties	P8
Personal attributes	S11	Educate IT professionals to increase their capability	P35
	S12	Learning by experimenting	P17
	S13	Improve interpersonal and technology management skills	P1
	S14	Proactive learning and peer-to-peer help	P25

Table 8: SLR mitigation strategies - Personnel factors.

cultural competence. One is to start site visits of client's employees to offshore sites. Second is to do replay sessions with offshore team members to remove misunderstandings in functional requirements. In these sessions, the knowledge recipients would explain what they understood by the knowledge given few days earlier.

Staffing: In order to bring inexperienced remote team members up to the knowledge level so that they can effectively deliver, one-to-one mentoring and shadowing is suggested by authors in P6 and P16. The mentors and shadow trainers were trained and worked hard to transfer their technical and practical experience. Authors in P1, P3 and P35 argue that the knowledge sender should be a person with known credibility to the remote members. This means that the knowledge sender should be trustworthy and reputable in terms of performance to be able to effectively transfer knowledge. Authors in P21 discuss a case where by stimulating motivation more knowledge was shared from client to the vendor. The motivation was enhanced by eliminating the fear of losing their jobs when moving to an outsourcing strategy. This fear was eliminated with a smooth restructuring where new opportunities were provided to the client side employees. Moreover the project managers were given clear responsibilities for the project which increased their motivation as they realized that project success would bring them a good name in the organization.

Promoting trust: A reliable relationship between client and vendor is a necessity for successful KT in GSD. Authors in P10 emphasize that to build trust, the outsourcing consultancy companies need to understand the language and business culture of the clients, reinforce communication and pay attention to client relationship management. Authors in P8 argue that clients need to allocate sufficient travel budget for vendor employees' visits at client side to foster friendlier relationship. The authors argue that friendship ties between knowledge provider and seeker will increase the amount of knowledge transferred.

Personal attributes: Authors in P35 argue that IT personnel in a client firm should have a cooperative relationship with vendors to acquire knowledge. To support this, the clients need to educate IT personnel with capability of business process, technology management and interpersonal skills to aid in KT. Authors in P17 highlight that learning by experimenting help developers orient themselves with the system early on. Authors in P25 describe a case where offshore employees relied on proactive self-study and peer-to-peer help to overcome difficulties in KT. Peers or group mates were easier to communicate with as compared to an overseas client. Authors in P1 conclude that for an individual to be perceived as a significant knowledge transferrer, he/she should extensively participate in conversations as indicated by the communication extent. Moreover the knowledge transferrer should be capable in terms of technical ability and project management ability.

Project factors			
Codes	ID	SLR - Strategies	Primary study
Community of practice (CoP)	S15	Getting knowledge through group discussions	P4, P5
Project guidelines	S16	Take offshore business analyst onboard during requirements engineering	P26
	S17	Map business terms to logical entities	P26
	S18	Maintain clear documentation process	P7, P20, P24
	S19	Handing over the acceptance test case specifications to the offshore development team	P31
	S20	Schedule additional weekly meetings to fill knowledge gap	P18
	S21	Invest resources in KT	P19
Verification	S22	Conducting oral and written tests/quizzes	P14, P19
	S23	Reverse presentations for requirements validation	P28
	S24	Support simulation	P14
	S25	Playback or replay sessions	P14, P21
Key facilitators	S26	Understanding of organizational learning subprocesses	P14
	S27	Leveraging knowledge base and experience of peers	P15
	S28	Dynamic navigation aids to search information	P17
	S29	Modularization	P29
	S30	Use of outside expertise	P29
	S31	Joint collaboration	P29
	S32	Personal identities at work	P29
Communication bridges	S33	Face-to-face classroom-based training to novices	P15
	S34	Frequent milestones, detailed status reports and frequent work meetings	P19
	S35	Formalized communication structures	P21
	S36	Client-vendor informal face-to-face meetings	P21
	S37	Promoting high volume of communication	P1

Table 9: SLR mitigation strategies - Project factors.

4.5 KT mitigation strategies in GSD - Project factors

Our data analysis of SLR grouped project factors for KT mitigation strategies in GSD into following codes: communities of practice (CoP), project guidelines, verification, key facilitators and communication bridges. Below is a description of primary studies within each of these codes while Table 9 presents a summary.

Community of practice (CoP): A community of practice (CoP) evolves naturally because of the members' common interest in a particular domain or it can be formed specifically for knowledge sharing (Lave and Wenger, 1991). Authors in P4 apply CoP supported by a portal to share knowledge and argue that by doing it, continuous process improvement can be achieved. Authors in P5 find that face-to-face CoP meetings has positive effect on user knowledge attainment.

Project guidelines: Authors in P26 emphasize that during requirements engineering, the offshore business/system analyst need to be involved in elicitation meetings with the clients. This helps transfer of tacit knowledge early in the project. The authors also recommend that in a SRS, the clients need to map business terms to entity attributes so that the SRS is understandable. They recommend adding a reference table to the document which maps business terms to logical entities or attributes. Authors in P7 conclude that maintaining documentation for the purpose of KT is a crucial success factor in GSD projects. Authors in P20 emphasize converting more and more knowledge into explicit knowledge and document it which then can be shared electronically. Authors in P24 argue that documentation plays an important role of regulation during KT. Authors in P31 claim that by using a two-stage test oriented review method and handing over the acceptance test case specifications to the offshore development team, KT can be improved. The two stages of the method consists of first creating the acceptance test case specifications for the SRS and secondly these test case specifications are reviewed by the customer with a potential creation of new acceptance test case specification. Authors in P8 noted that staff turnover and joining of new staff in the middle or towards the end of a project created a need for additional weekly meetings to fill the knowledge gap. Authors in P19 argue that unless senior executives commit enough of internal resources in KT (e.g., training, work shadowing, mentoring), the supplier work will be of poor quality.

Verification: Authors in P19 discuss situations where the project manager had to orally quiz the offshore contractors to ensure that KT has truly occurred. Similarly authors in P14 discuss how the presentations by client were followed by written and oral tests, playback (the offshore team presented back to the onshore team) and support simulation (simulated scenarios where the offshore staff had to provide solutions to a problem). Playback or replay sessions also helped KT in a case study presented in P21.

Technology factors			
Codes	ID	SLR - Strategies	Primary study
Use of and access to groupware software	S38	Using a document management system/Configuration management system	P9, P11, P22
	S39	Using videoconferencing and shared desktop technologies for less complex business matters	P26
	S40	Using emails, wikis and instant messaging for conveying detailed technical information	P22
	S41	Preference of emails as an asynchronous communication tool	P22, P23
	S42	Instant messengers as a substitute for informal verbal communication	P23
	S43	Web-based tutoring, web-based mentoring, web-based knowledge mining and web-based knowledge profiling	P2
	S44	Getting access to the knowledge repository	P9, P15

Table 10: SLR mitigation strategies - Technology factors.

Authors in P28 recommend reverse presentations for requirements validation in GSD. The client asks the vendor to capture, specify and present the requirements for validation purposes in an iterative manner. The client can then evaluate the vendor's understanding of the system to be developed.

Key facilitators: Authors in P14 emphasize that information about organizational learning sub-processes can help facilitate KT. This includes, e.g., grafting of staff with technical and application domain knowledge and enabling experiential learning through presentations, support simulation, on-the-job training and playback. Authors in P15 describe a case study where the novice employees consulted both the knowledge base and more experienced peers to obtain relevant knowledge. Authors in P17 argue that navigation aids available to help newcomers find and access relevant documentation is important for successful KT, especially dynamic navigation aids such as tools to help search and index documents, experiment with the system or learn about their colleague's current expertise. Authors in P29 highlight four key facilitators in KT. The first one is the modular structure of the application which helped the client in identifying the lost experiential knowledge due to staff turnover. The second one is making use of outside expertise such as consultants to recover the loss of operational knowledge. The third one is joint collaboration in which client and vendor worked closely in developing solutions. The fourth one is the attachment of personal identities of personnel with their work. The team members saw the success of the project as a success personally and for the organization.

Communication bridges: Authors in P15 discuss a case where the client went to the offshore location and provided face-to-face classroom-based training to novices. The training was about cultural awareness, business process and technical. The training was part of a four stage process (initiation, implementation, ramp-up and integration). Authors in P19 mention situations when the project manager, in order to manage supplier's work products, created more frequent milestones, required more detailed status reports and requested more frequent work meetings. Authors in P21 highlight that formalizing the communication structure can help remove barriers to KT, i.e, by making communication explicit, documenting results of KT and have defined roles and communication counterparts. The authors also mention that informal communication between client and vendor reinforces the formal communication structures. Authors in P1 argue that an individual who has a high volume of communication in terms of increased participation in chat sessions and high number of posts in threaded discussions, will end up in transferring more knowledge to remote team members.

4.6 KT mitigation strategies in GSD - Technology factors

Our data analysis of SLR grouped technology factors for KT mitigation strategies in GSD into a single code: use of and access to groupware software. Below is a description of primary studies within the code while Table 10 presents a summary.

Use of and access to groupware software: Groupware are collaborative software that help team members exchange information remotely. Authors in P11 describe groupware and document management systems as enablers for KT. Authors in P22 also highlight that a shared document management system such as a configuration management system that stores design documents, meeting minutes and source code facilitates KT. Authors in P9 emphasize that a web-based system to handle change requests facilitated critical stages of system integration. Authors in P19 mention a cataloguing system which served as a codified directory for remote team members. It included procedural standards, project documentation and the source code. It was also possible to search the codified directory for experts who developed a particular artifact so that they can be contacted for additional KT. Authors in P26 argue that for

specifying requirements to the offshore team, video conferencing and shared desktop technologies should be used for transferring knowledge about less complex business subject matters. In other words, more complex functionality is better to be communicated explicitly in a documented manner. Authors in P22 highlight that email, wikis and instant messaging are useful for conveying detailed technical information such as program source code. Authors in P23 highlight that remote team members, especially from Asia, prefer emails as an asynchronous communication tool. This allows them to properly format emails and to document agreements. The authors also mention that instant messengers are an efficient substitute for verbal informal communication. Authors in P22 argue that team members who are not confident with their English language skills prefer asynchronous communication over video and teleconferencing as they get more time to comprehend and compose a response. Authors in P2 highlight the more recent knowledge transfer mechanisms. In web-based tutoring, the tutor or the knowledge sender uploads a number of heterogeneous documents (e.g., textual files, presentations, simulations, etc.) to the web-based tutoring system and a schedule prescribing the learners which document should be read at a particular stage and what actions to take. During the time slot for the training session, the group discuss the document prescribed earlier by the tutor. This promotes interactive discussions and prevents passive learning. In web-based mentoring, a mentor can engage in synchronous meetings with persons requiring knowledge in a particular area. The mentor can let learners automatically visualize documents, can provide explanations about a document and can request a learner to perform an action. Th learners can provide text or voice comments and ask questions. In web-based knowledge mining, the learners can access knowledge resources uploaded on a server and then contact subject specialists for help. In web-based knowledge profiling, the learning resources are profiled in the form of knowledge domains. This facilitates reuse of knowledge resources as well as searching and browsing different knowledge domains. Authors in P15 argue that in order to bring novices up to the required levels of knowledge, they can access the knowledge in repositories and solve similar problems. This also helps them improve their problem solving skills. Authors in P30 emphasize on an integrated tool suite to make company's body of knowledge accessible to GSD teams.

5 Interview results

Similar to the SLR results, GT was used to analyze the interview data. The challenges and mitigation strategies in GSD, as analyzed from the interview data, are grouped into 2PT factors:

1. Personnel factors.
2. Project factors.
3. Technology factors.

Figure 8 presents a mapping between the 2PT factors and the interviewee IDs. In this figure, there are two symbols at the intersection of the factor vertical axis and the interviewee ID horizontal axis. The box symbol represents the number of challenges while the circle symbol represents the number of mitigation strategies.

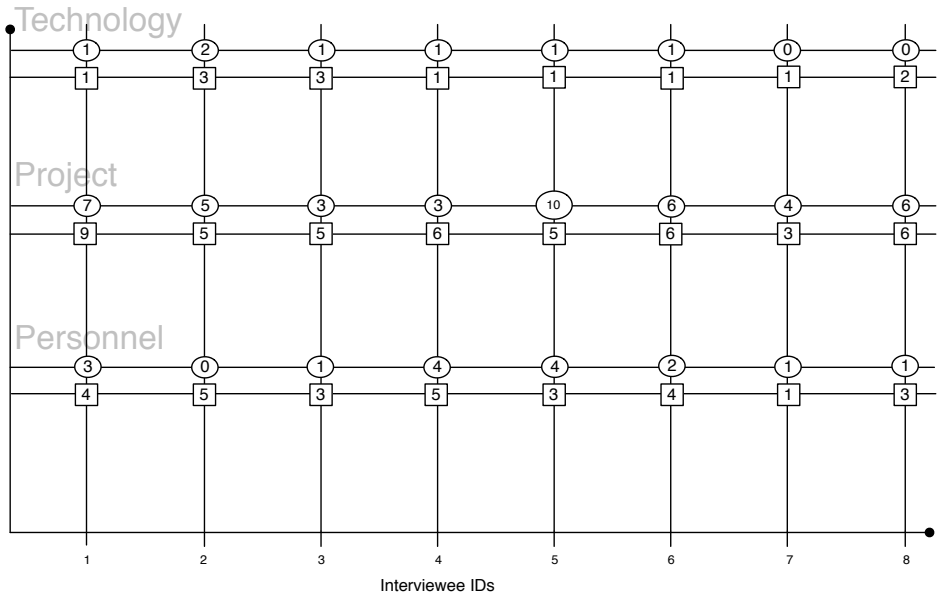
5.1 KT challenges in GSD - Personnel factors

Our data analysis of the interview results grouped personnel factors for KT challenges in GSD into following codes: language barriers, trust, personal attributes and staffing. Below is a description of each of the codes while Table 11 presents a summary.

Language barriers Five of the interviewees mentioned language differences as a barrier to KT. Differences in language accent was mentioned as a barrier by four interviewees, especially at the beginning of projects. Moreover, due to newer business domain, two interviewees highlighted the difficulty in understanding business terminology and acronyms as a challenge for KT in GSD projects.

Trust: A number of interviewees mentioned that insufficient KT from client to the vendor creates mistrust among remote teams. Similarly they mentioned that if some knowledge is sensitive or confidential, lack of trust affects transferring such knowledge. Also one factor that greatly creates mistrust is late delivery of work. The interviewees mentioned a number of cases, when due to various reasons, the clients are informed too late about the possibility of missing a deadline.

Fig. 8: Mapping between interviewee IDs and the 2PT factors for KT challenges and mitigation strategies in GSD found through SLR. The box represents number of challenges while the circle represents number of mitigation strategies.



Personnel factors			
Codes	ID	Interview - Challenges	Interview ID
Language barriers	C48	Differences in language accent	1, 2, 5, 8
	C49	Difficulty in understanding of acronyms and business terminology	2, 4
Trust	C50	Insufficient knowledge transfer leads to distrust	1, 8
	C51	Effect of confidential data on trust	3
	C52	Delay in work creates distrust	4
Personal attributes	C53	Reluctance of onsite managers to transfer knowledge	2, 4, 5, 6
	C54	Approaching other team members for domain knowledge	3
	C55	Knowledge transfer processes according to knowledge level	1, 2, 4, 5, 6, 7, 8
	C56	Novice level employee's low absorptive capability	2, 3, 4
Staffing	C57	Assigning novice members to new technology	1
	C58	Unavailability of subject matter experts to provide knowledge	6
	C59	Rescheduling for team members joining late in a project	6

Table 11: Interview challenges - Personnel factors.

Personal attributes: Some of the interviewees mentioned that sometimes the onsite project manager or the subject expert is reluctant in transferring knowledge to offshore staff. The reasons vary from time pressures, inability to answer questions to fear of losing one's competitive advantage. Similarly few interviewees mentioned how newer employees lacked fundamental knowledge and were not able to grasp the concepts. Therefore they had to be repeatedly given knowledge which is time consuming. A related issue to this was also highlighted that the knowledge should be given according to the expertise level of the recipients, otherwise there is a danger of much knowledge loss. The interviewees mentioned that once the KT is not understood by offshore team members, in order to fill the knowledge gap, they approach other team members in their organization. This creates more misunderstandings as they may not be the subject experts.

Staffing: One of the interviewees mentioned that if new/novice employees are assigned work in new technology/tool, they take time to absorb the given knowledge and this is costly. Another interviewee mentioned the unavailability of subject experts to clarify misunderstandings or to answer questions leads to unnecessary lags in project progress. Also when team members join a certain training program late, the schedule has to be re-organized and the given knowledge has to be repeated to make sure the new team members are at the same knowledge level as others in the training.

5.2 KT challenges in GSD - Project factors

Our data analysis of the interview results grouped project factors for KT challenges in GSD into following codes: requirements specification issues, temporal distance, changing vendor, extra costs, project deadlines, novelty, turnover and communication. Below is a description of each of the codes while Table 12 presents a summary.

Project factors			
Codes	ID	Interview - Challenges	Interview ID
Problems in requirements engineering	C60	Lack of requirements specification understandability	1, 4, 3, 5, 6, 7, 8
Temporal distance	C61	Lack of time coincidence resulting in delay in catchup and reporting time for distributed teams	1, 3, 5, 6, 8
	C62	Overhead due to increase in distributed sites	1
Changing vendor	C63	Loss of experiential knowledge	1, 7
Additional costs	C64	Improper KT planning	6, 3
	C65	Old vendor reluctant to provide proper KT to the new vendor	6
	C66	Lack of experience in the present working domain	1, 4
	C67	Extra costs due to several onsite employees traveling to offshore location	5
	C68	Repetition of KT	2
	C69	Extra costs for change requests	1, 4, 8
Meeting project deadlines	C70	Increase of design complexity and redesign requires more KT	1, 2, 3, 6
Coping with novelty	C71	Novelty in requirements for the project	2, 4, 5, 8
Turnover	C72	High rate of skilled employee turnover	1, 2, 3, 4, 5, 6, 7, 8
Communication challenges	C73	Loss of information due to centralized communication	1, 2, 4, 8

Table 12: Interview challenges - Project factors.

5.2.1 Problems in requirements engineering

Many interviewees highlighted the importance of understanding the requirements specification document for avoiding much rework in the project. Lack of understanding of SRS is thus a major challenge in KT as highlighted by the interviewees.

Temporal distance: Lack of time coincidence among distributed teams is mentioned by five interviewees as problematic since it creates delay in handshaking work assignments. One of the interviewees mentioned that increase in distributed development sites increases management overhead for the clients as it becomes a challenge to monitor progress.

Changing vendor: Two of our interviewees mentioned the loss of experiential knowledge as a result of changing vendor to be problematic for KT in GSD projects. They highlight that a shift from on old to a new vendor is challenging because the new vendor needs to understand the new work environment, business processes and workflow, which takes time.

Additional costs: One of the interviewees mentioned that KT has to be properly planned, otherwise there will be extra costs. For example, the KT has to deliver knowledge to team members despite differences in skills, knowledge levels and the turnover rates. Similarly if vendors are changed, the old vendor does not show seriousness in providing KT to the new vendor. This adds additional overhead for the client. Two of the interviewees mentioned that if the remote team is not experienced in the business domain, extra cost is incurred while they get used to the new environment. Similarly in order to fill the knowledge gap, several onsite team members may need to travel offshore which is costly. One of the interviewees mentioned that extra cost is incurred at the client end for repetitive KT, i.e, due to variety of reasons, the same knowledge has to be transferred multiple times. Three of the interviewees mentioned that change requests from the client end require additional KT and are expensive.

Meting project deadlines: 4 of our interviewees highlighted that in projects where the design complexity was high, extra KT sessions had to be arranged. Sometimes redesign activities had to be undertaken and required intense KT sessions.

Coping with novelty: 4 of our interviewees agreed that increased novelty in a project requires more knowledge to be transferred, particularly if the novelty is in the new requirements to be implemented.

Turnover: All of our interviewees mentioned staff turnover as a challenge to KT in GSD projects. The new employees who replace the old ones do not have required levels of knowledge and had to be provided with knowledge that, most of the times, is new for them. Therefore, the effort of providing them with new knowledge and the time it takes for them to come in terms with this new knowledge represents a challenge for KT in GSD teams.

Communication challenges: Four of our interviewees mentioned that the onsite team usually does not communicate directly with the offshore team, rather there is a project manager or an offshore coordinator that manages the communication to and from the offshore team. While this has advantages, a challenge is to avoid potential loss of information when the coordinator forwards information from onsite to the offshore team members.

5.3 KT challenges in GSD - Technology factors

Our data analysis of the interview results grouped technology factors for KT challenges in GSD into following codes: software support issues and issues with the TMS. Below is a description of each of the codes while Table 13 presents a summary.

Technology factors			
Codes	ID	Interview - Challenges	Interview ID
Challenges with tool support	C74	Lack of knowledge on tool selection criteria and usage	1, 2, 3, 4, 5, 6, 7, 8
	C75	Differences in communication media performance	2
Challenges with a transactive memory system (TMS)	C76	Delay in uploading documents in the knowledge repository	2, 3, 8
	C77	Uploading the wrong version of documentation	3

Table 13: Interview challenges - Technology factors.

Challenges with tool support: All of our interviewees mentioned that lack of knowledge on tool selection criteria and usage, both by clients and vendors, represents a challenge to KT in GSD. They emphasized that GSD teams must know the pros and cons of different tools for both synchronous and asynchronous communication as well as for data management. Secondly the interviewees highlighted that before communication between remote sites begin, the teams need to ensure the quality of audio and video to minimize differences in communication media performance.

Challenges with a transactive memory system (TMS): 3 interviewees mentioned that the knowledge repository should be kept up-to-date with proper revisions maintained. They highlighted cases when delay in uploading documents in the knowledge repository led to KT delays. Moreover one of the interviewees highlighted that correct version of the document should be shared as uploading the wrong version might lead to misunderstandings in KT.

5.4 KT mitigation strategies in GSD - Personnel factors

Our data analysis of interviews grouped personnel factors for KT mitigation strategies in GSD into following codes: language bridges, staffing, trust and personal attributes. Below is a description of each of these codes while Table 14 presents a summary.

Language bridges: One of our interviewees mentioned that in order to overcome some of the language barriers, the remote teams need to communicate verbally as often as possible. The differences in accent can be overcome once the team members get used to each others' way of communication.

Personnel factors			
Codes	ID	Interview - Strategies	Interview ID
Language bridges	S45	Communicate verbally as often as possible	8
Staffing	S46	Transfer knowledge with a knowhow of knowledge levels of recipients	1, 5, 6
	S47	Ensure KT whenever challenge arises	4
	S48	Record KT session for novice team members	3, 6, 7
	S49	Shadow supervising through desktop sharing and phone calls	5
Promoting trust	S50	Deploying offshore employee onsite	1
	S51	Communicate often	4
	S52	Face-to-face interaction promotes friendly ties	4
Personal attributes	S53	Repeat KT until the receiver understands completely	5
	S54	Extra effort in understanding requirements	1, 4, 5

Table 14: Interview strategies - Personnel factors.

Staffing: Two of our interviewees mentioned that while transferring knowledge to team members, consideration is made with respect to the knowledge level of the recipients, however assuming that a certain level of knowledge already exists can be dangerous. Therefore knowledge has to be transferred to team members with a plan and with a knowhow of the existing knowledge level of the recipients. One of the interviewees mentioned that since business domain mostly resides onsite, there will be occasions when the offshore team faces certain challenges in implementing functionality. This requires special KT sessions even though initial KT had been done. Three of the interviewees mentioned the benefit of recording the KT session, especially for novice recipients. The recordings can then be played multiple times as the knowledge requirement arises. One of the interviewees mentioned that assignment of a shadow supervisor with desktop sharing and phone calls greatly helped transfer knowledge in one of the projects.

Promoting trust: One of the interviewees mentioned that by deploying offshore employees onsite, trust is improved. Similarly another interviewee mentioned that by frequent communication (synchronous or asynchronous) between remote team members, a degree of trust is established. Moreover, face-to-face interactions promote friendly ties between remote team members.

Personal attribute: One of the interviewees mentioned that sometimes the client likes to repeat the transferred knowledge to make sure it is understood by the offshore team. This helps the remote team members if the knowledge is new and there exists communication differences. Three of the interviewees mentioned that the offshore team needs to put extra effort in understanding requirements. This involves being proactive in learning and keeping pace with provided knowledge and one's own understanding.

5.5 KT mitigation strategies in GSD - Project factors

Our data analysis of interviews grouped project factors for KT mitigation strategies in GSD into following codes: temporal distance, community of practice, project guidelines, task management, project deadlines, verification, reducing extra costs, novelty, employee turnover and communication bridges. Below is a description of each of these codes while Table 15 presents a summary.

Temporal distance: Two of the interviewees mention that barriers due to temporal distance can be reduced by the use of communication media tools. They highlighted the use of VoIP, Skype and WebEx to communicate across remote sites. Three of the interviewees mentioned that it is important to adhere to timings for KT, otherwise managing a number of remote teams will become difficult.

Community of practice: One of the interviewees mention the importance of group sessions for fixing a certain problem. The session consists of communication among subject experts to reach an acceptable solution. Another interviewee highlighted the importance of arranging group sessions at the beginning of work to let the team members know the subject experts. This helps them to contact persons when required for knowledge gathering. Two of the interviewees mentioned cases when a team member from another project conducted a group session as he was more experienced. Thus a group session becomes a forum for sharing one's experience regarding a subject matter.

Project factors			
Codes	ID	Interview - Strategies	Interview ID
Temporal distance	S55	Use communication media tools	3, 6
	S56	Strict adherence to KT schedule	1, 5, 6
Community of practice	S57	Arranging group sessions to fix a problem	2
	S58	Arranging group sessions at the beginning of work	8
	S59	Group sessions conducted by an experienced member of another team	1, 6
Project guidelines	S60	Practice of documentation	7
	S61	Reading documentation before KT	8
	S62	Provide overview of document before KT	5
Task management	S63	Allocate enough time to understand requirements	3
	S64	Building up team knowledge to reduce single points of failure	8
	S65	Allocate time to the next shift employee	3, 5
Project deadlines	S66	Properly planned KT	4
	S67	Conducting stand-up and end-of-the-day meetings	2
	S68	Allocate extra schedule hours for design phase	4
	S69	Involve as many team members as possible in design phase	5
	S70	Engaging offshore business analyst at client location	6
Verification	S71	E-learning courses structured to test current knowledge	8
	S72	Weekly oral tests	7
	S73	Regular updates via emails and shared screen meetings	8
	S74	Marking to ensure KT delivery	5
Reducing extra costs	S75	KT through communication media rather than onsite visiting	2, 5
	S76	Ensuring delivery of knowledge from old to new vendor	1
	S77	Quick and easy access to client's knowledge repository	1
	S78	Recruiting personnel based on past experience in a similar domain	1
Novelty	S79	Sending employees for training sessions to authorized institutions	5
	S80	Arranging classes by domain experts	5
	S81	Conducting brainstorming sessions	6
	S82	User guides and documentation to solve new problems	7
Employee turnover	S83	Maintain at least 30% of people in each tier of knowledge	8
	S84	Leaving employee to provide KT to its replacement	1, 2, 4, 5, 6
	S85	Prepare the KT plan before the employee leaves the job	7
Communication bridges	S86	Direct communication of offshore team with onsite	1, 2, 5

Table 15: Interview strategies - Project factors.

Project guidelines: One of the interviewees mentioned the good practice of documenting activities, i.e., the learning experiences, training materials and meeting minutes. This helps converting tacit knowledge into more accessible form. Another interviewee emphasized that the remote team members need to read the documentation before the KT from onsite. This helps them to grab the business domain quickly. Moreover once the KT begins, the knowledge provider should begin with a description of the purpose of the document about which the knowledge is to be transferred.

Task management: One of the interviewees mentioned that while allocating time for requirements engineering, sufficient time has to be fixed for understanding new requirements for the offshore team members. Moreover the delivery of knowledge should be in a way that promotes group knowledge to avoid single points of failure. Two of the interviewees mentioned that when an employee's shift change, the new shift should begin after some time so that the team member gets time to familiarize himself of the new changes since the last time the work was handed over.

Project deadlines: One of the interviewees mentioned that the KT has to be properly planned so that it does not affect the project delivery deadlines. Moreover, there has to be some buffer time allocated to counter unintended delays in KT. Another interviewee emphasized the importance of daily stand-up meetings and end-of-the-day project status meetings to monitor project progress. One other important strategy pointed out was the involvement of as many team members as possible in the design phase of the project. This helped knowledge about design decisions to be known quickly. Also in the project schedule, extra hours should be allocated in the design phase for gaining consensus on complex design decisions. Another interviewee mentioned that by engaging offshore business analyst at the client side, major knowledge issues were resolved since it increased communication and contact times.

Verification: One of the interviewees mentioned that e-learning courses were structured around small exercises to test whether the learner is gaining the intended knowledge or not. Moreover one of the

interviewees mentioned taking weekly oral tests with the team members to verify their current knowledge. Regular updates via emails and shared screen meetings are another strategy to verify if the given knowledge is being understood. One of the interviewees mention keeping a record of knowledge delivery items and a list of intended recipients. Once the knowledge about a topic was given, the item was marked while individual knowledge recipients were marked once they understood the delivered knowledge.

Reducing extra costs: Two of the interviewees mentioned that onsite visits can be reduced to a certain extent with the use of video conferences and Skype meetings. Moreover while changing vendors, it should be ensured that the old vendor provides all relevant knowledge to the new vendor. One of the interviewees mentioned that quick and easy access to client's knowledge repository is useful in narrowing down the knowledge gap of remote team members. Another interviewee mentioned that while recruiting new team members, it greatly helps to hire a resource with past experience in a similar domain.

Novelty: One of the interviewees mentioned that in order to deal with technical novelty, sending employees for training at authorized institutions can pay off in a longer run. Similarly another interviewee highlighted that subject experts can arrange training sessions to help reduce the complexity of a novel technology. Another way to deal with novel technical solutions is to take help from user documentation and guides. Brainstorming sessions to deal with solutions of newer problems are also emphasized by another interviewee.

Employee turnover: One of the interviewees mentioned that a medium sized project should maintain at least 30% of human resources at each tier of knowledge (novice, medium, expert). Five interviewees mentioned that it should be ensured that before an employee leaves, she should transfer the knowledge to the replacement (when there is one). In order to facilitate the transfer of knowledge, a proper KT plan should be put in place.

Communication bridges: Three of the interviewees mentioned that in order to reduce the potential loss of information, the remote team members should be able to directly communicate with the onsite staff. This will also help eliminate misunderstandings.

5.6 KT mitigation strategies in GSD - Technology factors

Our data analysis of interviews grouped technology factors for KT mitigation strategies in GSD into following codes: software tool support and maintaining a TMS. Below is a description of each of these codes while Table 16 presents a summary.

Technology factors			
Codes	ID	Interview - Strategies	Interview ID
Software tool support	S87	Use video conference and live meetings	2, 3, 6
	S88	Emails for asynchronous communication	1, 5
Maintaining a TMS	S89	Maintaining a repository and a change management system	2, 4

Table 16: Interview strategies - Technology factors.

Software tool support: The interviewees acknowledged the role of tools for communication in transferring knowledge among remote teams. Three of the interviewees mentioned the usefulness of video conferences and live meetings while two of the interviewees mentioned the preference of emails for asynchronous communication.

Maintaining a TMS: Two of the interviewees highlighted the importance of maintaining a transactive memory system (TMS) such as a document repository and a change management system.

Fig. 9: Challenges from both SLR and Interviews.

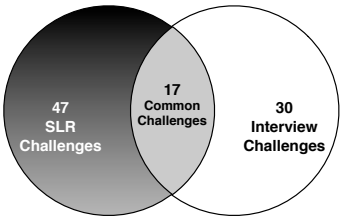
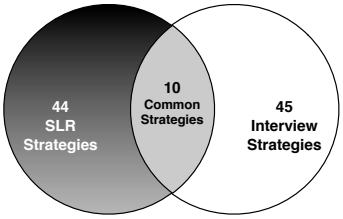


Fig. 10: Mitigation strategies from both SLR and Interviews.



6 Comparison of SLR and interviews using cross-case analysis

As mentioned in Section 3.1, cross-case analysis is used to find commonalities and dissimilarities in challenges and mitigation strategies for KT in GSD settings, collected from both SLR and interviews.

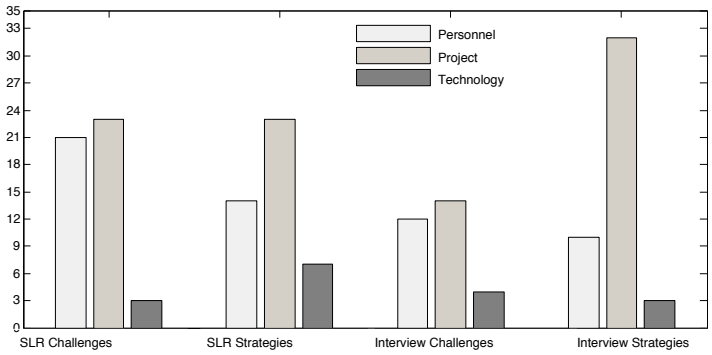
Comparing the open codes (the lowest level of theoretical codes), SLR identified a total of 91 codes (47 challenges, 44 mitigation strategies) in comparison with 75 (30 challenges, 45 mitigation strategies) identified from interviews. This shows that the expert interviews were more solutions-oriented as they presented more mitigation strategies than challenges. This was also expected as the practitioners are frequently used to solving the KT challenges in GSD projects.

When comparing the KT challenges found from both the SLR and interviews, a total of 77 challenges emerge, out of which 17 are common. The pair of common challenges are (C2, C48), (C3, C49), (C12, C52), (C13, C55), (C15, C53), (C20, C59), (C23, C60), (C28, C61), (C31, C63), (C32, C69), (C34, C67), (C38, C64), (C39, C68), (C42, C71), (C44, C73), (C45, C74) and (C46, C76). Figure 9 shows the distribution. The 77 open codes for the challenges were grouped, first into axial codes and then into the selective coding of 2PT conceptualization. Tables 5, 6, 7, 11, 12 and 13 in Sections 4 and 5 summarize these codes for KT challenges in GSD.

Comparing the KT mitigation strategies from both the SLR and interviews, a total of 89 strategies emerge, out of which 10 are common. The pair of common mitigation strategies are (S5, S49), (S10, S50), (S14, S54), (S15, S57), (S18, S60), (S22, S72), (S36, S86), (S38, S89), (S39, S87) and (S40, S88). Figure 10 shows the distribution. Similar to the challenges, the 89 open codes for the mitigation strategies were grouped, first into axial codes and then into the selective coding of 2PT conceptualization. Tables 8, 9, 10, 14, 15 and 16 in Sections 4 and 5 summarize these codes for KT mitigation strategies in GSD.

As the KT challenges and the mitigation strategies gathered from both SLR and interviews were conceptualized into 2PT factors, Figure 11 shows the distribution of challenges and mitigation strategies according to the 2PT conceptualization. What is evident from this figure is the dominance of challenges and mitigation strategies in the project factor, followed by the personnel factor. The technology factor presented the least number of challenges and mitigation strategies. This outcome highlights the complexity of managing a GSD project where issues such as geographical distances and cultural diversities make

Fig. 11: Distribution of challenges and mitigation strategies.



the context rich and complicated. Also a greater number of challenges and mitigation strategies in the personnel factor goes to show the human-intensive nature of GSD projects and thus a need to manage such factors effectively. We can also observe that technology alone is not sufficient to overcome barriers to KT, rather it is a facilitator and an enabler for successful KT in GSD projects.

Having identified the challenges and the mitigation strategies through SLR and interviews, we have devised a map which can assist practitioners in terms of mitigation strategies to use when faced with a specific KT challenge. This mapping is not exhaustive, meaning that there is a possibility that a challenge can be mitigated using strategies that are mapped to other challenge(s). The mapping is entirely based on the authors' insights about how best a challenge can be mitigated using a variety of strategies outlined in this paper. The mapping is presented in Table 17.

7 Validity of the study

There can be threats to the validity of the SLR and the interviews. For the SLR, we followed the guidelines proposed by Kitchenham and Charters (Kitchenham and Charters, 2007). The databases selected for the search of literature are most common in software engineering. There is a threat that we did not include any grey literature in the review, however this threat is minimized by conducting expert interviews. Rest of the steps in the SLR were carefully reviewed by authors. To ensure consistency of data extraction, a small sample of studies were used to extract data for second time. For the interviews, a number of measures were taken to enhance validity of results. The interviewees were guaranteed anonymity and were

No.	Challenge ID	Mitigation strategy to use
1	C1	S7, S9, S36, S45, S86
2	C2, C48	S7, S9, S45
3	C3, C49	S7, S9, S36, S45, S86
4	C4	S7, S9, S18, S60
5	C5	S7, S9, S18, S36, S45, S60, S86
6	C6	S1, S3, S2
7	C7	S1, S3, S2
8	C8	S2, S4, S46, S53
9	C9	S3
10	C10	S7, S8, S9, S10, S31, S50
11	C11	S7, S8
12	C12, C52	S7, S8, S51
13	C13, C55	S11, S12, S71
14	C14	S12, S13
15	C15, C53	S6, S14, S32, S54
16	C16	S11
17	C17	S12, S14, S54
18	C18	S11, S13
19	C19	S5
20	C20, C59	S13
21	C21	S5, S49
22	C22	S21
23	C23, C60	S16, S17, S18, S19, S20, S60, S62, S63
24	C24	S17, S18, S19, S60
25	C25	S27, S28
26	C26	S34, S35
27	C27	S34, S35
28	C28, C61	S35, S36, S37, S65, S86
29	C29	S35, S37
30	C30	S35, S37
31	C31, C63	S15, S26, S27, S57, S58, S59, S83, S84, S85
32	C32, C69	S16, S18, S34, S60, S77
33	C33	S16, S17, S18, S19, S60
34	C34, C67	S35, S37, S75, S77
35	C35	S27, S28
36	C36	S33, S35, S36, S37, S86
37	C37	S36, S37, S86
38	C38, C64	S34, S35, S56, S66, S67, S68, S69, S70, S73, S74
39	C39, C68	S7, S8, S9, S56, S66
40	C40	S21
41	C41	S36, S37, S86
42	C42, C71	S29, S30, S79, S80, S81, S82
43	C43	S35, S36, S37, S86
44	C44, C73	S36, S37, S64, S86
45	C45, C74	S39, S40, S41, S42, S87, S88
46	C46, C76	S38, S44, S38, S89
47	C47	S38, S43, S44, S89
48	C50	S10, S50, S51, S52
49	C51	S10, S50
50	C54	S48
51	C56	S22, S23, S24, S25 S48, S61, S72
52	C57	S5, S47, S48, S49
53	C58	S10, S50
54	C62	S55, S56
55	C65	S76, S78
56	C66	S77, S78
57	C70	S68, S69
58	C72	S83, S84, S85
59	C75	S39, S40, S41, S42, S87, S88
60	C77	S38, S89

Table 17: Mapping between challenges and mitigation strategies.

assured that the answers will not be disclosed and used for any evaluation. Another threat to validity is that due to subjective nature of the interview questions, interviewees might have misinterpreted the

questions. However the authors were available to clarify any misunderstandings during the interview conduct. The interviews were conducted at different companies therefore the responses have little chance of being influenced by internal discussions. The question structure for the interviews were properly checked before conducting the interviews. The time span of the interviews was kept under check to alleviate maturation threats. The interviewees were selected based on their experience in GSD projects therefore we are confident that their responses are correct and reliable. Finally, the large number of companies and their varying contexts contribute to generalizability; however it needs to be mentioned that qualitative interviews rarely attempt to generalize beyond the actual settings as they are more concerned with understanding the phenomenon of interest. Moreover the companies were selected from world-over and were involved in a variety of business domains.

8 Conclusions

This paper considers KT in GSD from the two perspectives of literature review and expert interviews. We are interested in finding out what are the challenges to KT in GSD settings and what mitigation strategies exist to deal with such challenges. To achieve this, the study applies grounded theory and cross-case analysis to come up with a conceptualization of KT challenges and mitigation strategies in to personnel, project and technology (2PT) factors. The results show that there are 79 different mitigation strategies to deal with 60 unique challenges. Most of the challenges and mitigation strategies belong to project and personnel factors while technology factor plays the role of a facilitator in ensuring successful KT. The study also maps the challenges with mitigation strategies with the aim to guide practitioners in selecting strategies when faced with different KT challenges. We conclude that in future, the researchers and practitioners need to focus on the 2PT factors for dealing with KT challenges in GSD.

9 Appendices

A Interview questions

Q.1. While engaged in KT, did you encounter situations where it became difficult communicating with receivers (due to e.g., differences in language and/or national culture)?
- If yes, how did you resolve some of the conflicts in KT?
- If no, what process did you follow to effectively manage different stakeholder's involvement during KT?

Q.2. How did you verify that the delivered knowledge was successfully understood at the remote site?

Q.3. While outsourcing a project, is the SRS document enough to deliver complete knowledge regarding a project to be developed? If not, what other ways are used to transfer important knowledge to ensure requirements are understood?

Q.4. Do you think that trust between a service provider and a receiver affect KT?
- If yes, how?
- If no, why?

Q.5. Did you improvise while transferring knowledge at different levels of expertise, i.e., to recipients who are either novice, advanced beginner, competent or proficient?
- If yes, what strategies did you use in KT at different levels? Were there any challenges encountered and how did you overcome those?
- If no, why?

Q.6. In an ongoing project, if an employee changes the team or leaves, will it affect the KT process?
- If yes, how will you mitigate that challenge?
- If no, how will you fill in the knowledge vacuum created?

Q.7. During KT in GSD, do you think that centralized communication (i.e., through an offsite person rather than face-to-face communication with the client) holds much promise? Is there any information loss through centralized communication? If so, how do you resolve it?

Q.8. If the offshore team is not able to understand the requirements or change requests as documented onsite, how will this be handled form both client and vendor perspective?

Q.9. KT is deemed to get affected if the number of distributed sites increase. What will you do or have done in the past to overcome such a challenge?

Q.10. When work is handed over to a distributed team member, due to lack of time coincidence (e.g., catch-up time to a next shift person and reporting time from past-shift employee) did you ever face any problem? If so, how did you overcome such problems?

Q.11. Are there any extra costs involved in transferring knowledge in a global context? If so, what are those costs and what can be done to avoid such costs?

Q.12. How do you ensure that the KT process follows a project schedule, i.e., you do not let deadlines slip while KT is complete?

Q.13. If the degree of novelty in a project is high, is it difficult to transfer knowledge? If so, what steps need to be taken to overcome this challenge?

Q.14. Will KT issues between the development and system testing team affect overall project schedule? If yes, what mitigation strategies you follow to remedy such a situation?
Q.15. What supporting technologies and organizational practices are used for effective KT?
Q.16. If the project-level knowledge is strongly coupled with organizational-level knowledge, does it become either easy or hard to transfer knowledge between the employees? If it becomes hard, what can be done to overcome this challenge?

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