Knowledge Management Practices in Global Software Development: A Systematic Literature Review

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Smeea Arshad

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Department of Computer Science

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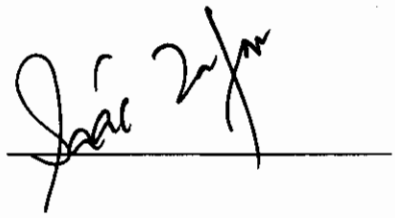
FINAL APPROVAL

It is certified that we have read the thesis, entitled **"Knowledge Management Practices: Systematic Literature Review"**, submitted by Smeea Arshad Reg. No. 154-FBAS/MSSE/F07 . It is our judgment that this thesis is of sufficient standard to warrant its acceptance by the International Islamic University Islamabad for MS Degree in Software Engineering.

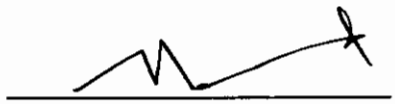
PROJECT EVALUATION COMMITTEE

External Examiner:
Dr. Saad Zafar,
Dean Faculty of Computing,
Ripah International University.

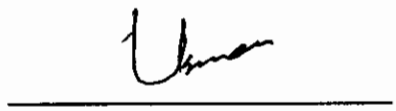


Internal Examiner:
Miss Muneera Bano, Assistant Professor,
Department of Computer Science,
Facutly of Basic and Applied Sciences,
International Islamic University Islamabad.

Supervisor:
Dr. Naveed Ikram,
Associate professor, Software Engineering,
International Islamic University Islamabad.



Co-supervisor
M. Usman, Assistant Professor,
Department of Computer Science,
Faculty of Basic and Applied Sciences,
International Islamic University Islamabad.



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Smeea Arshad

154-FBAS/MSSE/F07

Dedication:

I dedicate my work to:

My Parents

&

My Teachers

Abstract:

Developing software with geographically dispersed teams is becoming a norm these days. Organizations are mainly adopting this methodology to take the advantage of round the clock development and closeness to the customer. However, geographic separation introduces many issues such as communication, coordination and culture.

Knowledge Management (KM) is identified as a problem dimensions in GSD that gives rise to many GSD issue like communication, coordination and control. At the same time, KM practices (KMPs) help GSD organizations to reduce these problems.

The aim of this research is to identify the occurrence and effectiveness of the KMPs to deal with GSD issues due to lack of KM. Systematic Literature Review (SLR) is used as research methodology to identify and bring the evidence about GSD problems due to lack of KM and KMPs used to address these problems at one place. Frequency of problems and practices is identified to find out most occurring problems and most widely use practices. The identified problems and practices are also categorized and guidelines are suggested to select an appropriate practice.

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Chapter 1: Introduction

1.1 Introduction:

This research is intended to gain insight about the state of practice of knowledge management (KM) in global software development (GSD). GSD problems that arise due to lack of KM and knowledge management practices (KMPs) used to handle GSD problems due to lack of KM are identified. Identification of problems and practices will help the practioners in selecting the appropriate practice to deal with KM.

Knowledge is an important asset for an organization that is retained in individuals' mind, thus whenever a proficient person leaves, it creates knowledge gap. Organizations have to hire new people who need time and training. Furthermore, in an organization employees have to "coordinate and integrate different knowledge sources" in their projects. Organizations must employ an effective KM program to be successful in these activities within resource, budget and time constraints (Desouza, Awazu, & Baloh, 2006). KM is a discipline in software engineering that not only helps in creating and sharing knowledge but also helps in "software process improvement by explicitly and systematically addressing the management of organizational knowledge, such as its acquisition, storage, organization, evolution, and effective access" (Rus & Lindvall, 2002,p.4)

Global Software Development is a more prevailing trend these days due to less cost, skilled workforce, nearness to the market and round the clock development. But as the teams in GSD are scattered, they face issues of communication, coordination, knowledge management and control (Herbsleb & Moitra, 2002). Software development is a knowledge intensive task. It involves many people working in different phases and activities. In GSD these people are even separated by time and space. Their knowledge is required to be transferred and shared despite of the geographic and time zone difference (Rus & Lindvall, 2002). KM is a way to cope with the complexity of GSD by giving solution to innate issues in GSD. Knowledge management facilitates the organization operating globally to successfully integrate and coordinate knowledge resources in restricted resources and budget (Desouza et al., 2006). Awareness of multi team development activities and their consequences on share artifacts helps in correct integration of code by multiple teams (Anita & Andre vander, 2006). "Knowledge management stimulates the information sharing and stimulates the learning from experience" (Prikladnicki, Nicolas Audy, &

Evaristo, 2003). KM also enables organizations to achieve coordination and solve communication and cultural issues.

1.2 Global Software Development Issues due to lack of Knowledge Management:

Lack of KM gives rise to many issues. It effects different phases of software development life cycle such as requirements engineering (RE) and architecture and testing. (Damian & Zowghi, 2003;Clerc, Lago, & Vliet, 2009). Seeking relevant knowledge, knowledge sharing, synthesis and transfer are some of the problems faced in GSD because of lack of KM (Avram (n.d.); Herbsleb & Moitra, 2002).

Inability to seek out relevant knowledge, poor aggregation and integration procedures for knowledge synthesis and delays and blockage of knowledge transfer are some other KM problems identified. (Desouza, Awazu, & Baloh, 2006)

(Boden, et al., 2009) conducted an empirical study in a globally operating organization and found shared understanding, knowledge exchange, team relationship and maintaining awareness were problems that occurred due to lack of KM.

(Avram, 2007) studied influence of globally distributed software development on knowledge creation, transfer and retention. He identified that knowledge, if not properly managed affects knowledge externalization, knowledge transfer, finding the right people, knowledge creation, shared understanding and knowledge sharing.

Many other studies reported different issues that occur because of lack of knowledge Management. Some of the issues are: collaboration, coordination, formal and informal communication, trust, misunderstanding and conflicts, control and delay (Damian & Zowghi, 2003).

1.3 Knowledge Management Practices (KMPs):

Acknowledging the importance of KM, several knowledge management practices (KMPs) are defined and used to tackle GSD problems.

(Avram 2007) identified the knowledge work practices that are used in the actual work setting. The focus of the study is on people, their values and associations to deal with issues in

distributed development. The identified practices deal with the issues of knowledge transfer, mutual knowledge and knowledge sharing.

(Desouza et al., 2006) empirically found the strategies and models used to manage knowledge in software industry. They observed KMPs in different organizations and narrated the strategies and models used to manage knowledge in GSD. They also provided the guidelines to select the strategy and model.

(Clerc et al., 2009) performed similar work. They reviewed the architectural knowledge management approaches and categorized the approaches in personalization and codification strategies. They provided the guidelines for the selection of practice by empirically checking its perceived usefulness and suggested to focus on hybrid approaches.

(Paiva, 2006) narrates the experience of implementing community of practice (CoP) by Brazil Global Development Center. CoP helped in project management, information reuse, reducing time in trouble shooting, requirements specification and reverse engineering. A knowledge-based model was introduced to achieve coordination for geographically distributed software projects and implemented it in two GSD projects (Kotlarsky, van Fenema, & Willcocks, 2008). (Clerc, 2008) identified the practices to cope with the GSD issues where focusing on the architecture. Frequent interaction across sites, urgent request, having a single repository for architecture artifacts are some of the identified practices.

1.4 Problem Description:

GSD organizations operate their business across the globe. They face different issues that are introduced by time, culture and distance. Many of these problems can be resolved by proper implementation of KM. Variety of KMPs exist in literature and are being used to deal with GSD problems. Appropriate selection of the practice is necessary to better deal with the complexity of such problems.

1.5 Research Objective:

The aim of this research is to see what is the state of practice of KM in GSD so that practioners become aware of the problems that arise if knowledge is not managed and which KMPs are used to deal with these problems. To attain this following objective is set:

- to bring the evidence about GSD problems due to lack of KM and KMPs used to address these problems at one place.

The questions investigated are:

RQ1: What GSD Problems occur due to lack of KM?

RQ2: What KMPs are used in GSD Projects?

RQ3: What GSD problems are addressed by existing KMPs?

1.6 Expected Outcome:

Outcome of this research will be the guideline to select appropriate practice to deal with the GSD problems due to lack of KM.

GSD issues due to lack of KM and KMPs to address these issues will be identified as the end result of this Systematic Literature Review (SLR). Most commonly faced problems and widely used practices will also be identified.

1.7 Research Methodology:

Systematic Literature Review (SLR) is the methodology used to collect evidence about GSD problems due to lack of KM and KMPs used to address the identified problems. "A systematic literature review is a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest" (Kitchenham, Dyba, & Jorgensen, 2004). SLR is used to summarize the existing research in a fair, unbiased and rigorous manner. A predefined search strategy is followed that ensures the completeness of the research. Barbra recognized the importance of empirical research and found little empirical research is conducted in the field of software engineering. She proposed the guideline derived from the field of medicine, for conduction the SLR (Kitchenham,2004). The review process is categorized as:

Planning the Review

- Identification of the need for a review
- Development of a review protocol.

Conducting the Review

- Identification of research
- Selection of primary studies
- Study quality assessment
- Data extraction & monitoring
- Data synthesis.

Reporting the Review

- "is a single stage phase " (Kitchenham, 2004). In this phase results of SLR are reported effectively.

1.8 Thesis Structure:

The structure of this thesis is as follows: Section 2 describes the protocol defined to perform the SLR. Section 2.1 describes research questions, section 2.2 describes major search terms and their synonyms whereas section 2.3 and 2.4 describe search string and search sources. After the plan for conducting the SLR is devised, it is executed. Section describes the execution i.e., actual implementation of the protocol devised. Section 3.1 describes results retrieved by applying search string to data sources, section 3.2 shows selected studies' citation, section 3.3 shows quality assessment score. Section 4 describes the end results of the SLR and analysis of the results. Section 4.1 describes the Results. Section 4.2 describes the findings and section 4.3 describes the analysis. Section 5 concludes the thesis.

Chapter 2: Protocol Definition

This chapter describes the highlights of protocol defined to perform the Systematic Literature Review (SLR). SLR is conducted on the base of predefined plan (protocol). Main sections of protocol are defined in this section and full protocol is provided in appendix A.

2.1 Background and Motivation:

Organizations are adopting GSD to take advantages of less cost, skilled resources, close to customer and round the clock development. Conversely, strategic, cultural, communication, technical, knowledge management and project and process management issues are innate in GSD. (Damian & Moitra, 2006; Herbsleb & Moitra, 2002).

Knowledge is important asset for organizations. It makes most of the organization capital as well as contributes to software process improvement. However, managing knowledge in global software development is challenging. Seeking relevant knowledge, knowledge sharing, synthesis and transfer are some of the problems faced in GSD (Boden, Avram, Bannon, & Wulf, 2009; Herbsleb & Moitra, 2002).

Oxford dictionary definition of practice is "the actual application as opposed to the theories relating to it" and Webster defies practice as "carry out or apply." Therefore, KMPs include anything that is applied by a company to manage knowledge. Thus, KM tools, strategies, models, systems, environment, approaches and technology lie in this category (Avram, 2007; Clerc, 2008). Good knowledge management (KM) practices are a major success factor for software development, influencing software quality and team performance (Boden et al., 2009). Knowledge management practices reduce knowledge management and GSD problem to least level (Avram, 2007). Knowledge management strategies are broadly categorized under codification and personalization strategy (Clerc, 2008). The usefulness of architectural Knowledge Management Practices is proved (Clerc et al., 2009). Some of the practices are (Clerc et al., 2009; Avram, 2007; Clerc, 2008) :

- Frequent Interaction across Sites
- Cross-site Delegation
- Face-to-Face Project Kick-Off Meetings
- Urgent Request
- Collocated High-Level Architecture Phase
- A Clear Organization Structure with Communicating Responsibilities

- Surviving the Babel Tower
- Talking the developer through his assigned work

Evidence about the KMP's that address GSD problems due to lack of KM is scattered due to which selecting appropriate practice becomes an issue. Every organization makes its own practices for addressing GSD problems due to lack of KM that is" re-inventing the wheel". The main motivation behind this study is to collect the evidence about the KMP's that address GSD problems due to lack of KM, thus the organizations have not any need to "re-inventing the wheel".

2.2 Research Questions:

RQ1: What GSD Problems occur due to lack of KM?
RQ2: What KMPs are used in GSD Projects?
RQ3: What GSD problems are addressed by existing KMPs?

2.3 Major Search Terms and Synonyms:

Major search terms for the three questions are GSD and KM. Synonyms of major terms and search string are:

GSD: ("Global Software development" OR "distributed software development" OR "multi-site software development" OR "global software engineering" OR "global requirements engineering" OR "distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR GSD OR GSE OR "offshore software development" OR GRE)

Knowledge Management: ("knowledge management" OR "knowledge sharing" OR "knowledge acquisition" OR "knowledge transfer" OR "knowledge creation" OR "knowledge capture" OR "tacit knowledge" OR "explicit knowledge" OR "knowledge retention" OR "knowledge valuation" OR "knowledge use" OR "knowledge application" OR "knowledge discovery" OR "knowledge integration" OR "knowledge theory" OR "organization knowledge" OR "knowledge engineering" OR "information management" OR "information sharing" OR "information transfer" OR "information reuse" OR "common understanding" OR "shared understanding")

2.4 Search String:

("knowledge management" OR "knowledge sharing" OR "knowledge acquisition" OR "knowledge transfer" OR "knowledge creation" OR "knowledge capture" OR "tacit knowledge" OR "explicit knowledge" OR "knowledge retention" OR "knowledge valuation" OR "knowledge use" OR "knowledge application" OR "knowledge discovery" OR "knowledge integration" OR "knowledge theory" OR "organization knowledge" OR "knowledge engineering" OR "information management" OR "information sharing" OR "information transfer" OR "information reuse" OR "common understanding" OR "shared understanding") AND ("Global Software development" OR "distributed software development" OR "multi-site software development" OR "global software engineering" OR "global requirements engineering" OR "distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR GSD OR GSE OR "offshore software development") .

Customized search string for each data base is given in chapter 3 execution.

2.5 Search Sources:

Selected databases for search are:

- IEEE Explore
- ACM Digital Library
- Science Direct
- Springerlink
- ElCompendex

2.6 Study Selection Criteria:

Study Inclusion Criteria:

Following type of studies will be included:

- that are about KM in GSD AND
- that include case studies or industrial/Experience reports or experiment.
- that were published from 2001 to 2010.

Study Exclusion Criteria:

Following type of studies will be excluded:

- that are not about KM in GSD

- that lack evidence in the form of case study/experiment/experience report
- that are examples and expert opinion
- that include distributed but not geographically distributed development.
- that were published in/before year 2000.

2.7 Quality Assessment Criteria:

To build quality assessment criteria existing literature on SLR and concerned faculty members along with the co-supervisor are consulted. Guidelines proposed by Barbra (2007) to conduct SLR and "Review Protocol–Agile Software Development" (Dyba) are consulted among the other relevant research material to develop the quality criteria that covers the planning, execution and conclusion of a paper. The criteria will evaluate the evidence based studies and experimental/industrial reports separately. The quality assessment criteria described for industrial/experience report is:

- Does the study clearly describe the context?
- Does the links between data, interpretation and conclusion are illustrated well?
- Does study describe implications for future research/practice.

Quality assessment criteria to assess evidence based studies is:

- Does study clearly narrate objectives?
- Does study clearly describe the context?
- Does the sampling method and rational given?
- Does the data collection method and its rational given?
- How clear are the links between data, interpretation and conclusion? Do the links between data, interpretation and conclusion are clearly defined?
- Does study describe implications for future research/practice?

Each question will be marked as yes =2, no =0 and partial =1. Quality threshold is "0" i.e. if a paper scores 0 for all the questions it would not be included in SLR.

2.8 Protocol Validation:

External reviewer will validate the protocol.

For complete protocol and expert opinion please refer to appendix.

Chapter 3: Protocol Execution

Systematic Literature Review is performed to find out the GSD problems and KMPs used to handle these problems. A plan was defined to conduct the SLR. This chapter describes the steps performed during realization of the plan.

3.1 Search String Application to Databases and Results Retrieved:

General search string is provided in section 2.4. An initial scoping study helped in identifying search terms and search sources. Google scholar was included in search sources but later removed as it gave different search results of the same search string at different times. Some databases did not allow the complete search string. Different search sources have different search string format so search string was modified and then applied on such search sources.

Customized search string applied on each database and citations are downloaded in a master library in endnote X2 retrieved from the web: http://www.endnote.com/enhome.asp. Customized search string for each database and results retrieved are shown below:

EI Compendex accepted the complete search string. The search string with no. of results retrieved is shown in table 3.1:

Table 3.1 Search string for EI Compendex

EI Compendex		
Total Results Retrieved	107	
String Query	**Abstract**	**Full Text**
3.1.1 -((("knowledge management" OR "knowledge sharing" OR "knowledge acquisition" OR "knowledge transfer" OR "knowledge creation" OR "knowledge capture" OR "information management" OR "information sharing" OR "information transfer" OR "information reuse" OR "common understanding" OR "shared understanding" OR "tacit knowledge" OR "explicit knowledge" OR "knowledge retention" OR "knowledge valuation" OR "knowledge use" OR "knowledge application" OR "knowledge discovery" OR "knowledge integration" OR "knowledge theory" OR "knowledge engineering" OR "organization knowledge")WN ALL) AND (("global software development" OR "global software engineering" OR "global requirements engineering" OR "distributed software development" OR "distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR "multi-site software development" OR "offshore software development" OR GSD OR GSE)WN ALL))	46	107

Total results retrieved were 107 with no duplicates found.

Since IEEE did not allow the full search string to be executed, it was broken down into three search strings. The executed strings and no. of results retrieved are shown in table 3.2:

Table 3.2 Search string for IEEE

IEEE		
Total Results Retrieved	**40**	
String Query	**Abstract**	**Full Text**
3.2.1-(("Abstract":"knowledge management" OR "knowledge sharing" OR "knowledge acquisition" OR "knowledge transfer" OR "knowledge creation" OR "knowledge capture" OR "tacit knowledge" OR "explicit knowledge")AND ("Abstract":"global software development" OR "global software engineering" OR "global requirements engineering" OR "distributed software development" OR "distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR "multi-site software development" OR "offshore software development" OR GSD OR GSE OR GRE))	25	538
3.2.2-(("knowledge valuation" OR "knowledge use" OR "knowledge discovery" OR "knowledge integration" OR "knowledge theory " OR "organization knowledge" OR "knowledge engineering" OR "knowledge application")AND ("global software development" OR "global software engineering" OR "global requirements engineering" OR "distributed software development" OR "distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR "multi-site software development" OR "offshore software development" OR GSD OR GSE OR GRE))	3	298
3.2.3-(("knowledge retention" OR "common understanding" OR "shared understanding" OR "information management" OR "information sharing" OR "information transfer" OR "information reuse")AND ("global software development" OR "global software engineering" OR "global requirements engineering" OR "distributed software development" OR "distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR "multi-site software development" OR "offshore software development" OR GSD OR GSE OR GRE))	12	490

Total results retrieved were 40 and discarding duplicates provided 38 results.

Science Direct accepted the complete search string. The search string with no. of results retrieved is shown table 3.3:

Table 3.3 Search String for Science Direct

Science Direct		
Total Results Retrieved	**149**	
String Query	**Abstract**	**Full Text**
3.3.1-FULL-TEXT("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "information management" or "information sharing" or "information transfer" or "information reuse" or "tacit knowledge" or "explicit knowledge" or "knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or "knowledge application" or "organization knowledge" or "knowledge engineering")and FULL-TEXT("global software development" or "global software engineering" or "global requirements engineering" or "distributed software development" or "distributed software engineering" or "multisite software development" or "multi-site software development" or "offshore software development" or "distributed requirements engineering" or GSD or GSE or GRE)	1	149

Total results retrieved were 149 with no duplicates found.

Due to Springer Link's ability to search limited no. of terms provided in query, the search string is broken down into twenty one sub strings. Each string is executed separately. Search string with no. of results retrieved are shown in table 3.4:

Table 3.4 Search String for Springer Link

Springer Link		
Total Results Retrieved	**342**	
String Query	**Abstract**	**Full Text**
3.4.1-("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "tacit knowledge" or "explicit knowledge") and ("global software development" or "global software engineering")	2	27
3.4.2-("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "tacit knowledge" or "explicit knowledge") and ("multisite software development" or "global requirements engineering")	0	5(books)
3.4.3-("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "tacit knowledge" or "explicit knowledge") and ("multi-site software development" or "distributed software development")	0	28
3.4.4-("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "tacit knowledge" or "explicit knowledge") and ("distributed software engineering" or "distributed requirements engineering")	0	5
3.4.5-("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "tacit knowledge" or "explicit knowledge") and ("offshore software development" or "GSD")	0	12
3.4.6-("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "tacit knowledge" or "explicit knowledge") and (GSE or GRE)	0	60
3.4.7-("knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or "organization knowledge" or "knowledge engineering") and ("global software development" or "global software engineering")	0	13
3.4.8-("knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or "organization knowledge" or "knowledge engineering") and ("multisite software development" or "global requirements engineering")	0	0
3.4.9-("knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or "organization knowledge" or "knowledge engineering") and ("multi-site software development" or "distributed software development")	0	49
3.4.10-("knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or "organization knowledge" or "knowledge engineering") and ("distributed software engineering" or "distributed requirements engineering")	0	5
3.4.11-("knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or	0	5

Springer Link		
Total Results Retrieved	**342**	
String Query	**Abstract**	**Full Text**
"organization knowledge" or "knowledge engineering") and ("offshore software development" or GSD)		
3.4.12-("knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or "organization knowledge" or "knowledge engineering") and (GSE or GRE)	0	12
3.4.13-("common understanding" or "shared understanding" or "information management" or "information sharing" or "information transfer" or "information reuse") and ("global software development" or "global software engineering" or "global requirements engineering")	2	18
1.14-("common understanding" or "shared understanding" or "information management" or "information sharing" or "information transfer" or "information reuse") and ("multisite software development" or "multisite software development" or "distributed software development")	1	5
3.4.15-("common understanding" or "shared understanding" or "information management" or "information sharing" or "information transfer" or "information reuse") and ("distributed software engineering" or "distributed requirements engineering" or "offshore software development")	1	17
3.4.16-("knowledge application" OR "common understanding" OR "shared understanding" OR "information management" OR" information sharing" OR "information transfer" OR "information reuse") and (GSD or GSE or GRE)	0	81

Total results retrieved were 342 and discarding duplicates provided 215 results.

ACM allows limited no. of search terms to be executed. That's why major search string is broken down into sub strings. Search strings and no. of results retrieved are shown table 3.5:

Table 3.5 Search string for ACM

ACM		
Total Results Retrieved	**97**	
String Query	**Abstract**	**Full Text**
3.5.1- (((Abstract:"knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge") and (Abstract:"global software development"))) and (PublishedAs:periodical OR PublishedAs:proceeding)	25	187
3.5.2-(((Abstract:"knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge") and (Abstract:"global software engineering"))) (PublishedAs:periodical OR PublishedAs:proceeding)) and (PublishedAs:periodical OR PublishedAs:proceeding)	5	51
3.5.3-((("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge")and ("global requirements engineering"))) and (PublishedAs:periodical OR PublishedAs:proceeding)	0	4
3.5.4-((("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit	22	189

ACM		
Total Results Retrieved	**97**	
String Query	**Abstract**	**Full Text**
knowledge") and ("distributed software development")))		
3.5.5-(((Abstract:"knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge")and(Abstract:"distributed software engineering"))) and (PublishedAs:periodical OR PublishedAs:proceeding)	1	35
3.5.6-(((Abstract:"knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge")and(Abstract:"distributed requirements engineering"))) and (PublishedAs:periodical OR PublishedAs:proceeding)	1	11
3.5.7-((("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge")and("multisite software development"))) and (PublishedAs:periodical OR PublishedAs:proceeding)	0	1
3.5.8-((("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge")and("multi-site software development"))) and (PublishedAs:periodical OR PublishedAs:proceeding)	1	27
3.5.9-((("knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge")and("offshore software development"))) and (PublishedAs:periodical OR PublishedAs:proceeding)	6	67
3.5.10-(((Abstract:"knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge")and(Abstract:GSD))) and (PublishedAs:periodical OR PublishedAs:proceeding)	8	54
3.5.11-(((Abstract:"knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge")and(Abstract:GSE))) and (PublishedAs:periodical OR PublishedAs:proceeding)	4	30
3.5.12-(((Abstract:"knowledge management" or "knowledge sharing" or "knowledge acquisition" or "knowledge transfer" or "knowledge creation" or "knowledge capture" or "common understanding" or "shared understanding" or "tacit knowledge")and(Abstract:GRE))) and (PublishedAs:periodical OR PublishedAs:proceeding)	0	61
3.5.13-(((Abstract:"explicit knowledge" or "knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or "knowledge engineering" or "organization knowledge") and ("Abstract:global software development")))	3	51
3.5.14-(((Abstract:"explicit knowledge" or "knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or "knowledge engineering" or "organization knowledge")and (Abstract:"global software engineering")))	2	15
3.5.15-(((Abstract:"explicit knowledge" or "knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or "knowledge engineering" or "organization knowledge")	7	69

ACM		
Total Results Retrieved	**97**	
String Query	**Abstract**	**Full Text**
and (Abstract:"distributed software development")))		
3.5.16-(((Abstract:"explicit knowledge" or "knowledge retention" or "knowledge valuation" or "knowledge use" or "knowledge discovery" or "knowledge integration" or "knowledge theory" or "knowledge engineering" or "organization knowledge")and (Abstract:"distributed software engineering"))	0	27
3.5.17-(((Abstract:"information management" or "information sharing" or "information reuse" or "information transfer") and (Abstract:"global software development")))	7	378
3.5.18-(((Abstract:"information management" or "information sharing" or "information reuse" or "information transfer") and (Abstract:"global software engineering")))	1	6
3.5.19-(((Abstract:"information management" or "information sharing" or "information reuse" or "information transfer") and (Abstract:"distributed software development")))	4	1
3.5.20-(((Abstract:"information management" or "information sharing" or "information reuse" or "information transfer") and (Abstract:"distributed software engineering")))	0	1
3.5.21((("knowledge application") and ("global software development" or "global software engineering" or "distributed software development" or "distributed software engineering"))) and (PublishedAs:periodical OR PublishedAs:proceeding)	0	3

Total results retrieved were 97 and discarding duplicates provided 85 results.

Results retrieved from each database are stored in master library.

3.2 Level 1 Screening:

Level 1 searching is performed on title, keywords and abstract. The purpose is to exclude completely irrelevant articles. Abstract level screening provides an easy way to exclude unrelated articles. Applying search string on different databases retrieved 625 studies. Inclusion/exclusion criteria defined in protocol was applied on these studies. Studies that failed to fulfill the criteria i.e., that were unrelated studies were excluded. In case of confusion co supervisor was consulted. No. of articles found after level 1 screening were 51.

3.3 Level 2 Screening:

Inclusion/Exclusion criteria defined in protocol is applied for level 2 screening. First author, performed screening of the papers. The papers not meeting the inclusion criteria and fulfilling the exclusion criteria were rejected and the reason for rejection was recorded. In case of uncertainty about inclusion/exclusion of paper co-supervisor was consulted. No. of selected articles was 28 with 22 primary and 5 secondary studies.

Table 3.6 Search sources and results retrieved:

Search Sources	Results Retrieved	After Duplicate Discarded	Primary Selection	Final Selection
EI Compendex	107	43	8	4
IEEE	43	38	20	7
Springer Link	337	215	7	4
Science Direct	149	149	15	7
ACM	97	85	1	0

51 articles were selected in primary selection and were reduced to 27 in primary selection. The reason for selecting only 27 papers is being relevant to the research questions. Only studies or part of the studies that addressed GSD problems due to lack of KM or KMPs used in GSD organizations or both were included. Papers that focused on any other aspect of KM and lacking GSD problems due to lack of KM or KMPs were not considered for SLR.

Citation of the selected papers is given below:

Table 3.7 Citation of selected sources

Paper ID	Citation
1	Avram, G. (2007, 27-30 Aug. 2007). *Of Deadlocks and Peopleware - Collaborative Work Practices in Global Software Development.* Paper fpresented at the Global Software Engineering, 2007. ICGSE 2007. Second IEEE International Conference on.
2	Bosch, J., & Bosch-Sijtsema, P. From integration to composition: On the impact of software product lines, global development and ecosystems. [doi: DOI: 10.1016/j.jss.2009.06.051]. *Journal of Systems and Software, 83*(1), 67-76
3	Kotlarsky, J., van Fenema, P. C., & Willcocks, L. P. (2008). Developing a knowledge-based perspective on coordination: The case of global software projects. [doi: DOI: 10.1016/j.im.2008.01.001]. *Information & Management, 45*(2), 96-108
4	Avram, G. Knowledge Work Practices in Global Software Development. *The Electronic Journal of Knowledge Management, 5*(4).
5	Komi-Sirviö, S., & Tihinen, M. (2005). Lessons learned by participants of distributed software development. *Knowledge and Process Management, 12*(2), 108-122.
6	Biro, M., & Feher, P. (2005). *Forces affecting offshore software development.* Paper presented at the 12th European Conference on Software Process Improvement, EuroSPI 2005, November 9, 2005 - November 11, 2005, Budapest, Hungary
7	Kotlarsky, J., & Oshri, I. (2005). Social ties, knowledge sharing and successful collaboration in globally distributed system development projects. *European Journal of Information Systems, 14*(1), 37-48
8	Lee, S., & Yong, H.-S. Distributed agile: project management in a global environment. [10.1007/s10664-009-9119-7]. *Empirical Software Engineering, 15*(2), 204-217
9	Mohan, K., & Ramesh, B. (2007). Traceability-based knowledge integration in group decision and negotiation activities. [doi: DOI: 10.1016/j.dss.2005.05.026]. *Decision Support Systems, 43*(3), 968-989.

Paper ID	Citation
10	Mathrani, A., Parsons, D., & Stockdale, R. (2009). *Workgroup structures in offshore software development projects: A vendor case study.* Paper presented at the 2009 13th Enterprise Distributed Object Computing Conference Workshops, EDOCW - IEEE EDOC 2009 Workshops and Short Papers, September 1, 2009 - September 4, 2009, Auckland, New Zealand
11	Boden, A., & Avram, G. (2009, 17-17 May 2009). Bridging knowledge distribution The role of knowledge brokers in distributed software development teams. Paper presented at the Cooperative and Human Aspects on Software Engineering, 2009. CHASE '09. ICSE Workshop on software engineering.
12	E. Damian, D., & Zowghi, D. (2003). RE challenges in multi-site software development organisations. [10.1007/s00766-003-0173-1]. Requirements Engineering, 8(3), 149-160.
13	Ebert, C., & Man, J. D. (2008). Effectively utilizing project, product and process knowledge. [doi: DOI: 10.1016/j.infsof.2007.06.007]. *Information and Software Technology, 50*(6), 579-594
14	Taweel, A., Delaney, B., Arvanitis, T. N., & Zhao, L. (2009). *Communication, knowledge and co-ordination management in globally distributed software development: Informed by a scientific software engineering case study.* Paper presented at the 2009 4th IEEE International Conference on Global Software Engineering, ICGSE 2009, July 13, 2009 - July 16, 2009, Limerick, Ireland.
15	Wiener, M., & Stephan, R. Reverse Presentations. [10.1007/s12599-010-0100-1]. *Business & Information Systems Engineering.*
16	Munkvold, B. E., & Zigurs, I. (2007). Process and technology challenges in swift-starting virtual teams. [doi: DOI: 10.1016/j.im.2007.01.002]. *Information & Management, 44*(3), 287-299.
17	Clerc, V., Lago, P., van Vliet, H., (2009). The Usefulness of Architectural Knowledge Management Practices in GSD Paper presented at the 2009 4th IEEE International Conference on Global Software
18	Jensen, M., Menon, S., Mangset, L. E., & Dalberg, V. (2007). *Managing offshore outsourcing of knowledge-intensive projects a people centric approach.* Paper presented at the International Conference on Global Software Engineering, ICGSE 2007, August 27, 2007 - August 30, 2007, Munich, Germany.
19	Taxén, L. (2006). An integration centric approach for the coordination of distributed software development projects. [doi: DOI: 10.1016/j.infsof.2006.01.007]. *Information and Software Technology, 48*(9), 767-780
20	Avram, G. Developing Outsourcing Relationships: A Romanian Service Provider Perspective. *First Information Systems Workshop on Global Sourcing: Services, Knowledge and Innovation Val d'Isère, France 13-15 March 2007.*
21	Oshri, I., Fenema, P. v., & Kotlarsky, J. (2008). Knowledge transfer in globally distributed teams: the role of transactive memory. *Information Systems Journal, 18*(6), 593-616.
22	Gao, J. Z., Itaru, F., & Toyoshima, Y. (2002). Managing Problems for Global Software Production – Experience and Lessons. [10.1023/A:1013116910400]. *Information Technology and Management, 3*(1), 85-112.
23	Taweel, A., Delaney, B., & Lei, Z. (2009, 13-16 July 2009). *Knowledge Management in Distributed Scientific Software Development.* Paper presented at the Global Software Engineering, 2009. ICGSE 2009. Fourth IEEE International Conference on.
24	Pilatti, L., Audy, J., & Prikladnicki, R. (2006). *Software configuration management over a global software development environment: lessons learned from a case study.*
25	Desouza, K., Dingsøyr, T., & Awazu, Y. (2005). Experiences with conducting project postmortems: reports versus stories. *Software Process: Improvement and Practice, 10*(2), 203-215.
26	Espinosa, J. A., Slaughter, S. A., Kraut, R. E., & Herbsleb, J. D. (2007). Team knowledge and coordination in geographically distributed software development. *Journal of Management Information Systems, 24*(Compendex), 135-169
27	Gupta, A., Mattarelli, E., Seshasai, S., & Broschak, J. (2009). Use of collaborative technologies and knowledge sharing in co-located and distributed teams: Towards the 24-h knowledge factory. [doi: DOI: 10.1016/j.jsis.2009.07.001]. *The Journal of Strategic Information Systems, 18*(3), 147-161.

The papers included in this SLR are from different sources. Maximum papers are retrieved from ICGSE, International Conference on Global Software Engineering. Papers from

different journals are also retrieved. The journal of "Information and software technology" and "Information and management" provided the greatest no. of papers i.e. 2 for each journal.

3.4 Quality Assessment:

Quality assessment was performed following the criteria defined in protocol. Two types of studies: Industrial/Experience report and case studies are identified. Quality score is presented in two different tables for each type of studies. Table 3.8 shows the quality score for experience reports. No. of papers having industrial/experience report as research methodology are 9. Quality assessment score for each paper is provided in non increasing order from highest to lowest quality score. Maximum possible score for industrial/experience report is 6 and score obtained is 3 highest and 1 lowest. Quality assessment was validated by having a discussion with co-supervisor.

Table 3.8 Quality assessment score for experience/ industrial Report

Serial no.	Paper ID	Experience/Industrial Report			Total (Max total=6)
		Q1	Q2	Q3	
1	5	1	2	0	3
2	1	1	1	0	2
3	4	1	1	0	2
4	14	1	0	1	2
5	2	1	0	1	2
6	8	1	1	0	2
7	18	1	1	0	2
8	22	1	0	0	1
9	23	1	0	0	1

The papers obtained accumulative score of 3,2 and 1 against the quality criteria described. One paper obtained quality score 3, six papers obtained 2 and two papers scored 1. Separate score for each question for this paper is: two for clarity in links between data interpretation and conclusion and one for context description. All the papers that scored two got one in context description. Of these papers, four had partial clarity in links between data

interpretation and conclusion so they got one whereas two lacked the link between data interpretation and conclusion. Only two papers scored one for future work and practical implication and remaining four obtained zero score for this question.

Two papers scored 1 that is the lowest score. These papers had partly described the context and lacked any description of links between data interpretation. They also failed to provide directions for future research or practical implication.

Table 3.9 shows the quality score for case studies. Quality assessment score for each paper is provided in non increasing order from highest to lowest quality score. Maximum possible score is 12 and highest score achieved is 11. The lowest score is 4.

Table 3.9 Quality assessment score for evidence based studies

Serial no.	Paper ID	Evidence based Studies						Total (Max Total= 12)
		Q1	Q2	Q3	Q4	Q5	Q6	
1	26	2	1	2	2	2	2	11
2	27	2	1	1	1	2	2	9
3	12	2	1	1	1	1	2	8
4	15	1	1	1	1	1	2	7
5	19	1	1	1	1	2	1	7
6	20	2	1	1	1	1	1	7
7	10	1	1	1	1	2	0	6
8	9	2	1	0	1	1	1	6
9	3	2	1	1	1	1	0	6
10	11	1	1	1	1	1	1	6
11	7	2	1	1	1	1	0	6
12	16	2	1	1	0	1	1	6
13	17	2	1	1	1	1	0	6
14	25	1	1	0	0	2	1	5
15	21	2	1	0	1	0	0	4
16	13	1	1	0	0	1	1	4
17	6	2	1	0	0	0	1	4

18	24	1	1	0	0	1	1	4

The highest scores obtained are 11, 9 and 8 respectively for each paper. Three papers obtained 7, seven got 6, one got 5 and four papers scored 4 that is the lowest score obtained. One paper obtained highest score i.e., 11. Reasons for obtaining this score are clearly defined objectives, defining data collection and sampling method with rationale, link clarity for data interpretation and conclusion and implications for future research and practice. This paper got two score for each question except for describing context.

One paper obtained quality score 8. This paper had clearly defined objectives, partly described text and provided data collection and sampling method without reasoning, partial clarity in links between data interpretation and conclusion and defined implications for future research and practice.

Of the three papers with quality score 7, one had clarity in links between data interpretation and conclusion and other had defined implications for future research and practice. Third paper had link clarity in data interpretation and conclusion. They partly defined objectives and context, lacked reason for data collection and sampling methods.

Among paper with quality score 6, five papers scored two for clearly describing objectives whereas two papers scored one. For remaining questions all the papers scored either zero or one.

Paper that scored 5 got two in clarity in links between data interpretation and conclusion and zero or one for remaining.

Of the four papers with quality score 4 only two got highest score in one question i.e., q1.

Chapter 4: Results & Analysis

Systematic literature review (SLR) is performed to identify global software development (GSD) problems due to lack of knowledge management (KM) and knowledge management practices (KMPs) to handle the identified issues. This chapter describes the results and analysis of this SLR. This chapter is organized into three sections. First section presents results, second and third sections present findings and analysis of the data respectively.

4.1 Results:

This section presents the results of RQ1, RQ2 &RQ3. Results are the raw data extracted from the papers and presented without any processing.

RQ1: What GSD issues occur due to lack of KM in GSD?

RQ2: What KMPs are used in GSD Projects?

RQ3: What GSD problems are addressed by existing KMPs?

The purpose of these questions was to identify the problems GSD organizations face due to lack of KM and KMPs they use to address the problems faced. For each study GSD problems due to lack of KM and KMPs used to address these problems are extracted. Each row in the table represents one study.

The data extracted is shown in table 4.1 with paper ID, study ID and Quality score. Data is extracted on the basis of studies. Each study is presented in non increasing order of quality score obtained. Maximum quality score achieved for industrial/experience report is 3 and for evidence based studies is 11.

The data highlights that knowledge, if not managed properly gives rise to many problems such as shared understanding, knowledge transfer and knowledge/information sharing and different KMPs are used in different situations to deal with GSD problems due to lack of KM.

Table 4.1 GSD problems due to lack of KM and KMPs used

Paper ID	Study ID	Quality Score	GSD Problems	KMPs used to address GSD Problems due to lack of KM
26	30	11	1) Coordination	1) Shared team knowledge 2) Shared knowledge of task 3) Task awareness 4) Presence awareness
27	22	9	1) Knowledge sharing	1) Collaborative technology
			2) Maintaing awareness	1) Collaborative technology
12	8	8	1) Lack of awareness of local working context and informal communication	1) Documentation 2) Biweekly meetings
			2) Common understanding of requirements	1) Biweekly meetings 2) Repository

Paper ID	Study ID	Quality Score	GSD Problems	KMPs used to address GSD Problems due to lack of KM
			3) Strong position of power	1) Documentation and supporting documents
			4) Knowledge/expertise sharing	No Practice is suggested for this specific problem in this article
			5) Requirements negotiation, validation and prioritization(RE)	No Practice is suggested for this specific problem in this article
			6) Ineffective decision making meetings	No Practice is suggested for this specific problem in this article
			7) Trust	No Practice is suggested for this specific problem in this article
			8) Conflicts and having open discussion of interest	No Practice is suggested for this specific problem in this article
			9) Delay	No Practice is suggested for this specific problem in this article
15	18	7	1) Communication issues 2) RE (Social aspect : trust, Communication preferences, cultural sensitivity, coordination, control) 3) Common understanding	1) Reverse Presentation Method
19	27	7	1) Common undrstanding 2) Clarifying dependencies 3) Distributing tasks 4) Requirements engineering 5) Planning and controlling the project 6) Managing cultural divesity 7) Managing change	1) Integration centric development (ICD)
20	41	5	1) Shared understanding	1) Collaborative technology
			2) Relationship building	1) Face to face meeting
10	21	6	1) Understand implicit embedded knowledge 2) Control 3) Coordination	1) Client representatives and account executives (ae's) (boundary roles)
			4) Knowledge transfer 5) Mutual Trust	1) Collaborative technology 2) Personal meetings
7	11,40	6	1) Collaboration	1) Knowledge sharing
3	11	6	1) Knowledge sharing	1) Team building exercise 2) Collaborative technology
			2) Collaboration	1) Division of work
			3) Common understanding	1) Standardized tools and methods
			4) Knowledge reuse	1) Collaborative technology
			5) Relationship building (team cohesion)	1) Team building activities 2) Mutual adjustment
			6) Conflicts and misunderstanding	1) Team building exercise (visits) 2) Division of work
			7) Coordination	1) Frequent interaction 2) Division of work
			8) Knowledge transfer	No Practice is suggested for this specific problem in this article
			9) Knowledge integration	No Practice is suggested for this specific

Paper ID	Study ID	Quality Score	GSD Problems	KMPs used to address GSD Problems due to lack of KM
				problem in this article
			10) Who knows what	No Practice is suggested for this specific problem in this article
			11) Time-to-market	No Practice is suggested for this specific problem in this article
			12) Knowledge update	No Practice is suggested for this specific problem in this article
			13) Communication	No Practice is suggested for this specific problem in this article
			14) Trust	No Practice is suggested for this specific problem in this article
			15) Information loss	Clear definition of roles and responsibilities
	12		1) Knowledge sharing	1) Cross continental mini teams 2) Direct communication 3) Team building exercise
			2) Coordination	1) Knowledge sharing
			2) Knowledge reuse	1) Collaborative technology
			2) Time to market	1) Knowledge reuse
			3) Information loss	1) Clear definition of roles and responsibilities
			4) Team cohesion	1) Visits
			5) Shared understanding	1) Standardized tools and methods
11	2	6	1) Knowledge exchange	1) Visits 2) Meetings 3) Brief meeting-minutes
			2) Maintaing awareness	1) Asking the colleague 2) Meetings 3) Brief minutes 4) Collaborative technology
			3) Trust 4) Culture	1) Visits
			5) Communication	1) Culture mediator (bridges) 2) Visits
	3		1) Knowledge exchange 2) Shared understanding	1) Permanent communication channel on skype 2) Documentation
			3) Relationship building 4) Building Trust	1) Visits
			5) Maintaing awareness	1) Collaborative technology
16	20	6	1) Information sharing	1) Collaborative technology 2) Document repository 3) Discussion board
			2) Communication	1) Contact function
17	7	6	1) Team relationship	1) Meetings/Visit
			2) Information gathering	1) Collaborative technology
			3) Finding the right people	1) Directory
			4) Common understanding	1) Repository
			5) Knowledge sharing	1) Shared infrastructure
			6) Communication	1) Clear project structure with clear communication responsibilities 2) Frequent interaction

Paper ID	Study ID	Quality Score	GSD Problems	KMPs used to address GSD Problems due to lack of KM
9	19	6	1) Knowledge integration	1) Process knowledge tracer (PK Tracer)
25	32,33	5	2) Knowledge capture	1) Project postmortem reports
21	43	4	1) Knowledge transfer	1) Update directories 2) Codification 3) Use common terminologies, language and concepts
			2) Who knows what/whom to contact	1) Develop standards, guidelines and templates 2) Use common terminologies, language and concepts 3) Personalized directories 4) Frequent interaction 5) Central directory 6) Collaborative technology
			3) Shared understanding	1) Joint QUARTZ training program for all employees
13	9	4	1) Improved quality 2) Cycle time 3) Engineering flexibility 4) Reduced overheads 5) Communication 6) Alignment of processes and tools and faster ramp-up time 7) Skill management	1) Knowledge centric product life cycle management
24	28	4	1) Common understanding	1) CMM based model
6	26,34, 35	4	1) Knowledge transfer 2) Organization maturity	No Practice is suggested for this specific problem in this article
5	42	3	1) Knowledge transfer	1) Division of work 2) Appoint contact person at each site to control communication
			2) Knowledge sharing 3) Common understanding	1) Face-to-face meeting 2) Kick off meetings 3) Technical meetings
			4) Knowledge acquisition	1) Collaborative technology 2) Guidelines for use of common databases, tools, versions and configuration management
			5) Culture	1) Knowledge sharing
1,4	1	2	1) Knowledge externalization 2) Knowledge transfer	1) Collocation(learn by watching) 2) Documentation 3) Learn by watching 4) Asking the colleague 5) Collaborative technology 6) Surviving the babel tower
			3) Who knows what or Finding the right people (to find someone who knows)	1) Personal contacts network or Transactive memory 2) Collaborative technology 3) Asking the colleague (developer/boundary spanner/ knowledge broker)
			4) Knowledge creation 5) Shared understanding or	1) Asking the colleague (developer/boundary spanner/

Paper ID	Study ID	Quality Score	GSD Problems	KMPs used to address GSD Problems due to lack of KM
			mutual knowledge	knowledge broker) 2) Collaborative technology 3) Documentation for maintaing awareness and circulating it 1) Regular meetings
			6) Knowledge sharing	1) Surviving the Babel tower
8	15	2	1) Communication 2) Face-to-face meetings difficult 3) Increased communication costs	1) Collaborative technology 2) Information update 3) Client representative
			4) Trust	1) Adapt Scrum processes 2) Collaborative technology 3) Face-to-face interaction
18	24	2	1) Knowledge Reuse	1) Documentation
			2) Communication	1) Liaison
			3) Relationship building	No Practice is suggested for this specific problem in this article
14,23	17	2	No Problem is suggested for this specific practice in this article	1) Informal encounters and meeting 2) Collaborative technology 3) Document management system
2	4,5,6	2	1) Share/transfer tacit knowledge	No Practice is suggested for this specific problem in this article
22	10	1	1) Information sharing 2) Communication	1) Web based problem information management system

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4.2 Findings:

Findings are the aggregation of the data. Data extracted from different papers and presented in table 4.1 for RQ1, RQ2 and RQ3 is aggregated and presented in this section. Section 4.2.1 presents findings related to GSD problems due to lack of KM and section 4.2.2 presents findings relevant to KMPs used to address GSD problems.

4.2.1 Frequency table for Global Software Development problems due to lack of Knowledge Management:

RQ1: What GSD Problems occur due to lack of KM?

Frequency of GSD problems due to lack of KM is identified. This recognized no. of times each problem occurred in GSD. Identifying frequency of the problems faced helped to indentify the most occurring problems in GSD due to lack of KM.

Table 4.2 shows list of GSD issues confronted in GSD organizations due to lack of KM. Frequency of each problem is also shown along with the list of problems. Table is sorted in non increasing order from most occurring problems to least faced problems. The motivation for this table is to see the no. of occurrences of each problem as reported in literature. This provided a catalog of most commonly faced problems. Organizations/Practitioners can anticipate the problem that is more likely to occur in a project and can take proactive measure to eradicate that problem or minimize its severity/ impact.

Table 4.2 Frequency table for GSD problems due to lack of KM

#	GSD Problems due to lack of KM	Freq	References	Research Method
1	Knowledge sharing	11	2,22,1,4,5	Experience Report
			12,16,28,3,17,27	Evidence based studies
2	Shared understanding	11	1,4,5	Experience Report
			12,15,3,24,11,17,20,21	Evidence based studies
3	Communication	10	18,22,8	Experience Report
			11,13,12,15,3,16,17	Evidence based studies
4	Knowledge transfer	7	1,4,5,	Experience Report
			3,10,21,6	Evidence based studies
5	Trust	5	8	Experience Report
			3,10,12,11	Evidence based studies
6	Who knows what or finding the right people or whom to contact	5	1,4	Experience Report
			3,21,17	Evidence based studies
7	Relationship building or team cohesion or team building	5	18	Experience Report
			11,20,3,17	Evidence based studies
8	Coordination	3	26,3,10	Evidence based studies
9	Requirements engineering	3	12,15,19	Evidence based studies
10	Awareness	3	12,11,27	Evidence based studies
11	Culture	3	5	Experience Report
			11,19	Evidence based study
12	Delay	3	12,3,13	Experience Report
13	Collaboration	2	3,7	Evidence based studies
14	Knowledge creation	2	1,4	Experience Report
15	Knowledge externalization	2	1,4	Experience Report
16	Knowledge integration	2	9,3	Evidence based studies
17	Control	2	12,10	Evidence based studies
18	Conflict management	2	12,3	Evidence based studies
19	Information gathering	1	17	Evidence based studies
20	Knowledge exchange	1	11	Evidence based study
21	Cost	1	8	Experience Report
22	Quality	1	13	Evidence based study
23	Alignment of processes and tools	1	13	Evidence based study
24	Ineffective decision making meetings	1	12	Evidence based study
25	Information loss	1	3	Evidence based study
26	Face-to-face meeting difficult	1	8	Experience Report

#	GSD Problems due to lack of KM	Freq	References	Research Method
27	Understand embedded implicit knowledge	1	10	Evidence based study
28	Skill management	1	13	Evidence based study
29	Managing Change	1	19	Evidence based study
30	Clarifying dependencies	1	19	Evidence based study
31	Distributing tasks	1	19	Evidence based study
32	Project management and documentation	1	8	Experience Report
33	Knowledge reuse	1	13	Evidence based study
34	Engineering flexibility	1	19	Evidence based study
35	Reduced overheads	1	19	Evidence based study
36	Organization maturity	1	6	Evidence based study

The identified issues vary in frequency from commonly occurring in different organizations to unique to one organization/project. The most frequently reported issues in this study are shared understanding, knowledge sharing and communication. Frequency of knowledge sharing, shared understanding is 11 and of communication is 10. The higher range of frequency shows that these issues are widespread in most of the organizations across different projects. Consequently, the chances of occurrence of such issues are higher than the issues with lower frequency range. Therefore, organizations must focus on these issues to be successful in global markets. Such organizations should also adapt practices that better cope with these issues. They are required to define the strategy and take proactive measures to deal with these issues.

Higher frequency range also demonstrates the significant impact KM has on GSD. This confirms KM as an important area to be considered when starting any GSD project. Communication is important for GSD and impact of KM on GSD suggests that managers must keep KM in focus to deal with complexity of the communication.

Issues with lower frequency range are also identified and reported. The no. of such reported issues is 18 with frequency of 1. These issues are specific to only one organization/project and depict the minimal role of knowledge management in occurrence of these issues.

4.2.2 Frequency table for Knowledge Management Practices:

RQ2: What KMPs are used in GSD Projects?

Frequency of KMPs used in GSD projects is identified to observe the most frequently used KMP. Identifying frequency of KMPs used helped to indentify the most commonly used KMP in GSD.

Table 4.3 shows the frequency of KMPs used to handle GSD problems because of lack of KM. The motivation for this table is to identify KMPs with the rate they are reported in literature. The identified catalog will assist GSD organizations/practitioners to find out most frequently used practices in GSD projects. They can also identify variety of practices used in GSD projects.

Table 4.3 Frequency table for KMPs

#	KMPs used to address GSD Problems due to lack of KM	Freq.	References	Research Method
1	Collaborative technology	14	1,4,5,8,17,22	Experience Report
			3,10,11,16,21,20,17,27	Evidence based studies
2	Meetings or Visits	8	1,4,5	Experience Report
			3,10,11,12,13,17	Evidence based studies
3	Documentation	7	1,4,18	Experience Report
			11,13,21,30	Evidence based studies
4	Asking the colleague	7	1,4,14,5,8	Experience Report
			19,12	Evidence based studies
5	Transactive memory	6	1,4	Experience Report
			3,16,12,17	Evidence based studies
6	Knowledge sharing	3	5	Experience Report
			7,3	Evidence based studies
7	Standard tools and methods	3	3,21,24	Evidence based studies
8	Division of work	2	5	Experience Report
			3	Evidence based studies
9	Informal communication	2	14,23	Experience Report
10	Guidelines or training programs	2	23	Experience Report
			21	Evidence based study
11	Clear project/organization structure with clear roles and responsibilities	2	3,17	Evidence based study
12	Cross continental mini teams	1	3	Evidence based study
13	Adapt scrum	1	8	Experience Report
14	Learn by watching	1	1	Experience Report
15	Direct request	1	3	Evidence based study
16	Information update	1	8	Experience Report
17	Knowledge centric product life cycle management	1	14	Evidence based study
18	Reverse Presentation Method	1	1	Experience Report
19	Shared team and task knowledge	1	26	Evidence based study
20	Surviving the Babel tower	1	4	Experience Report
21	Mutual adjustment	1	3	Evidence based study
22	Process Knowledge Tracer	1	9	Evidence based study
23	Shared infrastructure	1	17	Evidence based study
24	Clear project structure with clear communication responsibilities	1	17	Evidence based study

#	KMPs used to address GSD Problems due to lack of KM	Freq.	References	Research Method
25	Discussion board	1	16	Evidence based study
26	Knowledge reuse	1	3	Experience Report

Table 4.3 shows the KMPs used to address the GSD problems due to lack of KM. A List of KMPs along with their frequency is provided. KMPs with different frequency are identified. Highest frequency is 14 and lowest is 1. The list is arranged in non increasing order from most used practices (14) to least used (1). The top ranked practices are collaborative technology (14), Meetings or Visits (8), Asking the colleague (7) and Documentation (7). Practices with low frequency (1) are 17 in number.

'Collaborative technology' (frequency=14) is found to be the most frequently used practice. The widespread adoption of this practice highlights its ability to deal with KM. It lies in hybrid category for personalization. It shows that collaborative tools are important to be competitive in global markets.

'Documentation' is also one of the practices with high frequency score. It shows the significance of codification strategy to deal with GSD issues. Furthermore, it also shows that organizations also need to execute practices supporting codification strategy to better manage GSD projects.

Varied frequency of the practices shows that "some practices remain specific to one team while others spread and are adopted across the global organizations" (Avram 2007).

Lower range of frequencies in practices shows use of practices only in particular situation which is the reinvention of the wheel. A guideline is needed to be proposed for the organizations to select from the available practices. The practices used by/in single organization/project depict that these may be designed for a particular situation and their further validation is necessary for implementation in different organizations.

4.3 Analysis:

This section presents the analysis of the data presented in table 4.1. Analysis is not mere aggregation of data but also processing of the data.

4.3.1 Global Software Development Problems addressed by Knowledge Management Practices:

This section provides the analysis of GSD problems due to lack of KM and KMPs used to address the identified problems. Table 4.4 addresses RQ3: What GSD problems are addressed by existing KMPs? The intention to take this table into account is to know different practices that solve one particular problem. A trade off can be made for selecting a practice by seeing this table.

Table 4.4 consists of three columns. First Column presents GSD problems due to lack of KM, second column presents KMPs used to address GSD problems due to lack of KM and third column shows frequency of KMPs i.e., no. of times each practice is used to solve one particular issue.

GSD problems due to lack of KM presented in table 4.4 are sorted on frequency, identified in table 4.3. The problems are presented in non increasing order from most occurring problem to least occurring problem. KMPs are presented in order from most frequently used to less frequently used for each problem.

Table 4.4 GSD problems due to lack of KM and KMPs used to address these problems

GSD Problems due to lack of KM	KMPs used to address GSD problems due to lack of KM	F
Shared understanding	1) Collaborative technology	3
	2) Meetings	3
	3) Documentation	3
	4) Standardized tools and methods	2
	5) Transactive memory	2
	6) Asking the colleague (developer or boundary spanner or knowledge broker or bridges)	1
	7) Guidelines/training program	1
	8) Reverse Presentation method (RPM)	1
Knowledge sharing	1) Collaborative technology	4
	2) Meetings	2
	3) Surviving the Babel tower	1
	4) Process Knowledge Tracer	1
	5) Cross continental mini teams	1
	6) Direct communication	1
	7) Division of work	1
	8) Shared infrastructure	1
	9) Discussion board	1
	10) Transactive memory	1

GSD Problems due to lack of KM	KMPs used to address GSD problems due to lack of KM	F
Communication	1) Meetings/Visits	3
	2) Asking the colleague(developer/boundary spanner/knowledge brokers)	3
	3) Collaborative technology	2
	4) Clear project/organization structure with clear roles and responsibilities	2
	5) Transactive memory	1
	6) Information update	1
	7) Adapt scrum process	1
	8) Reverse Presentation method (RPM)	1
	9) Knowledge centric product life cycle management	1
	10) Reverse Presentation Method	1
	11) Documentation	
Knowledge transfer	1) Collaborative technology	2
	2) Meetings	2
	3) Asking the colleague	2
	4) Documentation	2
	5) Division of work	1
	6) Transactive memory	1
	7) Standard tools and methods	1
	8) Surviving the Babel tower	1
Trust	1) Meetings/Visits	3
	2) Collaborative technology	2
	3) Adapt scrum	1
Who knows what/finding the right people/whom to contact	1) Transactive memory	3
	2) Collaborative technology	2
	3) Meetings or Visits	1
	4) Asking the colleague (developer/boundary spanner/knowledge broker)	1
	5) Standard tools and methods	1
Relationship building or team cohesion or team building	1) Visits/meetings	4
	2) Mutual adjustment	1
Coordination	1) Knowledge sharing	2
	2) Meetings/visits	1
	3) Asking the colleague	1
	4) Division of work	1
Requirements Engineering	1) Integration centric development	1
	2) Reverse Presentation Method	1
Awareness	1) Collaborative technology	2
	2) Meetings	2
	3) Documentation	2
	4) Asking to the colleague (developer/boundary spanner/knowledge broker)	1
Delay	1) Knowledge reuse	1
	2) Knowledge centric product life cycle management	1
Culture	1) Meetings or Visits	1
	2) Integration centric development	1
	3) Knowledge sharing	1
Collaboration	1) Division of work	1
	2) Knowledge sharing	1
Knowledge Creation	1) Collaborative technology	1
	2) Meetings or Visits	1
	3) Documentation	1

GSD Problems due to lack of KM	KMPs used to address GSD problems due to lack of KM	F
Knowledge externalization	1) Collaborative Technology 2) Meetings/Visits 3) Asking the colleague (developer/boundary spanner/knowledge broker) 4) Documentation 5) learn by watching	1 1 1 1 1
Knowledge integration	1) Process Knowledge Tracer	1
Information gathering	1) Collaborative technology	1
Control	1) Asking the colleague 2) Documentation	1 1
Conflict Management	1) Meetings or visits 2) Division of work	1 1
Knowledge Exchange	1) Collaborative technology 2) Meetings or visits 3) Documentation	1 1 1
Cost	1) Collaborative technlogy 2) Asking the colleague 3) Information update	1 1 1
Quality	1) Knowledge centric product life cycle management	1
Alignment of processes and tools	1) Knowledge centric product life cycle management	1
Information loss	1) Clear project/organization structure with clear roles and responsibilities	2
Face to face meeting difficult	1) Collaborative technology 2) Asking the colleague 3) Information updates	1
Understanding embedded implicit knowledge	1) Asking the colleague	1
Skill management	1) Knowledge centric product life-cycle management	1
Clarifying dependencies	1) Integration Centric Development	1
Distributing tasks	1) Integration Centric Development	1
Project management and documentation	1) Integration centric development	1
Knowledge reuse	1) Collaborative technology 2) Documentation	2 1
Knowledge acquisition	1) Collaborative technology 2) Training program	1 1
Managing change	1) Integration Centric Development	1
Engineering flexibility	1) Knowledge centric product life	1
Reduced overheads	1) Knowledge centric product life	1

GSD problems due to lack of KM and KMPs used to solve these problems have bi-directional relationship. More than one practice is used to solve one particular problem. Selecting a practice for one particular problem will give solution to more than one problem.

Importance of KM in GSD is obvious from the no. of issues identified due to lack of KM. This significance of KM in GSD is realized and many practices are being used to deal with GSD problems due to lack of KM. Ability of KMPs to solve multiple problems and variety of practices demonstrates the KM as an important area to be considered in GSD.

4.3.1.1 Discussion on Global Software Development Problems due to lack of Knowledge Management:

The most occurring problem identified during our study is knowledge sharing. High frequency (11) of knowledge sharing in our study shows it as the most important problem, confirming the previous studies that mentioned knowledge sharing as the critical success factor for outsourcing relationships success (Lee, Huynh, & Hirschheim, 2008). This shows the consistency of our study with the previous literature.

The main reasons of why knowledge sharing is considered to be a problem are its tacit nature and trust. Tacit nature of knowledge creates problem only in sharing implicit knowledge while trust is the factor that is necessary for sharing both kinds of knowledge either implicit or explicit (Bosch & Bosch-Sijtsema, 2010; Lee et al., 2008). So, for knowledge sharing we need to develop trust among the project participants. To build trust it is necessary that all participants must know each other but due to geographical distance, it is not possible for project participants to interact with each other directly i.e. face to face. While for sharing tacit knowledge someone needs directly talk to that person. It can't be transferred via documents. Tacit knowledge can only be shared through directly communicating that person, having that knowledge. Again due to geographical distance it is not possible for project participant to communicate face to face to the person having his/her required knowledge. Different Communication channels/mediums are necessary for this purpose. Project participant can communicate either formally or informally. Previous research suggests the informal communication as the most effective means of building trust and to share tacit knowledge (Lehtonen, 2009).

The second common problem is shared understanding (f =11) " - a collective way of organizing relevant knowledge" (Gibson & Cohen, 2003). Cultural diversity i.e. difference in organizational culture and national culture, communication gap, difference in technical background, gap in knowledge flow and time distance are the main reasons of lack of shared understanding. Difference in organizational culture have great impact on shared understanding

and creates problem in gaining common understanding of different aspects of project because the of the difference between terminologies used by organizations for the same concept, difference in standards of documentation etc. Because of these reasons, participants might perceive things differently that cause lack of shared understanding. Similarly due to difference in technical background one might not be at the level on which the others are, resulting into difficulty in achieving the shared understanding. Due to time distance the project participants don't have an opportunity to discuss their problems with each other so unable to establish shared understanding.

Lack of Communication (f =11) is another problem that arises mostly during global software development projects. Communication involves both formal and informal communication. The main reasons of lack of communication are geographical, socio-cultural and temporal distance. Due to lack of communication several problems arise i.e. lack of trust, relationship building etc. which ultimately cause lack of knowledge sharing. Informal communication is badly impacted and almost become impossible due to geographical distance. Formal communication can be done through formal communication channels. Recent studies are investigating the impact of using formal channels for informal communication within global software development teams.

Knowledge transfer (f=7), relationship building (f=5), and who knows what (f=5) are some other important problems that require social aspect to be considered. Various other problems are also identified but these are less important with low frequency.

The identified problems are grouped into communication and coordination and project management.

Communication & Coordination:

Shared understanding, Knowledge sharing/transfer/exchange, Trust, Who knows what/finding the right people/whom to contact, Relationship building/team building/ team cohesion, Requirements engineering, awareness, Collaboration, Culture, Knowledge externalization, Knowledge update, Knowledge creation, Knowledge acquisition, understanding embedded implicit knowledge, Knowledge reuse, Knowledge integration, Clarifying dependencies,Distributing tasks, Information gathering, face to face meetings difficult, Information loss.

Project Management:

Cost, Delay, Conflict management, Skill management, Control, Quality, Managing change, Alignment of processes and tools/objectives, Ineffective decision making meetings, Organization maturity, Information loss, Reduced overhead, Engineering flexibility, Project management and documentation.

Communication is identified as a major challenge in GSD which gives rise to further issues (Ågerfalk, Fitzgerald, Holmström, Lings, Lundell & Conchúir 2005; Conchuir, Holmström, Ågerfalk, Fitzgerald, 2006). Informal communication is critical factor for successful projects (Kraut, Fish, Root, & Chalfonte, 1990).

Software development requires many people working on different phases, performing different activities. Their work needs to be integrated at the end which calls for synchronous production schedules and coordinated tasks. These challenges are even exacerbated in geographically separated teams. GSD projects are behind schedule and over budget partly due to coordination issues introduced by distance and time (Taweel, Delaney, Arvanitis, & Zhao 2009).

Grouping of GSD problems due to lack of KM into communication & coordination and project management illustrates KM's ability to deal with major problem dimensions in GSD.

The analysis of GSD problems due to lack of knowledge management is given above. Now the analysis of knowledge management practices that are used to address the problems due to lack of knowledge management will be given below.

4.3.1.2 Discussion on Knowledge Management Practices:

Collaborative technology is an important practice with high frequency (14; table 4.3) supporting hybrid strategy (codification & personalization; table 4.5) and solves 14 problems (table 4.4). Use of collaborative technology reduces social distance, makes people aware of other's presence, produces the sense of being a team, synchronizes communication and reduces delay by providing in time feedback. Collaborative technology includes email, video conferencing, IM, online data bases etc (table 4.1). Reasons for using collaborative technology may be:

- Communication plays a vital role in software development. This SLR identifies communication as one of the major problems with the frequency of 10 (table 4.2). However, due to geographical distance face to face communication is not possible in GSD (Herbsleb, & Moitra, 2002). The only way to communicate is through the use of

collaborative technology that is rich media for communication. It is found in this piece of research that collaborative technology facilitates synchronous and asynchronous communication and also has the tendency to deal with implicit and explicit knowledge by supporting informal and formal communication (Avram 2007; Avram (n.d.)).

- Lack of social interaction or corridor talk is the main reason behind many problems identified such as knowledge sharing and transfer, trust and team cohesion. Collaborative technology fills the gap by promoting the social interaction and thereby developing the team relationship and trust among team members (Mathrani, Parsons, & Stockdale, 2009). Trust and sense of being one team are important factors that contribute to knowledge sharing and transfer (Kotlarsky, et al., 2008). This ability of collaborative technology to build social interaction is another reason for collaborative technology to be most used (14) practice.
- Of all the identified problems collaborative technology is used mostly to share knowledge (f=4; table 4.4). Developing trust by the use of collaborative technology makes it an attractive choice to solve knowledge sharing and transfer issues (Kotlarsky et al., 2008)..
- Another reason can be its support for the both personalization and codification strategy (table 4.5). Other practices supporting hybrid strategies contrary to collaborative technology are either specific to one or two organizations or some specific problems.
- However, use of collaborative technology is not without problems. Temporal distance can't be overcome by collaborative technology. For example when one team member is in Pakistan and other in Europe with minimum time overlap, collaborative technology can't bridge the time distance, one party has to suffer.
- Another limitation of collaborative technology is when a time slot is dedicated for informal communication but till the end of meeting formal conversation goes on leaving no room for informal communication.

Results of this SLR highlight Meetings/ visits as another important practice to deal with the issues that arise because of lack of knowledge management in GSD (table 4.3 & 4.4). The frequency of using meetings/visits is 8 (table 4.3) and these are considered more useful to cope with problems created by geographical, temporal and socio-cultural distance (table 4.4).

- The basic purpose of meetings/visits is to have face to face interaction that develops trust and sense of being a team among the geographically dispersed team members (Avram,

(n.d.)). This is the reason for high adoption of meetings/visits for knowledge sharing (2) and transfer (2; table 4.4). Thus, this practice is also aimed at building social interaction among team members that is severely influence by the geographic distance (Clerc, et al., 2009).

- Collocation helps in overcoming temporal distance by allowing team members to interact with each other during same work hours. Spending time at other's site helps in understanding their way of doing things and their culture, thereby bridging socio-cultural distance (Damian & Zowghi, 2003).
- Arranging visits can be costly as compared to technical meetings but these have more benefits. Research has shown that GSD projects that lack visits were unsuccessful and those supported traveling were successful (Kotlarsky, et al.,s 2008).

Documentation is third most frequently used practice with the frequency of 7 and solves seven issues among the issues identified (table 4.3 & 4.4). Reasons for using codification strategy are:

- to keep the group aware of what's happening in the project.
- when new person joins the team or some expert or relevant person leaves then codification strategy is the way to keep aware.

Asking the colleague (7) and transactive memory (7) also highlight the importance of social aspect in dealing with the GSD issues due to lack of KM (table 4.3). Transactive memory supports both codification and personalization strategy and indicates that both type of practices must be used to be successful in GSD projects (table 4.5).

Some other practices with low frequency are also identified (table 4.3). These are particular to one project or organization so effectiveness of these practices is not confirmed.

4.3.1.3 Categorization of Knowledge Management Practices used to address GSD Problems due to lack of Knowledge Management:

Knowledge management practices are broadly categorized in codification and personalization strategy. The knowledge management practices used to address GSD problems due to lack of KM identified in this SLR are also categorized along these two dimensions. The categorization of practices is shown in table 4.5:

Table 4.5 Categorization of KMPs

KMPs used to address GSD problems due to lack of KM	
Codification	-Documentation -Standardize tools, and methods -Shared infrastructure -Information update -Knowledge reuse
Personalization	-Meetings/visits -Asking the colleague(developers/ boundary spanners/broker) -Informal communication -Cross continental mini teams -Surviving the Babel tower -Direct request -Learn by watching -Mutual adjustment -Shared team and task knowledge -Adapt Scrum processes -Information update -Clear project/organization structure with clear roles and responsibilities -Discussion board
Hybrid	-Collaborative technology -Reverse Presentation Method -Transactive memory -Division of work -Process Knowledge Tracer -Knowledge centric product life cycle management -Guidelines/training programs -Knowledge sharing

Table 4.5 shows the categories of KMPs. KMPs are classified into existing dimensions of codification and personalization.

Most of the practices used to handle GSD problems due to lack of KM belong to personalization category. Organizations use personalization strategy to handle the tacit dimension of the knowledge. When transferring or sharing or externalizing the knowledge main concern is transfer the tacit knowledge and personalization strategy is considered better to tackle this dimension of knowledge. Practices that come under personalization strategy are perceived more useful than that of codification strategy (Clerc et al., 2009). Another reason for using personalization strategy practices is the social interaction required in this people oriented area. These practices focus on personal interaction and develop initial relations, sense of being a team and trust which help organization to be successful in GSD.

Though, practices supporting personalization strategy are greater in number value of practices supporting codification strategy can't be overlooked. Identification of practices

supporting codification strategy with high frequency (when considering over all frequency of practices used and no. of times each practice is used to deal with the particular problem) confirms their importance in projects.

Some of the practices identified belong to the hybrid category (personalization and codification) which shows that either codification or personalization strategy alone can't deal with GSD problems due to lack of KM. Their proper balance is necessary to remove these problems. Research also highlighted the use of codification and personalization strategies practices in the projects.

Re invention of wheel is still present in GSD projects. Most of the KMPs are used only in one organization/ project.

4.4 Guidelines:

- Lack of communication is one of the most frequently faced problems due to lack of KM in GSD (f=10) as identified in this SLR. It is also noted that lack informal communication is main cause behind several problems identified (Boden, Avram, Bannon & Wulf 2009). Therefore, encourage informal communication among team members. Informal communication will produce a sense of being a team and help in developing team relationship among team members, thereby, developing trust.
- Standardize tools /methods and procedures as it will keep all the team members at the same level of understanding.
- Focus on building social interaction that is badly impacted by geographic distance. It is identified as main reason behind many problems identified.
- Visiting other's place (f=8) is another important practice that builds social interaction and develops trust among team members. Therefore, arrange traveling across sites. This may be costly but has long range benefits. Research has shown that successful projects have adopted this practice (Kotlarsky et al., 2008).
- Use both personalization and codification strategies in the project. This SLR indicates that neither personalization nor codification strategy alone is sufficient for a GSD project to be successful. Combining both types of practices is necessary to appropriately manage knowledge in GSD context.
- Collaborative technology is one of the most used practice (f=14) and its use can be beneficial for the project. However, this piece of research sees it effective, when

accompanied by other practices such as meetings and documentation. Therefore, use collaborative technology along with other practices.

- Use appropriate mix of personalization and codification technology. Regularly plan for meetings as regular meetings are proved to be effective for successful projects. GSD organizations conduct meeting using collaborative technology and meeting is also supported by codification strategy by sharing the documents during or before meeting among team members. Therefore, regularly plan the meetings and use collaborative technology and documentation in these meetings. Use collaborative technology for communication between two meetings, mainly informal communication.
- Be proactive in dealing with the problems that arise in GSD projects due to lack of KM. Proactive planning helps in carrying out successful GSD projects (Kotlarsky et al., 2008). Frequency of GSD problems identified and KMPs used to address these problems can help you in doing so.

Chapter 5: Conclusion

5.1 Conclusion:

Systematic Literature Review is conducted to identify GSD problems due to lack of knowledge management (KM) and knowledge management practices (KMPs) to handle these problems. From the data, frequency of GSD problems due to lack of KM and KMPs used is originated to find out most commonly experienced problem and most commonly used practice. Next, the problem and practices used to address that problems are sorted out. These practices are used by multiple organizations to solve different problems. The GSD problems due to lack of KM are grouped in two categories: communication & coordination and project management. The practices are grouped under codification, personalization and hybrid strategy. By analyzing the findings it is seen that:

- Knowledge Management is an important area in GSD. It has tendency to deal with innate GSD problems such as communication, coordination and lack of trust.
- GSD problems due to lack of KM and KMPs have many to many relationship i.e., multiple KMPs exist to deal with a particular problem and one practice solves more than one problem.
- Most of the GSD problems due to lack of KM belong to communication & coordination. This shows that KM can effectively deal with communication in GSD.
- Most of the problems identified are rooted to lack of social interaction and informal communication (Boden, et al., 2009).
- Most of KMPs identified belong to personalization strategy which shows importance of human elements in software development and their importance over tools and methods.
- Personalization strategy practices also highlight the importance of social interaction and informal communication. Most of the problems identified are due to lack of social interaction or informal communication. Although technical aspect is important but role of informal communication is also vital for the successful GSD projects.
- KMPs supporting personalization strategy and KMPs supporting codification strategy both are used in a single project to deal with one particular problem. Therefore, organizations must use practices supporting both strategies in their projects. (Documentation supports codification strategy (f=7) and meetings/visits support

personalization strategy with the frequency of 8. Collaborative technology is most frequently used practice that supports hybrid strategy with frequency of 14).

- Trust is an important factor in GSD. The most frequently used practices collaborative technology (f=14) is used two times to deal with the issue of trust and meetings or visits (f=8) is also aimed at building initial relationship and hence trust.
- Lack of trust was also one of the reasons behind some of GSD problems due to lack of KM such as knowledge sharing (Lee, Huynh, & Hirschheim 2008).
- Shared understanding (f=11), knowledge sharing (f=11) and communication (f=10) are most widely reported problems.
- Collaborative technology (f=14) is the most used practice in GSD projects.
- Of codification strategy practices 'Documentation' (f=7) is most widely used practice.
- Documentation and meetings or visits along with collaborative technology are mostly used for solving GSD problems (Damian, & Zowghi 2003).
- Collaborative technology on its own can't provide solution to most of GSD problems due to lack of KM. It is accompanied by documentation or meetings/visits or both (Damian, & Zowghi 2003).
- Less important problems and practices were also identified. These possess frequency of 3 and below. These practices are specific to organization or project, therefore, their effectiveness is not ascertained.
- Reinvention of wheel is still present as it is obvious from the use of novel practices that have low frequency (most of these have frequency 1).
- Agile practices are also helpful in dealing with the complexity of GSD problems due to lack of KM. Their focus on developing social network may be the reason to be successful in this people oriented area (Avram, 2007).
- Organizations must practice KM to be successful in GSD.

However, this piece of work has some limitations. Literature for last ten years is considered for review and Papers that are written only in English language are considered.

5.2 Future Work and implications for practice:

The SLR conducted highlights the importance of KM by showing its tendency to address a large no of issues. It also shows how KM can play its role in solving GSD issues by showing a

no. of KMPs. Availability of variety of practices assists in making comparison among alternate solutions available for different problems and making a wiser choice. So, this work allows to identify different issues that can occur if Knowledge is not managed accurately or problems that can be solved by suitably addressing KM. It also sheds light on the various practices available to solve GSD issues due to lack of KM and facilitates the practioners in comparing which practice is better to adopt to deal with a certain issue. Frequency of each problem and practice narrates the severity of the problem in terms of its occurrence and effectiveness of a practice. This helps in identifying which problem will be confronted most and which practice is used widely to handle it. Making an informed choice by considering all the alternatives and consequences leads to better result. This piece of research helps in making an aware choice and thus leads to better results by applying this choice in offshore software development. This work also contributes to research by providing the guideline for selecting the appropriate practice.

Following directions can be taken into account for future research:

- Relatively little empirical work has been done in software engineering. Similar situation is prevailing in the area of KM. Studies have been identified that provide only the theoretical base and lack the empirical evidence. This area requires consideration for future research.
- An important area in KM that lacks empirical evidence is KM tools. No. of KM tools exist but they lack the empirical ground. This area also has the potential for considering it for future research.
- This work can be extended by providing industrial perspective from Pakistan. Studies included in this SLR did not account any organization from Pakistan. A survey can be launched to identify GSD problems due to lack of KM and KMPs used to handle these issues. The results can be compared with the above mentioned results and a model can be proposed and validated to select the best practice to solve GSD issues due to lack of KM.

Appendices

Appendix A: Protocol

Review Title:

Knowledge Management Practices in GSD: Systematic Literature Review

Team Organization:

- **Smeea Arshad**, MS Student, IIU
  Contribution: Team member, Primary Reviewer

Internal advisor:

- **Dr. Naveed Ikram**, Associate Professor, Software Engineering
  Contribution: Supervisor
  naveed.ikram@iiu.edu.pk
- **M. Usman**, Lecturer, IIU
  Contribution: Secondary Reviewer, Co supervisor
  m.usman@iiu.edu.pk

External Reviewers:

- **Muneera Bano**
  muneera@iiu.edu.pk

Abstract:

Knowledge management (KM) is identified as an important issue in global software development (GSD) (Herbsleb & Moitra, 2002). Many problems in GSD exist because of lack of KM such as knowledge sharing, knowledge integration, finding out the relevant people, lack of common understanding etc. (Anita & Andre van der, 2006; V. Clerc, 2008; Damian & Zowghi, 2003; Herbsleb & Moitra, 2002) . A large no. of knowledge management practices (KMPs) are found in literature to help practioners/researchers handle GSD problems due to lack of KM (Avram, 2007; V. Clerc, 2008; Desouza, Awazu, & Baloh, 2006).We are addressing the question to bring about existing body of knowledge at one place.

Systematic Literature Review (SLR) supports evidence-based paradigm. "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"(Kitchenham,2004; p.5). SLR is conducted on the basis of protocol defined. Guidelines by Barbra Kitchenham are referred to develop the protocol (Kitchenham, 2004). Aim of this protocol is to provide guide lines to conduct review in a systematic manner to find out GSD problems due to lack of KM and Knowledge Management Practices (KMPs) that are used to solve GSD problems due to lack of KM.

The probable outcome of this review will be GSD problems due to lack of KM and KMPs that are used to solve the identified problems.

Background and Motivation:

Organizations are adopting GSD to take advantages of less cost, skilled resources, close to customer and round the clock development. Conversely, strategic, cultural, communication, technical, knowledge management and project and process management issues are innate in GSD. (Damian & Moitra, 2006; Herbsleb & Moitra, 2002)

Knowledge is important asset for organizations. It makes most of the organization capital as well as contributes to software process improvement. However, managing knowledge in global software development is challenging. Seeking relevant knowledge, knowledge sharing, synthesis and transfer are some of the problems faced in GSD.(Boden, eta al., 2009; Herbsleb & Moitra, 2002)

Oxford dictionary definition of practice is "the actual application as opposed to the theories relating to it" and Webster defies practice as "carry out or apply." Therefore, KMPs include anything that is applied by a company to manage knowledge. Thus, KM tools, strategies, models, systems, environment, approaches and technology lie in this category(Avram, 2007; V. Clerc, 2008). Good knowledge management (KM) practices are a major success factor for software development, influencing software quality and team performance (Boden, et al., 2009). Knowledge management practices reduce knowledge management and GSD problem to least level (Avram, 2007). Knowledge management strategies are broadly categorized under codification and personalization strategy (Clerc, 2008). The usefulness of architectural Knowledge Management Practices is proved (Clerc, et al., 2009). Some of the practices are (Clerc, et al., 2009; Avram, 2007; Clerc, 2008) :

- Frequent Interaction across Sites
- Cross-site Delegation
- Face-to-Face Project Kick-Off Meetings
- Urgent Request
- Collocated High-Level Architecture Phase
- A Clear Organization Structure with Communicating Responsibilities
- Surviving the Babel Tower
- Talking the developer through his assigned work

Evidence about the KMP's that address GSD problems due to lack of KM is scattered due to which every organization make their own practices for addressing GSD problems due to lack of KM that is" Re-inventing the wheel". The main motivation behind this study is to collect the evidence about the KMP's that address GSD problems due to lack of KM, thus the organizations have not any need to "Re-inventing the wheel".

Research Questions:

RQ1: What GSD Problems occur due to lack of KM?

RQ2: What KMPs are used in GSD Projects?

RQ3: What GSD problems are addressed by existing KMPs?

2.3.1Structured Questions:

1. **What GSD Problems occur due to lack of KM?**

   Population: GSD

   Outcome: GSD Problems due to lack of Knowledge Management

   Intervention: KM

2. **What KMPs are used in GSD?**

   Population: GSD Projects **Outcome:** KMPs in GSD

   No Intervention, No Comparison

3. **What GSD problems are addressed by existing KMPs?**

   Population: software projects in GSD

   Intervention: KMPs.

   Outcome: Problems solved by KMPs in GSD

   No Comparison

   An example of research question comprising of above details is:

   [What KM Problems]---------- "OUTCOMES OF RELEVANCE"

   are addresses by

   [KM practices]---------- "INTERVENTION"

   in

   [GSD Projects]----------"POPULATION"

Search Strategy:

Kitchenham's guidelines (Kitchenham & Charters, 2007) are used to develop search strategy:

Search Terms:

- Derive major search strings from population, intervention, comparison and outcome.
- Identify alternative spellings and synonyms for major terms.
- Consider relevant terms used in literature.
- When database allows use the Boolean OR to integrate alternative spellings.

and synonyms and When database allows use the Boolean AND to link the major terms from population, intervention and outcome.

2.4.2 Key Search Terms and alternative spellings and synonyms:

RQ1: What GSD Problems occur due to lack of KM?

RQ2: What KMPs are used in GSD Projects?

RQ3: What GSD problems are addressed by existing KMPs?

Synonyms of major terms commonly used in three questions are:

GSD: ("Global Software development" OR "distributed software development" OR "multi-site software development" OR "global software engineering" OR "global requirements engineering" OR "distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR GSD OR GSE OR "offshore software development" OR GRE)

Knowledge Management: ("knowledge management" OR "knowledge sharing" OR "knowledge acquisition" OR "knowledge transfer" OR "knowledge creation" OR "knowledge capture" OR "tacit knowledge" OR "explicit knowledge" OR "knowledge retention" OR "knowledge valuation" OR "knowledge use" OR "knowledge application" OR "knowledge discovery" OR "knowledge integration" OR "knowledge theory" OR "organization knowledge" OR "knowledge engineering" OR "information management" OR "information sharing" OR "information transfer" OR "information reuse" OR "common understanding" OR "shared understanding")

Use of Boolean AND and OR:

("knowledge management" OR "knowledge sharing" OR "knowledge acquisition" OR "knowledge transfer" OR "knowledge creation" OR "knowledge capture" OR "tacit knowledge" OR "explicit knowledge" OR "knowledge retention" OR "knowledge valuation" OR "knowledge use" OR "knowledge application" OR "knowledge discovery" OR "knowledge integration" OR "knowledge theory" OR "organization knowledge" OR "knowledge engineering" OR "information management" OR "information sharing" OR "information transfer" OR "information reuse" OR "common understanding" OR "shared understanding") AND ("Global Software development" OR "distributed software development" OR "multi-site software development" OR "global software engineering" OR "global requirements engineering" OR

"distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR GSD OR GSE OR "offshore software development")

The search strategy will be modified according to the search criteria provided by each database.

Tools used for automating the search process:

- End notes will be used to maintain references obtained from the search of primary studies.

Search Sources:

Following databases will be searched to select the studies:

- IEEE Explore
- ACM Digital Library
- Science Direct
- Springerlink
- EICompendex

Division of task for searching:

I will perform the search on all databases.

Study selection criteria:

Study Inclusion Criteria:

Following type of studies will be included:

- that are about KM in GSD AND
- that include case studies or industrial/Experience reports or experiment.

Study Exclusion Criteria:

Following type of studies will be excluded:

- that are not about KM in GSD
- that lack evidence in the form of case study/experiment/experience report
- that are examples and expert opinion
- that include distributed but not geographically distributed development.

Study Selection Procedure:

Initial selection will be based on title, abstract and keywords. This will exclude the papers that are not relevant to our research question. Above mentioned inclusion/exclusion criteria will be applied on full text of paper. In case of uncertainty about inclusion/exclusion of paper co-supervisor will be consulted. Disagreement about inclusion/exclusion will be resolved by discussing with supervisor. Each article and study in the article will have a unique reference no. by the end of this procedure.

Repeat for each paper

1. Create KMPs SLR folder
2. Open Endnote.
   2.1. Create subfolders with database names. Within each folder
      2.1.1. Create libraries with string names for each folder.
   2.2. Create all papers, included, excluded, final included and pending libraries.
3. **Select a database in the list in "final protocol.doc".**
4. Select a Research Question string from "final protocol.doc" and copy paste it in the search box of the selected database.
5. Download all papers in corresponding end note library.
6. Go to next string. If end of string
   6.1. Go to next database (step 3). If end of database
      6.1.1. Go to next step (7)
7. Import results of each string of each database in all papers.enl.
8. For each paper read abstract of the paper.
   8.1. If paper meets the inclusion criteria.
      8.1.1. Place it in included.enl
   8.2. Else if paper meets exclusion criteria.
      8.2.1. Place it in excluded.enl.
   8.3. Else if inclusion criteria not decided
      8.3.1. Place it in pending.enl for arbitration.
         - If decision is to include the paper. Copy paste it in include.enl

- Else if decision is to exclude paper, copy paste in exclude.enl
- Go to next paper. If end of paper go to next step.

9. For each paper check paper for detail inclusion/exclusion criteria. The outcomes are:

9.1. If paper meets the inclusion criteria

9.1.1. Place it in final included .enl.

9.2. Else if inclusion criteria not decided.

9.2.1. List the reason for why paper can't be included.

- Give date and reviewer responsible
- Send it to pending.enl. Where paper will remain till decision is made.

9.2.1..1.If decision is made to include the paper go to step 9.1.1.

9.2.1..2. If decision is to exclude the paper go to step 9.3

9.3. Else if exclusion criteria meets place it to excluded papers.enl.

9.3.1. Give reason why paper can't be selected, date and reviewer responsible.

9.3.1..1.Go to next paper. Go to step 9. If end of papers

End Input

Study Quality Assessment:

Quality Assessment will be based on the guidelines provided by Barbra Kitchenham, co-supervisor, concerned faculty member and relevant research material (Dyba). Papers included in the review are 1) case study 2) experiment 3) industrial/experience report. Quality of each paper will be assessed against the given checklist. Each question will be marked as yes= 2, no= 0 and partly= 1. Paper that will not fulfill the quality criteria will be excluded and placed in rejected with reason.

Table 1: Quality Assessment Checklist

Quality Assessment Checklist		
#	**Questions**	**Score**
Questions for Industrial/Experience Report		
1	Does the study clearly describe the context?	Yes/no/partial
2	Does the links between data, interpretation and conclusion are illustrated well?	Yes/no/partial

Quality Assessment Checklist		
#	**Questions**	**Score**
3	Does study describe implications for future research/practice.	Yes/no/partial
Questions for Evidence Based Studies		
1	Does study clearly narrate objectives?	Yes/no/partial
2	Does study clearly describe the context?	Yes/no/partial
3	Does the sampling method and rational given?.	Yes/no/partial
4	Does the data collection method and its rational given?	Yes/no/partial
5	How clear are the links between data, interpretation and conclusion? Do the links between data, interpretation and conclusion are clearly defined?	Yes/no/partial
6	Does study describe implications for future research/practice.	Yes/no/partial

Secondary Source Documentation:

Procedure for documenting secondary search will be same as primary studies. These studies will be accomplished from accepted primary studies.

Data extraction strategy:

Primary and secondary reviewer will extract data from selected papers. In case of disagreement supervisor will be requested to arbitrate. Each study will be assigned a unique no. and duplicate studies will be considered only once. Data extracted from each accepted paper will be recorded into following forms:

General Information:

Following form shows the data to be extracted from the papers

Date of Data extraction	
Title	
Authors	
Journal/Conference	
Year of publication	
Publisher	

Volume	
Issue	
URL	
Keywords	
Abstract	
Teams' location	
Name of Reviewer	
Date of Review	
Team's Location	
Type of Organization	
Secondary Sources:	
References found in paper	

To address the research question following data will be extracted:

RQ1: What GSD Problems occur due to lack of KM?

RQ2: What KMPs are used in GSD Projects?

RQ3: What GSD problems are addressed by existing KMPs?

Form1:

Paper ID	Study ID	Quality Score	GSD Problems due to lack of Knowledge Management	KMPs used to address GSD problems

Dissemination Strategy:

The results of the literature review will be published in relevant academic journals and conferences.

Validation of Review Process

Protocol Evaluation:

- Protocol will be initially given for peer review to Co supervisor.

- Supervisor will evaluate the protocol after the peer review.
- Protocol will be sent to external reviewer for evaluation.

Protocol will be updated according to the comments of the reviewers.

Pilot Testing:

I will do pilot testing for sources to check the validity of search term results. For results see Appendix

Schedule of Activities:

Table 2: Schedule of Activities

Task	Date
Start of the Protocol	05-Dec-2009
Protocol version 1	20-Dec-2009
Protocol 1.2	10-Feb-2010
Protocol version 1.3	15-March-2010
Protocol version 1.4	15-April-2010
Pilot testing	28-April-2010
Submission of protocol for Review	11-May-2010
Completion of the Protocol	15-May-2010
Completion of Search	17-May-2010
Completion of Primary Study Selection	06-June-2010
Completion of Data Extraction	16-June-2010
Completion of Data Synthesis	30-June-2010
Completion of Review Report	07-July-2010

Appendix B:Pilot Study

Appendix B: Pilot Study

Table 1)

IEEE		
String Query	**Abstract**	**Full Text**
1.1-(("Abstract":"knowledge management" OR "knowledge sharing" OR "knowledge acquisition" OR "knowledge transfer" OR "knowledge creation" OR "knowledge capture" OR "tacit knowledge" OR "explicit knowledge")AND ("Abstract":"global software development" OR "global software engineering" OR "global requirements engineering" OR "distributed software development" OR "distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR "multi-site software development" OR "offshore software development" OR GSD OR GSE OR GRE))	25	538
1.2-(("knowledge valuation" OR "knowledge use" OR "knowledge discovery" OR "knowledge integration" OR "knowledge theory " OR "organization knowledge" OR "knowledge engineering" OR "knowledge application")AND ("global software development" OR "global software engineering" OR "global requirements engineering" OR "distributed software development" OR "distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR "multi-site software development" OR "offshore software development" OR GSD OR GSE OR GRE))	3	298
1.3-(("knowledge retention" OR "common understanding" OR "shared understanding" OR "information management" OR "information sharing" OR "information transfer" OR "information reuse")AND ("global software development" OR "global software engineering" OR "global requirements engineering" OR "distributed software development" OR "distributed software engineering" OR "distributed development" OR "distributed software engineering" OR "distributed requirements engineering" OR "multisite software development" OR "multi-site software development" OR "offshore software development" OR GSD OR GSE OR GRE))	12	490

Table 2)

Paper ID	Study ID	Paper Name
1	1	Of Deadlocks and Peopleware - Collaborative Work Practices in Global Software Development
2	2	RE challenges in multi-site software development organizations

Questions for Industrial/Experience Report:

1. Does the study clearly describe the context?
2. Does the links between data, interpretation and conclusion are illustrated well?
3. Is the study of value for research or practice? / Does study add value to research?

Questions for Evidence Based Studies:

1. Does study clearly narrate objectives?
2. Does study clearly describe the context?
3. Does the sampling method and rational given?
4. Does the data collection method and its rational given?
5. How clear are the links between data, interpretation and conclusion? Do the links between data, interpretation and conclusion are clearly defined?
6. Is the study of value for research or practice? /Does study adds value to the research?

Table 3)

Study ID	Experience/Industrial Report			Evidence based Studies						Total
	Q1	Q2	Q3	Q1	Q2	Q3	Q4	Q5	Q6	
1				2	2	1	1	1	0	8
2				2	1	1	1	1	2	8

Data Extraction:

General Data Extraction Form: Of Deadlocks and Peopleware -Collaborative Work Practices in Global Software Development

Table 1)

Name of Reviewer	Smeea
Date of Data extraction	21-07-2009
Title	Of Deadlocks and Peopleware - Collaborative Work Practices in Global Software Development
Authors	Avram, G.
Journal/Conference	Global Software Engineering, 2007. ICGSE 2007.
Year of publication	2007
Publisher	
Volume	
Issue	
URL	http://www.ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4299843
Keywords	Groupware Knowledge management Software development management Collaborative work Cultural aspects Distributed software development Ethnographically-informed methods Global software development Knowledge management

	Peopleware Social organizational
Abstract	"As part of a research project dedicated to the social organizational and cultural aspects of global software development, the author has chosen to focus on collaborative work practices and knowledge management aspects of collaborative work. More precisely, the focus is on how the global distribution of software development affects collaborative work. The current paper is a first attempt to unveil, through a concrete situation observed in a distributed software development environment, the complex ways in which people use technology to establish collaborative work practices. By using ethnographically-informed methods, the author presents a bottom-up study of actual work practices, meant to contribute to a better understanding of collaborative work and knowledge management processes in distributed software development".
Teams' location	Ireland, US, Germany, India
Type of Organization	Academia and industry
Secondary Sources	
References found in paper	

Table 2)

Name of Reviewer	Smeea
Date of Data extraction	24-07-2009
Title	RE challenges in multi-site software development organizations
Authors	E. Damian, Daniela Zowghi, Didar
Journal/Conference	Requirements Engineering
Year of publication	2003
Publisher	Springer London
Volume	8
Issue	3
URL	http://dx.doi.org/10.1007/s00766-003-0173-1
Keywords	Communication problems Global software development Requirements management Requirements process
Abstract	"The increasing globalization of the software industry demands an investigation of requirements engineering (RE) in multi-site software development organizations. Requirements engineering is a task difficult enough when done locally but it is even more difficult when cross-functional stakeholder groups specify requirements across cultural, language and time zone boundaries. This paper reports on a field study that investigated RE challenges introduced by the stakeholders' geographical distribution in a multi-site organisation. The goal was to examine RE practices in global software development, and to formulate recommendations for improvement as well as to provide directions for future research on methods and tools. Based on the empirical evidence, we have constructed a model of how remote communication and knowledge management, cultural diversity and time differences negatively impact requirements gathering, negotiations and

	specifications. Findings reveal that aspects such as a lack of a common understanding of requirements, together with a reduced awareness of a working local context, a trust level and an ability to share work artefacts significantly challenge the effective collaboration of remote stakeholders in negotiating a set of requirements that satisfies geographically distributed customers. The paper concludes with recommendations for improving RE practices in this setting".
Teams' location	Australia, New Zealand, USA, Europe
Type of Organization	Industry
Secondary Sources	
References found in paper	

RQ1: What GSD Problems occur due to lack of KM?

RQ2: What KMPs are used in GSD Projects?

RQ3: What GSD problems are addressed by KMPs?

Paper ID	Study ID	Quality Score	GSD Problems due to lack of Knowledge Management	KMPs used to address GSD problems
1	1	8	7) Knowledge externalization Knowledge transfer	7) Collocation(learn by watching) 8) Documentation 9) Learn by watching 10) Asking the colleague 11) Collaborative technology Surviving the babel tower
			8) Who knows what or Finding the right people (to find someone who knows)	4) Personal contacts network or Transactive memory 5) Collaborative technology Asking the colleague (developer/boundary spanner/ knowledge broker)
			9) Knowledge creation 10) Shared understanding or mutual knowledge	4) Asking the colleague (developer/boundary spanner/ knowledge broker) 5) Collaborative technology 6) Documentation for maintaing awareness and circulating it 6) Regular meetings
			11) Knowledge sharing	7) Surviving the Babel tower
2	2	8	4) Lack of awareness of local working context and informal communication	3) Documentation 4) Biweekly meetings
			5) Common understanding of requirements	3) Biweekly meetings 4) Repository
			6) Strong position of power	2) Documentation and supporting documents
			5) Knowledge/expertise sharing	
			10) Requirements negotiation,	

Paper ID	Study ID	Quality Score	GSD Problems due to lack of Knowledge Management	KMPs used to address GSD problems
			validation and prioritization(RE)	
			11) Ineffective decision making meetings	
			12) Trust	
			13) Conflicts and having open discussion of interest	
			14) Delay	

Appendix C: General Data Extraction

Appendix C: General Data Extraction

1)

Name of Reviewer:	Smeea
Date of Data Extraction:	21-07-2010
Title:	Of Deadlocks and Peopleware - Collaborative Work Practices in Global Software Development
Author:	Avram, G.
Journal/Conference:	Global Software Engineering, 2007. ICGSE 2007.
Year of publication:	2007
Publisher:	
Volume:	
Issue:	
URL:	http://www.ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4299843
Keywords:	Groupware Knowledge management Software development management Collaborative work Cultural aspects Distributed software development Ethnographically-informed methods Global software development Knowledge management Peopleware Social organizational
Abstract:	"As part of a research project dedicated to the social organizational and cultural aspects of global software development, the author has chosen to focus on collaborative work practices and knowledge management aspects of collaborative work. More precisely, the focus is on how the global distribution of software development affects collaborative work. The current paper is a first attempt to unveil, through a concrete situation observed in a distributed software development environment, the complex ways in which people use technology to establish collaborative work practices. By using ethnographically-informed methods, the author presents a bottom-up study of actual work practices, meant to contribute to a better understanding of collaborative work and knowledge management processes in distributed software development".
Teams' location:	Ireland, US, Germany, India
Type of Organization:	Academia and industry
Secondary Sources:	
References found in paper:	"Social ties, knowledge sharing and successful collaboration in globally distributed system development projects.

2)

Name of Reviewer	Smeea
Date of Data extraction	24-07-2009
Title	From integration to composition: On the impact of software product lines, global development and ecosystems
Authors	Bosch, Jan Bosch-Sijtsema, Petra
Journal/Conference	Journal of Systems and Software
Year of publication/conference	2010
Publisher	Elsevier
Volume	83
Issue	1
URL	http://www.sciencedirect.com/science/article/B6V0N-4WPJ5XY-1/2/e69f658f21dfa50b9d1aa468a6cfb46d
Keywords	Software product lines Software ecosystems Global development Software integration Software composition
Abstract	"Three trends accelerate the increase in complexity of large-scale software development, i.e. software product lines, global development and software ecosystems. For the case study companies we studied, these trends caused several problems, which are organized around architecture, process and organization, and the problems are related to the efficiency and effectiveness of software development as these companies used too integration-centric approaches. We present five approaches to software development, organized from integration-centric to composition-oriented and describe the areas of applicability".
Teams location	UK, USA, Asia
Type of Organization	Industry
Secondary Sources:	
References found in paper	

3)

Name of Reviewer	Smeea
Date of Data extraction	21-07-2010
Title	Developing a knowledge-based perspective on coordination: The case of global software projects
Authors	Kotlarsky, Julia van Fenema, Paul C. Willcocks, Leslie P.
Journal/Conference	Information & Management
Year of publication	2008
Publisher	Gabler Verlag
Volume	5
Issue	2
URL	http://www.sciencedirect.com/science/article/B6VD0-4RWB0WD-1/2/2515030f8a1e447ed51d630ebe1ac0ad

Keywords	Knowledge management Knowledge flows Coordination Coordination mechanisms Global software projects Software development
Abstract	"We have attempted to bring together two areas which are challenging for both IS research and practice: forms of coordination and management of knowledge in the context of global, virtual software development projects. We developed a more comprehensive, knowledge-based model of how coordination can be achieved, and illustrated the heuristic and explanatory power of the model when applied to global software projects experiencing different degrees of success. We first reviewed the literature on coordination and determined what is known about coordination of knowledge in global software projects. From this we developed a new, distinctive knowledge-based model of coordination, which was then employed to analyze two case studies of global software projects, at SAP and Baan, to illustrate the utility of the model".
Teams' location	Germany, India, USA India, Neitherlands
Type of Organization	Industry
Secondary Sources:	
References found in paper	

4)

Name of Reviewer	Smeea
Date of Data extraction	21-07-2010
Title	Knowledge Work Practices in Global Software Development
Authors	Gabriela Avram
Journal/Conference	The Electronic Journal of Knowledge Management
Year of publication	2007
Publisher	The electronic journal of Knowledge Management
Volume	5
Issue	4
URL	
Keywords	collaboration, work practices, distributed work environments, global software development, knowledge work, mutual knowledge, transactive memory
Abstract	"This paper is an exploration of knowledge work practices in a distributed software development setting. The author has undertaken an empirical study in the Irish subsidiary of a multinational company over a 16-month period. Our methods were inspired by ethnography; by spending an extended period of time with a software development team working on a specific project, we had the opportunity to observe real work practices in a real work setting in the specific circumstances of distributed work. The purpose of the current study is to highlight the ways in which technical and social factors are inextricably entwined in distributed work settings".

Teams location	US, Germany,India, Ireland
Type of Organization	Industry
Secondary Sources:	
References found in paper	

5)

Name of Reviewer	Smeea
Date of Data extraction	21-07-2010
Title	Lessons learned by participants of distributed software development.
Authors	Seija Komi-Sirvio Maarit Tihinen
Journal/Conference	Knowledge and Process Management
Year of publication	2005
Publisher	
Volume	12
Issue	2
URL	http://dx.doi.org/10.1002/kpm.225
Keywords	
Abstract	
Teams location	
Type of Organization	Industry
Secondary Sources:	
References found in paper	

6)

Name of Reviewer	Smeea
Date of Data extraction	24-07-2009
Title	Forces affecting offshore software development
Authors	Biro, Miklos Feher, Peter
Journal/Conference	12th European Conference on Software Process Improvement. EuroSPI 2005, November 9, 2005 - November 11, 2005
Year of publication	2005
Publisher	Springer Verlag
Volume	3792 LNCS
Issue	
URL	http://www.springerlink.com/content/y6k2h31p33425k41/
Keywords	Software engineering Computer applications Database systems Education Information dissemination Information management Information technology Knowledge based systems
Abstract	"This paper identifies the forces affecting offshore software development based on a knowledge management perspective. The identified four major forces act along the dimensions of finance,

	individual education, organizational maturity, and culture. The analysis is validated on cases of European offshoring practice exhibited in the database of the EuroSPI (European Software Process Improvement) series of conferences".
Teams' location	Germany, Hungary
Type of Organization	Industry
Secondary Sources	
References found in paper	

7)

Name of Reviewer	Smeea
Date of Data extraction	24-07-2009
Title	Social ties, knowledge sharing and successful collaboration in globally distributed system development projects
Authors	Kotlarsky,J Oshri,Ilan
Journal/Conference	European Journal of Information System
Year of publication	2005
Publisher	
Volume	14
Issue	1
URL	http://www.springerlink.com/content/y6k2h31p33425k41/
Keywords	Software engineering Computer applications Database systems Education Information dissemination Information management Information technology Knowledge based systems
Abstract	"Traditionally, the main focus of the information system (IS) literature has been on technical aspects related to system development projects. Furthermore, research in the IS field has mainly focused on co-located project teams. In this respect, social aspects involved in IS projects were neglected or scarcely reported. To fill this gap, this paper studies the contribution of social ties and knowledge sharing to successful collaboration in distributed IS development teams. Data were drawn from two successful globally distributed system development projects at SAP and LeCroy. Data collected were codified using Atlas.ti software. The results suggest that human-related issues, such as rapport and transactive memory, were important for collaborative work in the teams studied. The paper concludes by discussing the implications for theory and suggesting a practical guide to enhance collaborative work in globally distributed teams".
Teams' location	Germany, Hungary
Type of Organization	Industry
Secondary Sources	
References found in paper	

8)

Name of Reviewer	Smeea
Date of Data extraction	24-07-2009
Title	Distributed agile: project management in a global environment
Authors	Lee, Seiyoung Yong, Hwan-Seung
Journal/Conference	Empirical Software Engineering
Year of publication/conference	2010
Publisher	Springer
Volume	15
Issue	2
URL	http://dx.doi.org/10.1007/s10664-009-9119-7
Keywords	Agile methods Scrum Distributed software development Software globalization
Abstract	"Agile methods have been gaining acceptance in the mainstream software development community. At the same time, globally distributed software development is another trend delivering high-quality software to global users at lower costs. Little is published about the adoption and adaption of Agile methods in a distributed team and software globalization/localization project environment. The overall performance and satisfaction with the international deployment of the latest version of My Yahoo! increased by more than 30% after the global product team, distributed over three continents, adopted Agile methods. Our objective is to highlight successful practices and challenges that have been overcome by the globalization project, and suggest a framework for software globalization project management using a distributed Agile approach".
Teams/location	Asia pacific, Europe, America and US
Type of Organization	Industry
Secondary Sources	
References found in paper	

9)

Name of Reviewer	Smeea
Date of Data extraction	21-07-2009
Title	Traceability-based knowledge integration in group decision and negotiation activities
Authors	Mohan, Kannan Ramesh, Balasubramaniam
Journal/Conference	Decision Support System
Year of publication/conference	2007
Publisher	Elsevier
Volume	43
Issue	3
URL	http://www.sciencedirect.com/science/article/B6V8S-4GH49J4-3/2/f69978dc6c15e5eb95fd388ec038fa5a
Keywords	Knowledge integration

	Traceability Collaborative software development Decision making Group decision and negotiation Work process
Abstract	"Group decision and negotiation (GDN) in distributed collaborative environments involves the acquisition and use of extensive knowledge. Knowledge elements that play a critical role in guiding GDN activities are distributed across different work environments that are not seamlessly integrated with each other. We argue that integrating fragmented knowledge will improve the process of GDN in software development. In this paper, we present an approach to knowledge integration using traceability. Our approach comprises of: (a) a traceability framework that identifies the key knowledge elements that are to be integrated, and (b) a prototype system that supports the acquisition, integration, and use of knowledge elements represented by the traceability framework. We illustrate the usefulness of our approach with a case study in a software development organization".
Teams' location	Germany, Asia (India/Ukrine)
Type of Organization	Industry
Secondary Sources	
References founding paper	

10)

Name of Reviewer	Smeea
Date of Data extraction	21-07-2010
Title	Workgroup structures in offshore software development projects: A vendor case study
Authors	Mathrani, Anuradha Parsons, David Stockdale, Rosemary
Journal/Conference	2009 13th Enterprise Distributed Object Computing Conference Workshops, EDOCW - IEEE EDOC 2009 Workshops and Short Papers, September 1, 2009 - September 4, 2009
Year of publication/conference	2009
Publisher	Institute of Electrical and Electronics Engineers Inc.
Volume	
Issue	
URL	
Keywords	Technical presentations Communication Computer science Computer software Virtual reality
Abstract	"Studies have shown that offshore development of software projects is not without its challenges, as development teams try to make sense of the organisational artefacts sent to them from distributed sites. These challenges are associated with: lack of implicit knowledge related to the client's functional work processes, inadequate coordination and control mechanisms, and

	lack of trust across dissimilarities. This paper describes how a vendor's organisational structures have been used to overcome the struggle associated with knowledge sharing in a virtual environment. The vendor has developed workgroup structures involving new boundary roles for building relationships with clients and coordination of project schedules at offshore development sites. Vendor employees located at the client country interpret the implicit knowledge related to the client's functional work processes, which are then translated over a centralised organisational portal to offshore development locations. Regular updates are maintained in the organisational portal to provide information on current project tasks to both clients and distributed team members. English language training is also provided to developers to improve trans-global communications".
Teams' location	US, India
Type of Organization	Industry
Secondary Sources	
References found in paper	

11)

Name of Reviewer	Smeea
Date of Data extraction	30-07-2009
Title	Bridging knowledge distribution - The role of knowledge brokers in distributed software development teams
Author	Boden, A. Avram, G.
Journal/Conference	Cooperative and Human Aspects on Software Engineering, 2009. CHASE '09. ICSE Workshop on software engineering
Year of publication	2007
Publisher	
Volume	
Issue	
URL	http://www.computer.org/portal/web/csdl/doi/10.1109/CHASE.2009.5071402
Keywords	DP industry Knowledge management Boundary spanners Context specific knowledge Distributed software development teams Knowledge brokers Knowledge distribution Knowledge management
Abstract	"Software development requires the handling of complex and context specific knowledge to be successful. Hence, efficient knowledge management (KM) counts amongst the most important challenges for any software project, but especially for small enterprises working with distributed teams. One important topic for KM in distributed teams is the role of ldquobridgesrdquo enacted by people who become boundary spanners and facilitate the exchange of knowledge between the sites. In our paper we present empirical findings related to such bridges in the context of

	two small companies with offshore sites. In doing so, we concentrate on the particular roles these knowledge brokers play in the distributed development practices. We show how small software companies rely on the commitment of particular team members and informal knowledge management practices. The paper concludes with a number of open questions to be addressed by future studies".
Teams' location	German, Russia Ireland, Dublin
Type of Organization	Industry
Secondary Sources:	
References found in paper	

12)

Name of Reviewer	Smeea
Date of Data extraction	24-07-2009
Title	RE challenges in multi-site software development organisations
Authors	E. Damian, Daniela Zowghi, Didar
Journal/Conference	Requirements Engineering
Year of publication	2003
Publisher	Springer London
Volume	8
Issue	3
URL	http://dx.doi.org/10.1007/s00766-003-0173-1
Keywords	Communication problems Global software development Requirements management Requirements process
Abstract	"The increasing globalization of the software industry demands an investigation of requirements engineering (RE) in multi-site software development organizations. Requirements engineering is a task difficult enough when done locally but it is even more difficult when cross-functional stakeholder groups specify requirements across cultural, language and time zone boundaries. This paper reports on a field study that investigated RE challenges introduced by the stakeholders' geographical distribution in a multi-site organisation. The goal was to examine RE practices in global software development, and to formulate recommendations for improvement as well as to provide directions for future research on methods and tools. Based on the empirical evidence, we have constructed a model of how remote communication and knowledge management, cultural diversity and time differences negatively impact requirements gathering, negotiations and specifications. Findings reveal that aspects such as a lack of a common understanding of requirements, together with a reduced awareness of a working local context, a trust level and an ability to share work artefacts significantly challenge the effective collaboration of remote stakeholders in negotiating a set of requirements that satisfies geographically distributed customers. The paper concludes with recommendations for improving RE

	practices in this setting".
Teams location:	Australia, New Zealand, USA, Europe
Type of Organization:	Industry
Secondary Sources:	
References found in paper:	

13)

Name of Reviewer:	Smeea
Date of Data extraction:	21-07-2009
Title:	Effectively utilizing project, product and process knowledge
Authors:	Ebert, Christof Man, Jozef De
Journal/Conference:	Information and Software Technology
Year of publication:	2008
Publisher:	Elsevier
Volume:	50
Issue:	6
URL:	http://www.sciencedirect.com/science/article/B6V0B-4P5NX2G-3/2/2c19a5ee0e3353c6649ef494a92a8821
Keywords:	CMMI KM, knowledge management PLM, product life-cycle management Process improvement Project management
Abstract:	"Improving project management, product development and engineering processes is for many companies crucial to survive in a fast changing environment. However, these activities are rarely integrated well due to the diversity of stakeholders with individual knowledge about projects, products and processes. This case study shows how Alcatel-Lucent over time achieved effective interaction of engineering processes, tools and people on the basis of a knowledge-centric product life-cycle management (PLM). Starting from identifying project, product and process knowledge, we show how they can be effectively integrated for best possible usage across the enterprise. The case study provides insight into how to best embark on PLM and how to effectively integrate product development with supportive tools. It describes how the concepts can be transferred to software engineering teams and IT departments in other companies. Concrete results from several product lines, such as efficiency improvement and better global development underline the business value".
Teams location:	
Type of Organization:	Industry
Secondary Sources:	
References found in paper:	

14)

Name of Reviewer:	Smeea
Date of Data extraction:	24-07-2010
Title:	Communication, knowledge and coordination management in globally distributed software development informed by a

	scientific software engineering case study
Authors	Taweel, Adel Delaney, Brendan Arvanitis, Theodoras N Zhao, Lei
Journal/Conference	2009 4th IEEE International Conference on Global Software Engineering, ICGSE 2009, July 13, 2009-July 16,2009
Year of publication	2009
Publisher	IEEE Computer Society
Volume	
Issue	
URL	http://dx.doi.org/10.1109/ICGSE.2009.58
Keywords	Computer software Distributed computer systems Knowledge engineering Research Software design
Abstract	"With the global distribution of scientific and software engineering skills and with the need to foster multidisciplinary research collaboration across organizations result in teams dispersed separated by time and distance. However to attain the potential benefits of such collaboration, there is a critical need for a better management of communication, knowledge and co-ordination across distributed teams. The importance of these factors is becoming increasingly known to organizations requiring them to develop methods and enabling mechanisms in need for more successful and efficient collaboration outcomes. This paper dicusses and empahsises the importance of managing these factors in distributed software engineering projects based on experiences drawn from an international scientific research and software engineering project (ePCRN). It presents their impact on the collaborative process and how they may hinder the progress of the software development process. It also presents the methods and mechanisms used in the project to address some of these factors".
Teams location	UK, USA
Type of Organization	Academia
Secondary Sources	
References found in paper	

15)

Name of Reviewer	Smeea
Date of Data extraction	21-07-2010
Title	Reverse Presentations
Authors	Wiener, Martin Stephan, Rolf
Journal/Conference	Business & Information Systems Engineering
Year of publication	05-07-2010
Publisher	Elsevier
Volume	2
Issue	3

URL	http://dx.doi.org/10.1007/s12599-010-0100-1
Keywords	Offshore outsourcing - Software development - Requirements validation - Reverse presentations method - Knowledge transfer
Abstract	"Reverse Presentations is a method for requirements validation in offshore software development. In this paper, the authors present and conceptually refine this method and carry out an initial evaluation. The method provides cross-phase support and is characterized by a structured and iterative validation process. In contrast to existing methods, it focuses on the client perspective and takes into account social distance challenges. The method aims at creating a common understanding of the future system by means of "reverse presentations". This core element of the method facilitates the transfer of knowledge across social worlds for validation purposes. Case studies with clients confirm that the method fits well with the offshore software development context. The cases point to the method's positive impact on the interorganizational interaction and control".
Teams' location	Germany, Asia (india/ukrine)
Type of Organization	Industry
Secondary Sources	
References found in paper	

16)

Name of Reviewer	Smeea
Date of Data extraction	21-07-2010
Title	Process and technology challenges in swift-starting virtual teams
Authors	Munkvold, Bjørn Erik, Zigurs, Ilze
Journal/Conference	Information and Management
Year of publication	05-07-2010
Publisher	
Volume	44
Issue	3
URL	http://www.sciencedirect.com/science/article/B6VD0-4N0HJF0-1/2/a457fe554e3dd574c8ae87b870ae520a
Keywords	Virtual teams Ad hoc teams Systems development teams Time-interaction-performance theory Collaboration technology
Abstract	"Virtual teams often face tight schedules and a need to start quickly and perform instantly. The goal of our study was to enhance understanding of the challenges faced by such teams. We used time-interaction-performance theory as the framework for following the processes and functions within virtual teams working on a systems development task. Our study provided a detailed examination of the group process, applied to virtual teams working under time pressure. The challenges faced by virtual teams in such settings showed that teams must work to enhance their effectiveness in multiple dimensions".

Teams' location	Norway, US
Type of Organization	Academia
Secondary Sources:	
References found in paper	

17)

Name of Reviewer	Smeea
Date of Data Extraction	21-07-2010
Title	The Usefulness of Architectural Knowledge Management Practices in GSD
Authors	Clerc, V. Lago, P. Van Vliet, H.;
Journal/Conference	Global Software Engineering, 2009. ICGSE 2009. Fourth IEEE International Conference on
Year of publication	13-16 July 2009
Publisher	
Volume	
Issue	
URL	http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5196921
Keywords	
Abstract	"Practices for architectural knowledge management (AKM) may alleviate the challenges involved with GSD. We have conducted empirical research at a large Dutch IT service provider to validate a set of practices for architectural knowledge management in GSD and to specifically investigate the relation between the number of sites and the perceived usefulness of these practices. The results show that AKM practices supporting a personalization strategy towards knowledge management are perceived to be more useful than practices that support a codification strategy. Further, the usefulness of AKM practices in general is confirmed. Finally, we observe a peak in the perceived usefulness of AKM practices in projects that evolved to a multi-site situation. This high perceived usefulness denotes a more critical need to plan for AKM practices in advance".
Teams' location	Netherlands
Type of Organization	Industry
Secondary Sources:	
References found in paper	

18)

Name of Reviewer	Smeea
Date of Data Extraction	31-07-2009
Title	Managing offshore outsourcing of knowledge-intensive projects a people centric approach
Authors	Jensen, Morten Menon, Shashi

	Mangset, Lars Erik Dalberg, Vibeke
Journal/Conference	International Conference on Global Software Engineering, ICGSE 2007, August 27, 2007 - August 30, 2007
Year of publication/conference	2007
Publisher	Inst. of Elecnd Elec. Eng. Computer Society.
Volume	
Issue	
URL	http://dx.doi.org/10.1109/ICGSE.2007.28
Keywords	Outsourcing Information management Knowledge management Software engineering
Abstract	"This paper illustrates a multinational company encountering specific challenges with respect to the leveraging offshore outsourcing for knowledge intensive software development tasks. Following a gathering of corporate experiences and vendor interviews, an active management model was implemented with explicit focus on people and their working environment. The impact of this initiative was immediately visible in terms of increased productivity, improved quality of deliverables and a dramatic reduction in vendor employee turnover. Based on these results we believe that knowledge-intensive projects can be offshore outsourced with a people-centric approach".
Teams' location	Multi-national
Type of Organization	Industry
References found in paper	

19)

Name of Reviewer	Smeea
Date of Data extraction	21-07-2010
Title	An integration centric approach for the coordination of distributed software development projects
Authors	Taxén, Lars
Journal/Conference	Information and Software Technology
Year of publication	2006
Publisher	Elsevier
Volume	48
Issue	9
URL	http://www.sciencedirect.com/science/article/B6V0B-4JF8H93-1/2/08ff2e6bb3373629365e323151457440
Keywords	Distributed software development Integration centric engineering Coordination Common understanding Flexible IS/IT support Telecom systems

Abstract	"This paper presents an approach for Distributed Software Development (DSD) that is based on two foundations. The first one is an integration centric engineering process, which aims at managing crucial dependencies in DSD projects. The second foundation is a strategy for operationalizing the coordination of the engineering process. The purpose of this strategy is to simultaneously provide global information system support for coordination and achieve common understanding about what should be coordinated and how. The approach has been successfully used at Ericsson, a major supplier of telecommunication systems worldwide, for coordinating extraordinary complex projects developing nodes in the third generation of mobile systems. Although many obstacles have to be addressed, the results indicate that the approach is a viable way to manage DSD during very demanding circumstances".
Teams' location	Sweden, Germany, Italy, Australia, Norway and Croatia
Type of Organization	Industry
Secondary Sources	
References found in paper	

20)

Name of Reviewer	Smeca
Date of Data extraction	21-07-2010
Title	Developing Outsourcing Relationships: A Romanian Service Provider Perspective
Authors	Gabriela Avram
Journal/Conference	First Information Systems Workshop on Global Sourcing: Services, Knowledge and Innovation
Year of publication	2007
Publisher	
Volume	44
Issue	3
URL	http://www.sciencedirect.com/science/article/B6VD0-4N0HJF0-1/2/a457fe554e3dd574c8ae87b870ae520a
Keywords	Virtual teams Ad hoc teams Systems development teams Time-interaction-performance theory Collaboration technology
Abstract	"Virtual teams often face tight schedules and a need to start quickly and perform instantly. The goal of our study was to enhance understanding of the challenges faced by such teams. We used time-interaction-performance theory as the framework for following the processes and functions within virtual teams working on a systems development task. Our study provided a detailed examination of the group process, applied to virtual teams working under time pressure. The challenges faced by virtual teams in such settings showed that teams must work to enhance their effectiveness in multiple dimensions".

Teams' location	Norway, US
Type of Organization	Academia
Secondary Sources:	
References found in paper	

21)

Name of Reviewer	Smeea
Date of Data Extraction	25-07-09
Title	Knowledge transfer in globally distributed teams: the role of transactive memory
Authors	Ilan Oshri Paul van Fenema Julia Kotlarsky
Journal/Conference	Information Systems Journal
Year of publication/conference	
Publisher	Elsievier
Volume	
Issue	
URL	http://dx.doi.org/10.1111/j.1365-2575.2007.00243.x
Keywords	Knowledge transfer, transactive memory, globally distributed teams, expertise
Abstract	"This paper explores the role of transactive memory in enabling knowledge transfer between globally distributed teams. While the information systems literature has recently acknowledged the role transactive memory plays in improving knowledge processes and performance in colocated teams, little is known about its contribution to distributed teams. To contribute to filling this gap, knowledge-transfer challenges and processes between onsite and offshore teams were studied at TATA Consultancy Services. In particular, the paper describes the transfer of knowledge between onsite and offshore teams through encoding, storing and retrieving processes. An in-depth case study of globally distributed software development projects was carried out, and a qualitative, interpretive approach was adopted. The analysis of the case suggests that in order to overcome differences derived from the local contexts of the onsite and offshore teams (e.g. different work routines, methodologies and skills), some specific mechanisms supporting the development of codified and personalized 'directories' were introduced. These include the standardization of templates and methodologies across the remote sites as well as frequent teleconferencing sessions and occasional short visits. These mechanisms contributed to the development of the notion of 'who knows what' across onsite and offshore teams despite the challenges associated with globally distributed teams, and supported the transfer of knowledge between onsite and offshore teams. The paper concludes by offering theoretical and practical implications".
Teams' location	India, Switzerland, USA
Type of Organization	Industry
References found in paper	

22)

Name of Reviewer:	Smeea
Date of Data extraction:	21-07-2010
Title:	Managing Problems for Global Software Production – Experience and Lessons
Authors:	Gao, Jerry Z. Itaru, Fukao Toyoshima, Y.
Journal/Conference:	Information Technology and Management
Year of publication:	2002
Publisher:	Springer
Volume:	3
Issue:	1
URL:	http://dx.doi.org/10.1023/A:1013116910400
Keywords:	Software engineering, software maintenance, problem management, software management tool, web application system
Abstract:	"With the increase in size and complexity of current software projects, many large companies have established global software production lines over the world to develop and deliver software products with collaborative software development processes involving multiple teams located at different sites. Supporting global software production needs an effective software-engineering environment to meet the special requirements of the collaborative software development process, diverse management methods and engineering practice. WWW technology provides powerful means to set up an enterprise-oriented software engineering environment for global software production due to its advantages in networking, global access, internationalization, and communication. Although there are many articles addressing the methods and experience in building web-based applications systems and tools, very few papers discuss the real-world problems and solutions in the development and deployment of web-based software tools to support a collaborative software development process for global software production. This paper discusses the real world issues, and reports our experience and lessons in building and deploying a web-based problem information management system (PIMS) to support global software development processes at Fujitsu. It focuses on the real issues and needs of current collaborative development process involving multiple teams, and highlights the benefits and impact of the PIMS on global software production. Moreover, it discusses our technical solutions and trade-offs in the development of PIMS, and shares our experience and lessons. Furthermore, it introduces a new data-centered conceptual process model to support diverse collaborative processes for project and problem management in global software production. Finally, the paper shares our key successes and weaknesses, and reports our experience and lessons in the deployment of the system".
Teams' location:	World-wide
Type of Organization:	Industry
Secondary Sources:	
References found in paper:	

23)

Name of Reviewer:	Smeea
Date of Data Extraction	24-07-2009
Title	Knowledge Management in Distributed Scientific Software Development
Authors:	Taweel, Adel Delaney, Brendan Arvanitis, Theodoras N. Zhao, Lei
Journal/Conference:	Global Software Engineering, 2009. ICGSE 2009. Fourth IEEE International Conference on
Year of publication/conference:	2009
Publisher:	IEEE Computer Society
Volume:	
Issue:	
URL:	http://dx.doi.org/10.1109/ICGSE.2009.58
Keywords:	distributed algorithms knowledge management project management scientific information systems software engineering distributed scientific software development global multidisciplinary scientific research collaborations knowledge exchange knowledge management software projects
Abstract:	"Global multidisciplinary scientific research collaborations are increasingly becoming a necessity to create global solutions. However to attain the potential benefits of such collaborations, there is a critical need for a more efficient management and exchange of knowledge between the distributed teams. Unlike traditional software projects, the knowledge management requirements of such teams is much more complex and requires different types of interaction and knowledge management environments to support such collaboration. In such projects, the need is to capture not just software artefacts, but also the scientific research process and its artefacts and their translation to their respective software needs. This paper discusses the knowledge management needs in distributed scientific projects based on experiences drawn from an international research project. It presents the different types of knowledge in such projects and outlines a mechanism to capture them".
Teams' location:	UK, USA
Type of Organization:	Academia
Secondary Sources:	
References found in paper:	

24)

Name of Reviewer:	Smeea
Date of Data extraction:	25-07-09
Title:	Software configuration management over a global software development environment: lessons learned from a case study
Authors:	Pilatti, L Audy, JLN Prikladnicki, R
Journal/Conference:	Proceedings of the 2006 international workshop on Global software development for the practitioner
Year of publication/conference:	2006
Publisher:	ACM
Volume:	10
Issue:	
URL:	10.1145/1138517
Keywords:	Global software development Software process improvement Software configuration management
Abstract:	"Software configuration management is an important support activity in the software development process. In global environments. The software configuration becomes critical due to the characteristics of the distributed development (physical distance, cultural differences, trust, communication and other factors). The objective of this paper is to analyze the software configuration management in a global software development environment, identifying the main challenges. The results are based on a case study carried on at a multinational organization that has offshore software development centers in Brazil, India and Russia, and was recently recognized in the CMM Model level 2 in the Brazilian unit. The results suggest the necessity to adapt and implement some activities in the software configuration management process addressing the main existing challenges. These activities were identified as lessons learned, collected at the end of each project. The problems and the solutions adopted are presented, aiming to relate these solutions to the organization distribution level, considering the project team, users and customers".
Teams' location:	USA, Brazil, India
Type of Organization:	Industry
Secondary Sources:	
References found in paper:	

25)

Name of Reviewer:	Smeea
Date of Data extraction:	25-07-09
Title:	Experiences with conducting project postmortems: reports versus stories
Authors:	Desouza, KC Dingsoyr, T

	Awazu, Y
Journal/Conference	Software Process: Improvement and Practice
Year of publication/conference	
Publisher	
Volume	10
Issue	2
URL	
Keywords	Software engineering Knowledge management Projects Postmortems review
Abstract	"The most popular unit of work in organizations is a project. Managing knowledge in and about projects is salient for successful project management. In this article, we will discuss how postmortems can be used to capture tacit experiences in projects. Conducting a postmortem, either after a milestone or at the end of a project, is salient in order to gauge what has been learnt, what were the main issues faced, and what can be used to improve the processes of work in the future. The conducting of postmortems aids in articulation of tacit experiences into explicit forms. This enables for experiences to be better reused in the future. Re-using of postmortem findings depends heavily on the nature of the postmortem outcome. We will compare two kinds of postmortem outcomes-traditional reports and stories. Both types have their pros and cons, and management must choose the right kind of postmortem report to calibrate, depending on the project and learning outcomes. The article will also highlight lessons learnt from conducting postmortem reviews in several software organizations".
Teams' location	Norway, US, India
Type of Organization	Industry
Secondary Sources:	
References found in paper	

26)

Name of Reviewer	Smeea
Date of Data extraction	26-07-09
Title	Team knowledge and coordination in geographically distributed software development
Author	Espinosa, J. Alberto Slaughter, Sandra A. Kraut, Robert E. Herbsleb, James D.
Journal/Conference	Journal of Management Information Systems

Year of publication/conference	2007
Publisher	M.E. Sharpe Inc.
Volume	24
Issue	1
URL	http://dx.doi.org/10.2753/MIS0742-1222240104
Keywords	Software engineering Engineering research Information management Information technology Knowledge engineering
Abstract	"Coordination is important in software development because it leads to benefits such as cost savings, shorter development Cycles, and better-integrated products. Team cognition research suggests that members coordinate through team knowledge, but this perspective has only been investigated in real-time collocated tasks and we know little about which types of team knowledge best help coordination in the most geographically distributed software work. In this field study, we investigate the coordination needs of software teams, how team knowledge affects coordination, and how this effect is influenced by geographic dispersion. Our findings show that software teams have three distinct types of coordination needs - technical, temporal, and process - and that these needs vary with the members' role; geographic distance has a negative effect on coordination, but is mitigated by shared knowledge of the team and presence awareness; and shared task knowledge is more important for coordination among collocated members. We articulate propositions for future research in this area based on our analysis".
Teams' location	Europe
Type of Organization	Industry
Secondary Sources:	
References found in paper	

27)

Name of Reviewer	Smeea
Date of Data extraction	26-07-09
Title	Use of collaborative technologies and knowledge sharing in co-located and distributed teams: Towards the 24-h knowledge factory
Authors	Gupta, Amar Mattarelli, Elisa Seshasai, Satwik Broschak, Joseph
Journal/Conference	The Journal of Strategic Information Systems
Year of publication/conference	2009
Publisher	

Volume	18
Issue	3
URL	http://www.sciencedirect.com/science/article/B6VG3-4X076VC-1/2/51baccfa08d6ad00ce1bf2ab504e2977
Keywords	Globally distributed teams 24-h Knowledge factory Knowledge sharing
Abstract	"The relocation of knowledge work to emerging countries is leading to an increasing use of globally distributed teams (GDT) engaged in complex tasks. In the present study, we investigate a particular type of GDT working around the clock': the 24-h knowledge factory (Gupta, 2008). Adopting the productivity perspective on knowledge sharing ([Haas and Hansen, 2005] and [Haas and Hansen, 2007]), we hypothesize how a 24-h knowledge factory and a co-located team will differ in technology use, knowledge sharing processes, and performance. We conducted a quasi-experiment in IBM, collecting both quantitative and qualitative data, over a period of 12 months, on a GDT and a co-located team. Both teams were composed of the same number of professionals, provided with the same technologies, engaged in similar tasks, and given similar deadlines. We found significant differences in their use of technologies and in knowledge sharing processes, but not in efficiency and quality of outcomes. We show how the co-located team and the GDT enacted a knowledge codification strategy and a personalization strategy, respectively; in each case grafting elements of the other strategy in order to attain both knowledge re-use and creativity. We conclude by discussing theoretical contributions to knowledge sharing and GDT literatures, and by highlighting managerial implications to those organizations interested in developing a fully functional 24-h knowledge factory".
Teams' location	Boston (America), Banglore (India)
Type of Organization	Industry
Secondary Sources	
References found in paper	

Appendix D: Review from External Reviewer

Appendix D: Review from External Reviewer (Miss Muneera Bano):

Protocol was sent to the external reviewer and was modified according to the changes proposed. Following section shows the modifications made to the protocol.

"I will search a wide range of resources to avoid research bias and include conference proceedings, technical and experience reports and journal papers and secondary studies.I will not include books for review. " its obvious that you will go after these resources. you need to mention here about how you will get secondary search results, discuss with Dr. Naveed as well on this point.

I discussed the issue with the supervisor and we decided to search the secondary search results from the references papers selected for data extraction.

"Studies those are not relevant to research question" isn't this an obvious exclusion criteria?

Her concern was to be more specific about the exclusion criteria. After discussing it with the supervisor, I modified it as: exclude studies that were not about knowledge management in Global Software Development.

" Studies that include distributed but not geographically distributed development." discuss this point with supervisor."

I had a discussion with supervisor and decided to keep these criteria.

"Duplicates of papers will be removed" i think duplicate studies should be removed as well.

I had a discussion with the supervisor and we decided to consider duplicate studies only once.

Design your own tables for Search Documentation and Extraction

Tables for search documentation and extraction were designed again according to the requirements of the research questions. Initially data extraction table was designed as:

Study ID	Quality Score	GSD Problems due to lack of KM	Geographical Location	Year of study

I decided to remove the last two columns (geographical location and year of study) after discussion with supervisor. We came to the point that GSD problems faced by organizations due to lack of KM will not be influenced by geographic or temporal duration of the study and later on, this was confirmed during the pilot study.

Search documentation form was modified by adding "type of organization" as it can help in identifying which type of problems are faced by small, medium or large organizations.

References:

Ågerfalk, P. J., Fitzgerald, B., Holmström, H., Lings, B., Lundell, B., & Conchúir, E. Ó. (2005). A framework for considering opportunities and threats in distributed software development.

Anita, S., & Andre van der, H. (2006). Towards Awareness in the Large. Paper presented at the Global Software Engineering, 2006. *ICGSE '06. International Conference on Global Software Engineerig.*

Avram, G. (2007). Knowledge Work Practices in Global Software Development. *The Electronic Journal of Knowledge Management, 5*(4).

Avram, G. (2007) Developing Outsourcing Relationships: A Romanian Service Provider Perspective. *First Information Systems Workshop on Global Sourcing: Services, Knowledge and Innovation Val d'Isère, France 13-15 March 2007.*

Bjørnson, F. O., & Dingsøyr, T. (2008). Knowledge management in software engineering: A systematic review of studied concepts, findings and research methods used. *Information and Software Technology, 50*(11), 1055-1068.

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Boden, A., & Avram, G. (2009, 17-17 May 2009). Bridging knowledge distribution.The role of knowledge brokers in distributed software development teams. *Paper presented at the Cooperative and Human Aspects on Software Engineering, 2009. CHASE '09. ICSE Workshop on software engineering.*

Bosch, J., & Bosch-Sijtsema, P. From integration to composition: On the impact of software product lines, global development and ecosystems. *Journal of Systems and Software,* 83(1), 67-76.

Clerc, V. (2008). Towards architectural knowledge management practices for global software development.

Clerc, V., Lago, P., van Vliet, H., (2009). The Usefulness of Architectural Knowledge Management Practices in GSD. *Paper presented at the 2009 4th IEEE International Conference on Global Software Engineering.*

Conchúir, E. Ó., Holmström, H., Ågerfalk, P. J., & Fitzgerald, B. (2006). Global Software Development: Never Mind the Problems–Are There Really Any Benefits?

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