IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received December 19, 2018, accepted January 2, 2019, date of publication January 31, 2019, date of current version March 7, 2019.

*Digital Object Identifier 10.1109/ACCESS.2019.2895690*

# Systematic Literature Review of Knowledge Sharing Barriers and Facilitators in Global Software Development Organizations Using Concept Maps

**RAYHAB ANWAR[1], MOBASHAR REHMAN[1], KHOR SIAK WANG[1], AND MANZOOR AHMED HASHMANI[2]**

[1]Department of Information Systems, Faculty of Information and Communication Technology, Universiti Tunku Abdul Rahman, Kampar 31900, Malaysia
[2]High Performance Cloud Computing Centre, Centre for Research in Data Science, Computer and Information Sciences Department, Universiti Teknologi Petronas, Seri Iskandar 32610, Malaysia

Corresponding author: Mobashar Rehman (mobashar@utar.edu.my)

This work was supported by the Universiti Tunku Abdul Rahman through the Universiti Tunku Abdul Rahman Research Fund for the project, A Comprehensive Study on Implementation of Knowledge Sharing in Small and Medium Enterprises.

**ABSTRACT** Knowledge is the most important resource in software development. The success of software development relies on knowledge sharing between software developers working across the globe. Global software development has brought many benefits to the software industry; however, at the same, time knowledge sharing across diverse team members is one of the main concerns of global software development organizations. This paper provides a systematic literature review of 42 studies on knowledge sharing barriers and facilitators from 2010 to 2017 and classifies them into five main categories: Individual, Organizational, Technological, Cultural, and Geographical. In order to synthesize and represent the complexity of the knowledge sharing factors in a more manageable and visual manner, this paper proposes concept maps for each category. The identified factors can be strategically used as the guidelines in the global software development organizations to boost the culture of knowledge sharing.

**INDEX TERMS** Knowledge sharing barriers, knowledge sharing facilitators, global software development organizations, cultural barriers, geographical barriers.

## I. INTRODUCTION

Successful software development involves unification of widespread knowledge distributed across domains of specialization [1], [2]. In order to promote smooth execution of any software product development the individual's knowledge needs to be managed properly [3]. In this digital information society knowledge sharing (KS) has become an essential element for the strategic operation of any organization [4]. Studies have shown that significant contribution of KS has direct impact on the performance of any organization [5]. The organization's top management and leaders can help to promote the culture of KS. It has been shown that less abusive supervision strengthens KS culture in coworkers, which in return accelerates task performance [6]. Irrespective of the constant development in KS approaches, shared knowledge has not always been properly used in software development [7]. KS process consists of various challenges, in order to reduce these challenges, it has become necessary to identify KS factors.

However, despite the significance of the KS, to the best of our knowledge, the comprehensive and systematic research about the KS factors in Global software development (GSD) organizations is rare. The motivation of this paper is to present a comprehensive and useful insight into the KS factors in GSD. To effectively implement KS practices, it is mandatory for software developers to have a detailed understanding of KS barriers and facilitators in the context of GSD. The systematic literature review includes a descriptive analysis of KS factors and provides a graphical illustration via of identified factors. Covering the last seven years (2010-2017) of KS factors including facilitators and barriers, the aim of this paper is to provide a consolidated view of the field of study and to integrate it with concept maps.

The associate editor coordinating the review of this manuscript and approving it for publication was Saqib Saeed.

**TABLE 1. Overview of selected KS definitions.**

| Definition of KS | Source |
|---|---|
| KS is the *"provision of task information and know-how to a person, so that (s) he can collaborate with others to solve problems, develop new ideas or implement policies or procedures".* | [9] |
| The term KS *"implies the giving and receiving of information framed within a context by the knowledge of the source".* | [10] |
| KS is the *"deliberate act in which knowledge is made reusable through its transfer from one party to another".* | [11] |
| KS is the "*provision of task information and know-how to collaborate with others to solve problems, develop new ideas, or implement policies or procedures".* | [12] |
| KS is defined as the "*provision or receipt of task information, know-how, and feedback regarding a product or procedure*". | [13] |
| KS occurs *"when an individual disseminates his knowledge (i.e., know-what, know-how, and know-why) to other members within an organization".* | [14] |

### A. TOPIC CONCEPTUALIZATION

Topic conceptualization provides in depth information of the topic under the study. In order to get *"a broad conception of what is known about the topic and potential areas where knowledge may be needed"*, topic conceptualization is required [8]. In order to achieve this, table 1 formulates the working definitions of KS proposed by various authors:

### B. IMPORTANCE OF KS IN GLOBAL SOFTWARE DEVELOPMENT ORGANIZATIONS (GSDOs)

In today's dynamic and aggressively competitive era, the success of any software organization depends largely on the ability to leverage knowledge that will aid the development of new products and processes which outperform those of competitors. Software industry is a highly competitive and innovative industry. Due to high competition, software organization needs to launch highly competitive and innovative products in order to stay on the top [15]. In the recent times many software organizations have started to invest offshore, mostly in emerging countries like Brazil, Russia and India to enhance profitability and productivity [16]. Popular examples include Microsoft, Google and IBM which have moved part of their activities offshore such as in India, China and Russia [17]. The use of global teams by firms has quickly become a preferred option in high-tech firms [18]. GSD has brought many advantages to the software industry such as cheap resource utilization, follow the sun approach, opportunities for merger and utilization of expert talent from various regions [19]. But at the same time GSD faces many challenges [19], [20]. Several challenges may complicate KS process in GSD teams [20]–[22]. Geographical dispersion factors make communication more difficult [23] and KS across diverse team members is one of the main concerns of global teams [21]. Success of software development relies upon effective KS among software development teams [19], [23].

## II. RESEARCH METHODOLOGY

Systematic Literature Review (SLR) has been used for reviewing the studies published from 2010 to 2017.

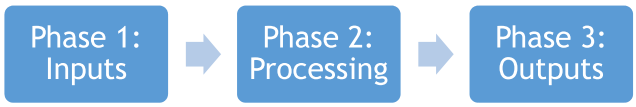


**FIGURE 1. Systematic literature review methodology.**

**TABLE 2. Systematic literature review activities.**

| Steps | Activities |
|---|---|
| Planning the review | Defining "research questions"<br>Identifying "data sources"<br>Defining "inclusion" and "exclusion" criteria |
| Conducting the review | Defining "quality criteria for study selection"<br>Conducting "primary study selection"<br>Data "extraction" and "synthesis" |
| Reporting the review | Documenting the "extracted results" |

SLR primarily involves three stages which include ''planning'', ''conducting'' and ''reporting'' the review [24]. Many researchers have used SLR in a variety of domains [19], [25]–[27]. This research followed the guidelines of authors [28], [29] who proposed three main phases presented in Fig. 1:

This systematic literature review follows the ''3-stage review step'' which are shown in table 2 [28].

### A. PHASE 1: PLANNING THE REVIEW

#### 1) RESEARCH QUESTIONS

This study addressed the following research questions:
Research Question 1: What are the KS barriers in GSDOs?
Aim: Identification of KS barriers frequently reported in GSDOs.
Research Question 2: What are the KS facilitators in GSDOs?
Aim: Identification of KS facilitators frequently reported in GSDOs.

#### 2) SEARCH STRING

The search string used in this SLR is given below:

TITLE-ABS-KEY (''knowledge sharing'' OR ''knowledge transfer'' OR ''knowledge exchange'' OR ''knowledge distribution'' OR ''tacit knowledge'' OR ''explicit knowledge'' OR ''knowledge sharing process'') AND (''software'' or ''software organization'' OR ''software development'' OR ''software engineering'' OR ''global software organization'' OR ''global software teams'') AND (''factors'' OR ''facilitators'' OR ''enablers'' OR ''methods'' OR technique∗ OR strategy∗ OR approach∗ OR process∗ OR practice∗)

#### 3) DATA SOURCES

The search was conducted in December 2017 using an advanced search in the electronic databases such as Scopus,

**TABLE 3.** Overview of data sources.

| Data Source (2010-2017) | Publication Count | URL |
|---|---|---|
| Wiley Online Library | 36 | http://onlinelibrary.wiley.com/ |
| Scopus | 109 | https://www.scopus.com |
| Emerald Insight | 201 | http://www.emeraldinsight.com/ |
| EBSCOhost | 6 | https://www.ebscohost.com |
| ACM | 17 | http://dl.acm.org/ |
| Science Direct | 390 | http://www.sciencedirect.com |
| IEEE Xplore | 47 | http://ieeexplore.ieee.org |
| ProQuest | 1514 | http://search.proquest.com |
| Total | 2320 | |

Emerald Insight, Wiley Online Library, Academic Search Complete, ACM and Science Direct. Table 3 presents the overview of data sources.

#### 4) INCLUSION CRITERIA

The inclusion criteria for the studies is given below:

(i) Studies should have been published between January 2010 and December 2017 (including these dates).
(ii) Studies should be related to GSDOs.
(iii) Studies should discuss the importance of KS in software organizations.
(iv) The main objective of the study should have been investigating and exploring KS factors (in the form of facilitators or barriers) within GSDOs.

#### 5) EXCLUSION CRITERIA

Studies were excluded on the basis of the following criteria:

(i) Studies which were published in language other than English
(ii) Keynotes, lab reports, tutorial summaries and presentations.
(iii) Duplicated studies were detected and removed.
(iv) Studies which were not relevant to KS in context of GSDOs were removed.

### *B. PHASE 2: CONDUCTING THE REVIEW*

Studies identified in "Phase A" were refined on the basis of "title", "abstract" and "keywords". Further studies were narrowed on the basis of "introduction", "conclusion" and "full text".

### *C. PHASE 3: REPORTING THE REVIEW*

Fig. 2 presents the publication venues for each selected study from 2010 to 2017. The shortlisted studies published for each year along with their distribution over public venues are presented in Fig. 3. Table 4 presents the "summary" of the selected studies with details "research method", "data analysis", "study setting" and "data collection".

#### 1) VALIDITY PROCESS

The key doubts to the "validity process" rely upon the "research paper selection", "inaccurate data extraction", "incorrect classification of studies", "research methods and

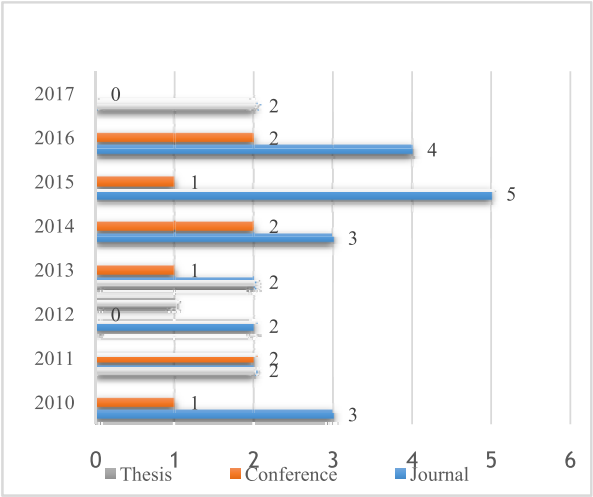


**FIGURE 2.** Data sources publication venues.

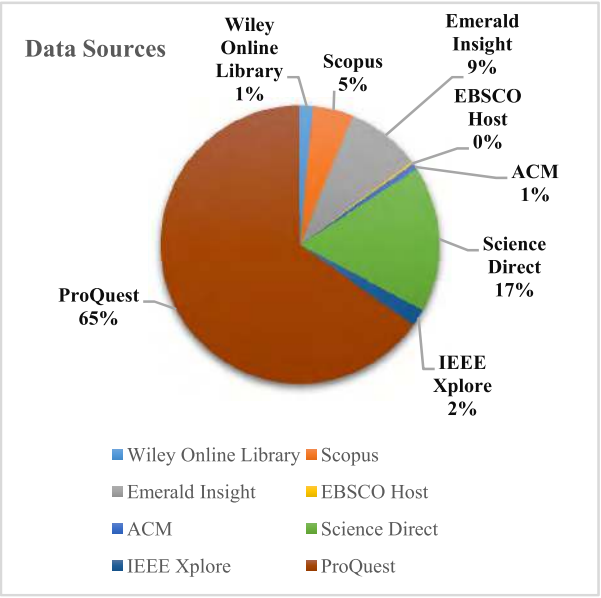


**FIGURE 3.** Selected studies publication venues.

types" and "potential author bias". To ensure that study selection process and inaccuracy in data extraction were unbiased, authors followed Kitchenham and Charters (2007) recommendations [63]. Two authors were involved in the "classification" of each paper. To overcome difference of opinion, the matter was discussed until mutual understanding was developed between authors.

## III. FACTORS DERIVED FROM SYSTEMATIC LITERATURE REVIEW

The identified KS factors in GSDOs industry have been classified in five categories: "individual", "technological", "organizational", "cultural" and "geographical".

### KNOWLEDGE SHARING BARRIERS

This section presents the findings for the first research question "Research Question 1: What are the KS sharing barriers in GSDOs?".

**TABLE 4.** Summary of selected STUDIES.

| YEAR | 2010 | 2010 | 2010 | 2010 | 2011 | 2011 | 2011 | 2012 | 2012 | 2012 | 2013 | 2013 | 2013 | 2014 | 2014 | 2014 | 2014 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Source | [31] | [32] | [33] | [34] | [35] | [59] | [21] | [36] | [37] | [38] | [39] | [40] | [41] | [42] | [20] | [43] | [44] | [45] |
| **Method** | | | | | | | | | | | | | | | | | | |
| Case Study | X | | | | | | X | | X | X | X | X | | X | X | | | X |
| Action Research | | | | | | | | | | | | X | | | | | | |
| Survey | | | | | X | | X | | | | | | X | | | X | | |
| Systematic Literature Review | | | X | X | | | | X | | | | | | | | | | |
| Systematic Mapping | | | | | | | | | | | | | | | | | | |
| Exploratory Research | | | | | | | | | | | | | | | | X | | |
| Controlled experiment | | X | | | | | | | | | | | | | | | | |
| Literature Survey | | | | | | X | | | | | | | | | | | | |
| Unclear | | | | | | | | | | | | | | | | | | |
| **Data Analysis** | | | | | | | | | | | | | | | | | | |
| Qualitative | | | | | | | X | | | X | X | X | | X | X | | X | X |
| Quantitative | X | X | | X | X | X | | X | X | | | | X | | | X | | |
| Mixed | | | | | | | X | | | | | | | | | | | |
| Unclear | | | X | | | | | | | | | | | | | | | |
| **Study Setting** | | | | | | | | | | | | | | | | | | |
| Academic | | X | | | | | | | | | | | | | | | | |
| Industry | X | | | | X | | X | | X | X | X | X | X | X | X | X | X | X |
| Unclear | | | X | X | | X | | X | | | | | | | | | | |
| **Data Collection Approach** | | | | | | | | | | | | | | | | | | |
| Observation | X | | | | | | X | | | | X | | | | | | | |
| Training | | | | | | | | | | | | | | | | | | |
| Workshop | | | | | | | | | | | | | | | | | | |
| Questionnaire | | X | | | X | | | | | | | | X | | | X | X | X |
| Interviews | X | | | | | | X | | X | X | X | X | | X | | | | |
| Archival Record | | | X | X | | X | | X | | | | X | | | X | | | |
| Visits | X | | | | | | | | | | | | | | | | | |
| Experiment | | X | | | | | | | | | | | | | | | | |

### A. INDIVIDUAL BARRIERS

#### 1) LACK OF TRUST

Many studies reported that lack of trust between employees results in weakened relationships, which create hindrance in KS [33], [35], [51], [52], [55], [56], [59]. Zahedi et al. reported three types of ''lack of trust'' which inhibit KS. The identified types of *''trust''* included ''*lack of trust in competency of remote team members''*, *''lack of companion trust''* and *''lack of commitment trust''* [19]. Employees followed the belief *''think who you can trust to share your knowledge with''* [39]. Also because of ''lack of trust'', communication between new and old team members declines with passage of time.

#### 2) LACK OF SOCIAL NETWORKS

Having a good social network with team members facilitates KS. On the other hand ''lack of social networks'' created challenges for the teams [19], [40]. Relationships between old and new team members were negatively impacted by the absence of *''social networks''* [39]. Low level and inadequate ''social skills'' of software development team were also impacted KS relationship between clients and team members [51]. ''Cross-division socialization'' is also a significant factor in GSD, but unfortunately this processes was not practiced in the GSDOs due to lack of technical KS and transfer between cross divisions of teams [52].

**TABLE 4.** *(Continued.)* **Summary of selected STUDIES.**

| YEAR | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2016 | 2016 | 2016 | 2016 | 2016 | 2016 | 2016 | 2017 | 2017 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Source | [46] | [47] | [48] | [19] | [49] | [50] | [51] | [52] | [53] | [54] | [55] | [56] | [57] | [58] | [59] | [33] |
| **Method** | | | | | | | | | | | | | | | | |
| Case Study | | | | | X | | | X | X | | X | X | | X | | 15 |
| Action Research | | | | | | | | | | | | | | | | 1 |
| Survey | X | | | | | | X | | | | | | | X | X | 8 |
| Systematic Literature Review | | X | X | X | | | | | | | | | X | | X | 8 |
| Systematic Mapping | | | | | | X | | | | | | | | | | 1 |
| Exploratory Research | | | | | | | | | | | | | | | | 1 |
| Controlled experiment | | | | | | | | | | | | | | | | 1 |
| Literature Survey | | | | | | | | | | | | | | | | 1 |
| Unclear | | | | | | | | | | X | | | | | | 1 |
| **Data Analysis** | | | | | | | | | | | | | | | | |
| Qualitative | | | | X | | X | | | | X | X | X | | | | 13 |
| Quantitative | X | X | | | | | X | X | | | | | X | | X | 15 |
| Mixed | | | X | | | | | | X | | | | | X | | 4 |
| Unclear | | | | | X | | | | | | | | | | | 2 |
| **Study Setting** | | | | | | | | | | | | | | | | |
| Academic | | | | | X | | | | | | | | | | | 2 |
| Industry | X | | X | X | X | X | X | X | X | X | X | X | | X | X | 26 |
| Unclear | | X | | | | | | | | | | | X | | | 6 |
| **Data Collection Approach** | | | | | | | | | | | | | | | | |
| Observation | | | | | | | | | | | X | | | X | | 5 |
| Training | | | | | X | | | | | | | | | | | 1 |
| Workshop | | | | | | | | | | | | | | | | 0 |
| Questionnaire | X | | | | | | X | | X | | | | | | X | 9 |
| Interviews | | | X | X | | | | X | | X | X | X | | X | | 15 |
| Archival Record | | X | | X | | X | | | | | | | X | | X | 11 |
| Experiment | | | | | | | | | | | | | | | | 1 |

### 3) PERSONAL FEAR AND SHYNESS

It was found in various studies that reluctance for KS between distributed employees was due to the *"fear of losing job"* [19], [33]. Fear related to individual's self-exposure to technical skills limited the KS activities. Team members were reluctant to share knowledge considering themselves inferior in the development teams [51]. A survey was conducted at Siemens Middle East to identify the reasons of KS problems between employees. It was reported that 8% of employees were reluctant to share and ask questions because of the culture of *"it is shame to ask"* [52]. Reduced KS occurred between remote team members due to general *"lack of confidence and shyness"* of the offshore developers [44].

### 4) INCOMPATIBLE PROFESSIONAL QUALIFICATION

It was observed that individual's with different levels of professional qualification required more time for KS [40]. Difference in educational background, lack of technical skills [35] and absorptive capacity [56] created issues while sharing knowledge between team members [51]. Further, difference in educational and technical knowledge impacted the quality knowledge transfer process due to technical knowledge imbalance [40].

### 5) LACK OF MOTIVATION

Lack of motivation between employees [56] specially in the case of sharing knowledge from senior employees to new employees created lot of issues for the KS process [19].


**FIGURE 4.** Individual barriers.

KS challenges tend to increase between development teams due to lack of motivation between team members [51].

#### 6) LACK OF TIME

Individuals who become overloaded with tasks often did not get enough time to share or seek new knowledge [39], [52], [59]. Due to extra work load employees were not able to share knowledge. Extra work load made team members less aware of the knowledge possessed by their co-workers. This knowledge gap due to overload was specifically observed between new and old team members [39].

#### 7) LOW AWARENESS OF SELF KNOWLEDGE

Self-knowledge is "*self digest that summarizes one's relations to the world and the personal consequences of these relations*" [60]. Sometimes individuals had required knowledge but had little awareness about their "*self knowledge*". This behavior created reluctance in sharing of knowledge and ideas with team members [39]. Fig. 4 presents the individual barriers identified in this SLR.

### B. TECHNOLOGICAL BARRIERS

#### 1) LACK AND IMPROPER UTILIZATION OF KS TOOLS

Technology helps in aiding the KS process. But in many studies it has been found that team members make little or no use of available technological tools and resources [19], [39], [43], [51], [52], [56]. In one survey it was found that 21% of the employees did not make use of available KS tools [52]. Another barrier with the potential to affect KS in distributed teams is "lack of suitable KS tools" Unfamiliarity with the available collaborative technologies also negatively impacts KS [51]. Kuko et al. (2013) reported that many of available tools e.g. *"wiki pages"* were not used properly by the team members. These *"wiki pages"* were unpopulated or did not provide appropriate information [39]. There are specific tools designed to maintain communication in GSDOs, lacking of these tools specifically aimed at managing architectural knowledge in a global setting caused many challenges in KS and knowledge management (KM) [32].

#### 2) TECHNOLOGICAL KNOWLEDGE GAP

Many of the selected studies have highlighted "technological gap" as one of the major factor that impedes KS [19], [38], [44], [51], [56], [58], [61]. In globally dispersed teams, technological knowledge gaps arise due to difference in experience and educational background. By increasing the number of team members in offshore teams, significant amount of technological knowledge gap was noticed in geographically dispersed team members. The difference in educational level of offshore team members was identified as the main reason for this problem. It was also noted that vast majority of the offshore team members were fresh graduates who had no knowledge regarding complex software testing within virtual teams [19]. Another study also highlighted the fact that domain knowledge varies from country to country. This leads to critical situation in which onsite team members assume that the project specifications have been understood whereas team members on other locations did not provide a valid feedback because of lack of understanding [20].

#### 3) LACK OF CENTRAL KNOWLEDGE REPOSITORY AND STANDARDIZED TEMPLATES

In order to get full access to resources of GSDOs assets, central knowledge repository is required. Lack of such resources causes lot of clashes in smooth flow of knowledge between team members, especially for the offshore members [21]. Study reported that instead of using central repositories to store knowledge most of the project requirements were noted on *"white boards"* and *"personal note books"* [19]. It was also observed in the survey that 24% of the team members considered "*inability to locate the correct knowledge source*" as a major cause for inadequate KS [52]. Standardization of template plays an important role when it comes to software development. A case study conducted to explore KS barriers in agile development found that project managers faced issues to share knowledge because of "lack of standardized templates" while using team collaboration tools like "confluence" [51].

#### 4) CONTEXTUAL DIFFERENCE

In globally distributed teams, individuals working in different contexts usually neglect to share the relevant information which may be beneficial to offshore team members. The reason for this behavior is the non-awareness of identification of information [56] required by the remote team members [19] and ambiguous nature of project [35]. This factor influences the capability to share knowledge and develop a common understanding with team members who are in different contexts [19]. Lack of understanding of business domain and context [44] e.g. banking regulation which is different for each country can make KS process challenging [51].

#### 5) LACK OF TRAININGS

As software development is an innovative process, KS problems arise if management does not focuses on

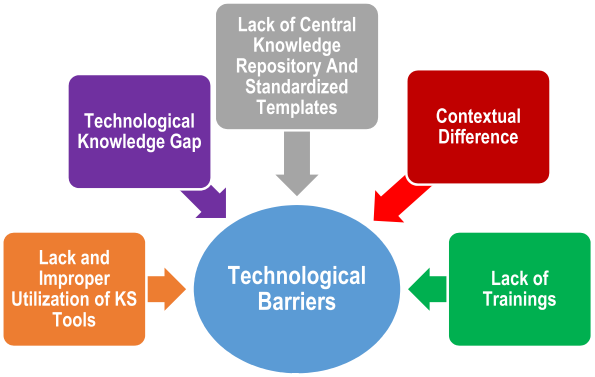


**FIGURE 5.** Technological barriers.

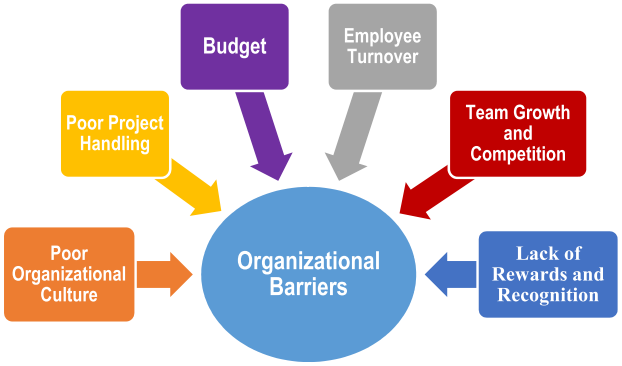


**FIGURE 6.** Organizational barriers.

conducting regular training for new employees and also for experts [35], [39]. Fig. 5 presents the technological barriers identified in this SLR.

### C. ORGANIZATIONAL BARRIERS

#### 1) POOR ORGANIZATIONAL CULTURE

Many studies have found that poor organizational culture negatively influence KS [19], [21], [32], [33], [35], [43], [46], [51], [61]. An unstable organizational structure and hierarchy leads to flaws in proper KS. To make use of effective KS in agile development, adequate planning and organization is required. Inadequate planning and insufficient documentation was found to negatively impact KS [56]. It was also observed that tight schedules, multi-tasking and frequent changes without consulting the clients in sprints resulted in less interaction which lead to KS problems [51]. Although team members considered KS as an important element, but they believed that management lacked in defining a well-formed process and did not clearly laid emphasis on KS practices while defining organization's goal. It was also observed that main focus of the managers was on ''marketing'' and ''sales'' which lead to a gap between development team and management team [39]. Working conditions and physical layout of organization also lead to stress which acted as barrier for KS [59].

#### 2) POOR PROJECT HANDLING

Several software projects close successfully, while others are absolute disasters. When project abstract requirements are not readily available for offshore teams, then project may end up unsuccessfully due to insufficient knowledge [38]. It was observed in a study that 39% of the employees considered ''*lack of lessons-learned sessions*'' as a barrier for KS [52]. In long term projects, the knowledge possessed by the off-shore team members was ''absorbed'' by individuals before reaching to distant team members and was not completely shared. Furthermore, handling and supervision of ''*back flow*'' of knowledge complicates the KS strategy, because ''*knowing what you don't know*'' negatively influenced KS [20].

#### 3) BUDGET

In distributed teams, KS is associated with high costs which are usually not predicted timely. At times proper KS does not take place due to lack of travel expenses and lack of virtual communication tools [19]. Small budg et al located for project acted as barrier for setting offshore project meetings [40], [51]. Surprisingly even if the management was aware of the cost related to KS, still the budget allocated for visits was underestimated and none of the managers defined it before starting project [20].

#### 4) EMPLOYEE TURN OVER

Lack of job security and employee turnover created barriers and gaps in KS [19], [21], [52]. Due to employee turnover sharing of knowledge with new comers becomes a tedious process as it creates demotivation among the senior employees. A huge number of employee turnover on offshore sites impacted the willingness of the on-shore team members to share knowledge as it was found to be a time consuming task [19]. It was observed in a study that 28% of the employees considered *"lack of job security"* as a barrier for KS [52].

#### 5) TEAM GROWTH AND COMPETITION

Rapid growth causes increase in the complexity of the organization, which resulted in creating problems to share knowledge [39]. Due to high competition employees were reluctant in sharing information with co-workers of different departments. 32% of the employees considered ''*competition between employees*'' as a challenge which effects KS process negatively [52].

#### 6) LACK OF REWARDS AND RECOGNITION

''Lack of recognition'' for KS by the management reduced KS between software developers. The software developers felt that their work was ''less appreciated'' which in return reduced their motivation to share knowledge [39]. Also lack of incentives and rewards by management hindered individual's motivation to share valuable knowledge [56]. Fig. 6 presents the organizational barriers identified in this SLR.

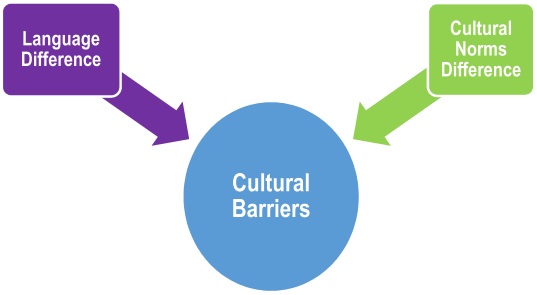


**FIGURE 7.** Cultural barriers.

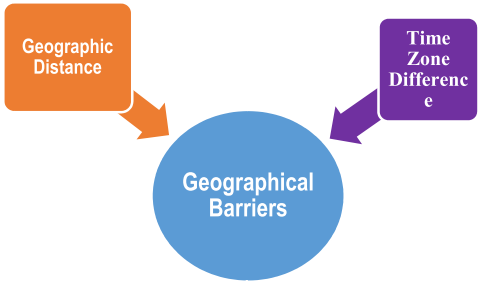


**FIGURE 8.** Geographical barriers.

### D. CULTURAL BARRIERS

#### 1) LANGUAGE DIFFERENCE

Many studies [19], [33], [38], [39], [51], [56] have reported "language difference" as one of the top most barrier for KS in GSDOs [20], [39], [40], [43], [48], [50], [51]. Globally distributed team members found it very difficult to share knowledge due to differences in the language [19]. Having team members with heavy accents also made communication very difficult [20], [40]. Team members whose native language was not English e.g. German [20] or Chinese [50] suffered from communication issues which resulted in improper flow of knowledge and information exchange. Additionally, when the native language was not found to be same, the diversity in terms of a common language (usually English) also lead to various problems and misunderstandings [31].

#### 2) CULTURAL NORMS DIFFERENCE

In a global team, the cultural practices and norms vary from region to region [48]. Studies [31], [33], [38], [40], [42], [44], [47], [55], [57], [62] mentioned cultural difference as a challenge faced by the team members during KS process. The study [48] identified differences in cultural norms acted a barrier which usually hinder KS. Zhang et al. (2011) conducted a survey from the employees working in outsourcing projects in a software park. It was found larger cultural difference had negative impact on KS [34]. Cultural barriers are presented in Fig. 7.

### E. GEOGRAPHICAL BARRIERS (GB)

#### 1) GEOGRAPHICAL DISTANCE

The distance between geographically dispersed team acts a barrier and causes communication issues [35], [46], [56]. The physical distance between subproject participants prevented informal communication [32]. The study [52] found that 23% of the team members considered "*far distance between work locations*" as a barrier for KS. Distance was also mentioned as barrier by an interviewee as it limits the connectivity to the right resources [40]. KS process becomes easier when team members meet casually, which happens when the distance between team members is not a concern. However, in case of growing software development organizations, the growing distance between offshore team members hinders KS [39]. Face to face communication is also difficult when large distance is involved in teams, hence communication becomes difficult as compared to nearby team members [20], [35].

#### 2) TIME ZONE DIFFERENCE

Time zone difference makes communication between distributed team members difficult and challenging [33], [43], [51], [55]. Difference in time zone decreases the mechanisms of KS and creates communication gaps between distant team members [19], [40]. Time zone variance is found to negatively impact knowledge transfer and overall success of any project [20]. Delays in overall project execution and delivery occur due to absence of synchronous collaboration because of difference in time zone [31]. Fig. 8 presents the geographical barriers identified in this SLR.

#### 3) KNOWLEDGE SHARING FACILITATORS

This section presents the answers to the second research question "Research Question 2: What are the KS facilitators in GSDOs?".

### F. INDIVIDUAL FACILITATORS

#### 1) SOCIAL INTERACTION

Social interaction and relationships play an important role in KS [30], [40], [54]. Strong social ties enable faster exchange of information [50]. A survey which involved 150 software developers concluded that personal interactions positively effects KS [37].

#### 2) TRUST

Trust impacts significantly both tacit and explicit KS [49]. In order to facilitate KS between GSD teams, trust plays a significant role [19]. Trust not only holds a strong impact on KS [37], but it also has a positive impact on the overall team performance [58]. Interpersonal trust positively impacts KS. The study suggested that trust between remote sites can be enhanced by promoting visits between globally distributed teams which can eventually build up trust [33], [56].

#### 3) MOTIVATION

Individual motivation is the key factor which strongly influences KS. It was found in a survey that participative motivation is positively related to KS [50]. The studies [21], [49], [56] reported that self-motivation influences the KS process

positively. It was found that individual's motivation impacted KS process. The study also reported that motivation to share knowledge is influenced by the quality of management [48].

#### 4) INDIVIDUAL PARTICIPANT'S SATISFACTION

The individual satisfaction with the management plays a significant role to share knowledge. It was found in a survey that KS is influenced by the individual participant satisfaction with the management of open source software communities [45].

#### 5) MANAGEABLE WORKLOAD

Manageable workload provides time to employees to share knowledge and enables exchange of KS. Because of fairly distributed work load, individuals get spare time to exchange information and new ideas [48].

#### 6) PROFESSIONAL QUALIFICATION

It was reported in a study [40] that mostly firms seek to hire skilled and qualified professionals who are familiar with process of KS. Highly qualified individuals influence the absorptive capacity of firms which eventually facilitate KS [40]. Individual facilitators are shown in Fig. 9.

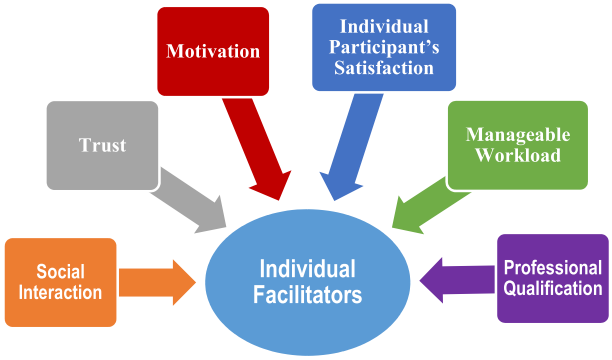


**FIGURE 9.** Individual facilitators.

### G. TECHNOLOGICAL FACILITATORS

#### 1) TECHNOLOGICAL SUPPORT

Latest knowledge management tools like *"wiki, pair-programming and video-conferencing"* [33] facilitate KS in distributed agile team members [43]. It was evident that various enabling technologies [56] and tools which cater to the needs of distributed stakeholders in the decision making promote KS [32]. In order to facilitate KS software organizations, it is suggested to make use of "*technical and electronic discussion boards*". The technical boards enabled team members to share information, experiences and technical skills for a specialized discipline. The electronic discussion boards allowed team members to share the task lists, latest technical and business information. Visual prototypes were also created to solve issues of miscommunication between onshore and offshore teams [43]. KS tools act as a key success factor and enable necessary KS culture among team members [52]. In order to facilitate KS, both synchronous (instant messaging, video conferencing) and asynchronous (e-mailing) communication tools are required depending upon needs for different purposes [33]. Distributed teams used synchronous communication method such as "instant messaging" to share knowledge [38]. Physically distributed teams also make use of tools such as "*intranets, groupware, teleconferencing, videoconferencing, online chats*" to easily exchange information [40]. Also some physical meetings can be substituted with [20]. This fact was further supported by a study which observed that all spatial knowledge with remote members was shared using communication tools [38]. It was observed in a study that analyzing individual team member's preferences (based upon their cognitive characteristics) can help in selecting the appropriate tools desired by the team. This technique of selection of groupware tool in return can improve stakeholders' satisfaction with requirement specifications shared between distributed members [19]. To reduce the risk of possible misinterpretations for offshore co-workers, it is essential to provide explicit knowledge by providing documents to the offshore team including "*business process, elaboration on functional requirements and solution description, detailed design, and development guidelines*" [46].

#### 2) CENTRALIZED LIBRARIES, KNOWLEDGE REPOSITORIES AND MAPS

Establishment of centralized libraries and knowledge repositories ("e.g., wiki, discussion forums, portals, document management systems, scrum boards") allowed "*centralized organizational knowledge*" to be available for remote team members [19], [38]. It was found that wikis aid in initiating new threads [43]. An example of using centralized libraries was reported at the Siemens. Full library of control function block was made available to the Siemens automation engineer. This library provided exposure to the functionalities which are useful to the industrial application [52]. It may also be noted that some software offshore companies used "wiki" as their knowledge base repository. A centralized knowledge repository can be considered as a positive factor in support of KS in offshore outsourcing projects [20]. Another important factor which aids KS in offshore software team are "*knowledge maps*". These knowledge maps are made accessible to all team members via common database or repository and provide accessible solution [20]. "*Adoption of common platforms and tools among sites*" [56] and establishment of "*common KS practice*" for distributed teams can minimize the cost spent on KS awareness and training programs [21]. Standardization of templates and methodologies supports KS between onsite and offshore software development teams [49].

#### 3) TECHNICAL INFRASTRUCTURE

Proper technical infrastructure costs, such as cost for equipment and tools etc. can facilitate in the KS process [20], [33]. Easy access to "employees", "peers" and "managers"

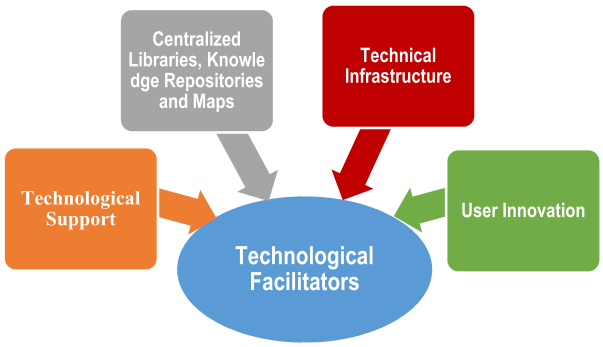


**FIGURE 10.** Technological facilitators.

provides comfort level to team members to inquire about specific knowledge with other team members [52]. Well defined project methodology can have a positive impact on KS e.g. pair programming can be considered as suitable means to exchange design knowledge [49].

#### 4) USER INNOVATION

User innovation allows user to share knowledge directly with GSD teams in open source platform. This allows exchange of knowledge and creates a positive relationship with KS [50]. Fig. 10 presents the technological facilitators identified in this SLR.

### H. ORGANIZATIONAL FACILITATORS

#### 1) ORGANIZATIONAL SUPPORT

Various studies have laid focus on the importance of proper organizational infrastructure which support KS [19], [20], [33], [45], [49], [50], [52], [56], [57]. An autonomous team, where members have been given the freedom and independence leads to frequent communication and enable knowledge transfer [49]. A proper organizational design facilitates KS between team members by defining clear roles and responsibilities of team members [19], [49]. The study [43] found that "*common chat rooms*" facilitated communication and enabled faster knowledge exchange among distributed teams [43]. Flexible communication and team hierarchy enables KS by facilitating communication at different stages in GSD [19]. Proper documentation [55] such as business documents, systematic reviews, codification and artifacts serves as a reference point for communicating and sharing knowledge [19]. Proper utilization of available assets infrastructure before starting a project can help in streamlining the knowledge transfer process [20]. Authors observed that good managers can play an significant role to boost KS within organization [45]. It was observed in a study that organizational culture and tolerance to accept failures by managers had a positive impact on KS [50]. Further, implementation of mechanism to retain knowledge of old employees for new employees can help in promoting KS culture [21]. Onshore managers can help in reducing the misinterpretations by minimizing complex domain knowledge at offshore e.g. the parts of the project which have to go through legal rules (such as "integrations" and "data migration") may not be allocated to offshore team [44].

#### 2) TEAM COMMUNICATION

Frequent communication and "scrum meetings" between team members allowed exchange of knowledge [19], [55], [56] and facilitated KS in distributed teams [43] Physical meetings were identified as a top facilitator and most preferred method for KS inside organization [52]. It was reported in a study, that high frequency of communication between offshore team members positively influenced KS [19]. "Face to face" interaction made communication easier between team members [49]. Adequate communication infrastructure can lead to development of knowledge networks in large scale software projects [57]. By including a lead architect to discuss practices for improving coordination and knowledge management strategies, team communication in distributed teams can be improved [32].

#### 3) REWARDS, INCENTIVES & RECOGNITION

Management can play an important role in boosting up team members moral by offering rewards and incentives [21]. A survey conducted on 150 software developers directly involved in developing and maintaining a software product from project teams reported "rewards" to have positive and significant impact on KS [37]. Incentives ultimately improve the flow of knowledge transfer among distant workers [19]. Rewards and incentives were found to be very useful especially in offshore teams to promote KS. The study found that by assigning a status to employees e.g. "expert" as a reward helped to share knowledge [20]. A very different scheme for rewarding employees by making use of "Small Gift Recognitions" facilitated KS culture. It consisted of gift vouchers which were distributed to each business and it allowed the manager to reward the employees immediately without the involvement of top management [52].

#### 4) TRAININGS AND WORKSHOPS

Weekly and monthly workshops and seminars helped in understanding project knowledge between "business teams", "technical teams" and "customers" in distributed agile teams [43]. In a survey it was reported that 74% of employees preferred meetings/workshops as a method for sharing knowledge between employees. It was also found that tacit knowledge was easily shared through seminars via socialization [52]. Formal training arrangements facilitated KS between team members [19]. Employees participation in forums facilitated the interaction between team members in the organization [57].

#### 5) JOB SECURITY

A good and stable reputation of secured work environment allows employees to feel satisfied with their jobs. This secured work environment allows employees to freely exchange knowledge without fear of losing jobs. The results of the survey conducted at Siemens found that positive feeling


**FIGURE 11.** Organizational facilitators.

of job security is higher at Siemens (75%) compared to other corporations (52%) [52]. Fig. 11 presents the organizational facilitators identified in this SLR.

### *I. CULTURAL FACILITATORS*

#### 1) RELOCATION OF MEMBERS BETWEEN REMOTE SITES

Relocation of team members between remote sites allows alternations in the structure of team members in different work locations. The relocation of team members makes it easy to share knowledge and technical expertise between different teams [33], [49]. Temporary relocation of team members helped individuals to share knowledge effectively and enabled mutual learning [54]. Further, it was also found that temporary rotation of team members between on-site and distributed teams allowed easier sharing of "business" and "domain" related knowledge [43]. It was reported in a study that temporary job assignments between different departments acts as a socialization facilitator. By assigning team members from one department to another allows individuals to learn new processes and techniques, which helps in creating and transferring knowledge [52].

#### 2) CULTURAL EXCHANGE PROGRAMS AND WORKSHOPS

In order to solve cultural KS barriers, one should implement cultural exchange programs. These exchange programs help in understanding the behavior, work practices and attitudes of team members from distributed teams [43], [56]. Lot of misunderstandings and issues occur between onsite and offshore team members from the beginning of the project. In order to mitigate these issues interviewees reported that by initiating "cultural workshops" at the start of the project allowed team members to share knowledge effectively [20].

#### 3) VISITS

Regular visits between the dispersed teams accelerates the sharing of "business" and "domain" related knowledge [30], [33], [56]. These visits also allowed team members to understand culture of offshore team members and developed social relations which aid in sharing of knowledge [19]. It was a practice for team members to visit remote teams to boost up communication and trust between the team members [43].

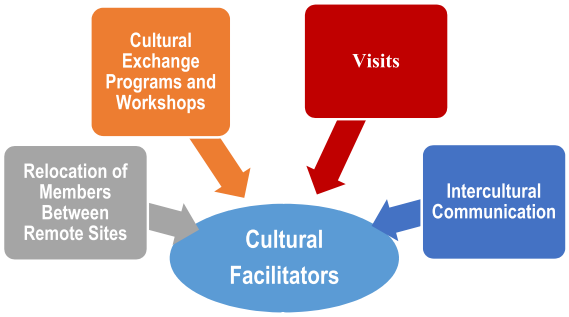


**FIGURE 12.** Cultural facilitators.

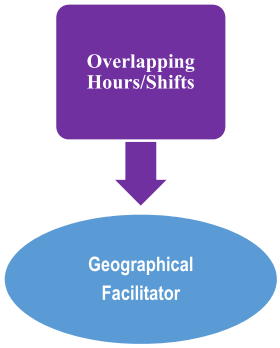


**FIGURE 13.** Geographical facilitators.

Authors suggested that onsite team members visits to offsite team members and vice versa should be given high priority to promote KS [20].

#### 4) INTERCULTURAL COMMUNICATION

Cultural awareness can be created by assigning *"cultural ambassadors"* between remote sites who can interpret remote team communication and actions [33]. Cultural ambassadors [56] and culturally marginal people can be assigned for mediating roles between different team members, as they have common understanding of both cultures [41], [63]. Expatriate manager can be assigned to control and coordinate knowledge transfer and introducing corporate culture between remote sites [41]. *"Information gatekeeper"* can be used as they have skills of understanding and translating knowledge into more meaningful way for their locally oriented colleagues [41]. Fig. 12 presents the cultural facilitators identified in this SLR.

### *J. GEOGRAPHICAL FACILITATORS*

#### 1) OVERLAPPING HOURS/SHIFTS

Working with team members from different geographical locations and time zones requires proper time management. By assigning rotational duties [56] and overlapping shifts properly, software organizations can solve time zone and communication issues and more importantly allow team members to share knowledge [43]. Only one geographical facilitator was identified in this SLR which is shown in figure 13.


**FIGURE 14.** Knowledge sharing facilitators and barriers.

## IV. JOINING OF FACTORS

In this section KS factors are joined together. The KS barriers are on the left side in orange color and KS facilitators are on the right side in blue color as shown in Fig. 14.

## V. FACTORS ANALYSIS

This paper has presented a review of knowledge sharing factors with respect to the global software development. The identified knowledge sharing facilitators and barriers have been classified in five categories: individual, technological, organizational, cultural and geographical. In order to achieve effective KS in GSDOs, the software developers need to understand dynamics of all categories identified in this study. Fig. 15 presents KS factors for each category divided into barriers and facilitators. ''Individual'' category had the highest frequency of factors reported (13) followed by ''organizational'' category with eleven factors. ''Technological'' category had nine factors reported and six factors were reported in the ''cultural'' category. ''Geographical'' category had the lowest frequency of factors reported (3).

## VI. SIGNIFICANCE OF THE IDENTIFIED FACTORS

Software developers may consider utilizing the identified factors by going through the list of KS factors (drivers and barriers) and evaluate themselves against each factor to understand their strengths (e.g., organizational support) as well as potential weakness (e.g. language). The results of such analysis may suggest where managerial efforts and resources may be required to nurture KS in software project. The summary of all factors is presented in Table 5. Fig. 16 presents factors most cited factors. From the facilitator's category ''organizational support'' emerged as the most cited factor (13 times). Therefore, GSDOs need to focus on increasing the organizational support activities for their team members to facilitate KS process. According to the analysis of this study, three barriers ''poor organizational culture'', ''language

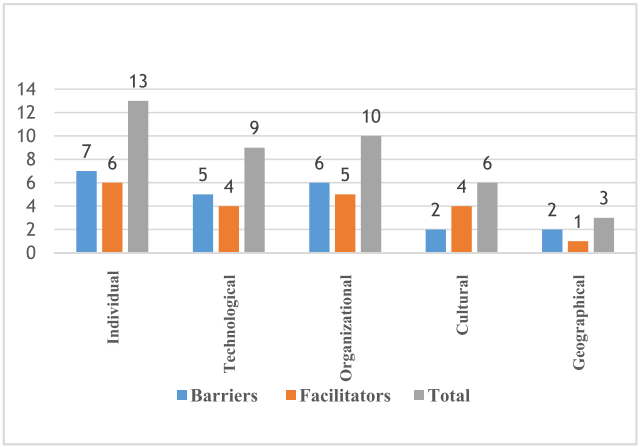


**FIGURE 15.** Categorization of knowledge sharing barriers and facilitators.

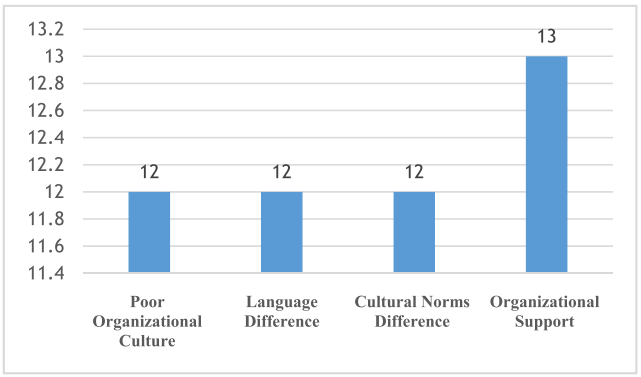


**FIGURE 16.** Knowledge sharing factors with highest frequency.

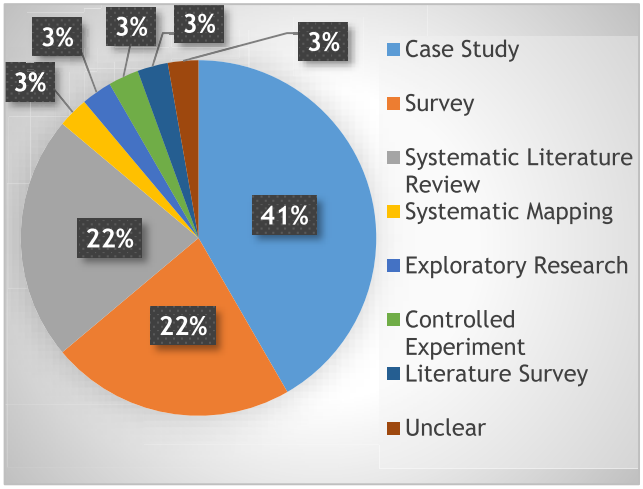


**FIGURE 17.** Research method.

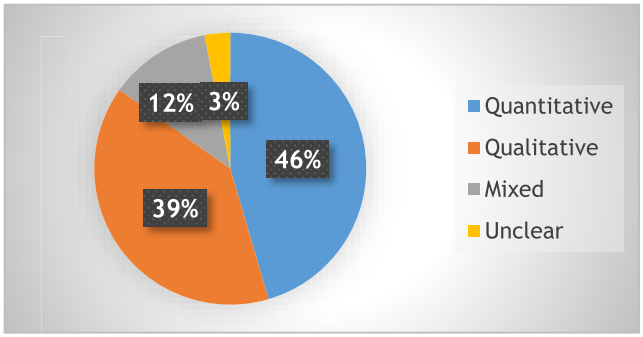


**FIGURE 18.** Data analysis approaches.

difference'' and ''cultural norms difference'' were cited 12 times each. Special measures and steps may be taken (well defined knowledge sharing processes, working conditions, and physical layout) to overcome the difficulties faced by employees due to lack of organizational support. Similarly, special measures such as ''cultural exchange workshops'' and ''language training'' should be implemented to overcome the difficulty faced by software developers who face cultural and linguistic differences. Fig. 16 presents KS factors with highest frequencies.

## VII. DISCUSSIONS AND FINDINGS

This review analyzed 33 studies. Maximum number of studies were conducted in the year 2015 and 2016 based upon our selected inclusion and exclusion criteria.

### A. RESEARCH METHOD

Fig. 17 presents the ''types'' of research methods used in the selected studies. The ''case study'' research method has the highest frequency among all research methods used in the selected studies. Fifteen studies used ''case study'' research method. ''Survey'' and ''systematic literature review'' were the next common method used. Eight papers used ''survey'' and ''systematic literature review'' as the research method. ''Systematic mapping'', ''exploratory research'', ''controlled experiment'' and ''literature survey'' were used in one study each. Only in one study the research method was ''unclear''.

### B. DATA ANALYSIS APPROACHES

Fig. 18 presents data analysis approach. fifteen studies used ''quantitative'' research approaches and thirteen selected studies used ''qualitative'' research approaches. Four studies used ''mixed'' approach and in only one study the approach was unclear.

### C. STUDY SETTING

The selected studies were classified into two main cases: academic and industry. Fig. 19 presents that twenty-six studies were conducted in ''industrial setting'' only two studies were carried out in ''academic setting''. For the remaining six studies, the study settings were not clearly mentioned in the studies.

### D. DATA COLLECTION APPROACH

Fig. 20 presents data collection approach. It can be seen that ''interviews'' (15 studies) were used in most studies for data collection, followed by ''archival record'' (11 studies). Nine studies used ''questionnaire'' as data collection approach and

**TABLE 5.** Summary of factors.

| Identified Barriers | Studies | Frequency | Identified Barriers | Studies | Frequency |
|---|---|---|---|---|---|
| **Individual Barriers** | | | **Organizational Barriers** | | |
| Lack of Trust | [34, 36, 52, 53, 56, 57, 60] | 7 | Poor Organizational Culture | [19, 21, 33, 34, 36, 44, 47, 52, 62, 57, 40, 59] | 12 |
| Lack of Social Networks | [19, 41, 40, 52, 53] | 5 | Poor Project Handling | [38, 52, 20 ] | 3 |
| Personal Fear and Shyness | [19, 33, 51, 52, 44] | 5 | Budget | [19, 20, 42, 53] | 4 |
| Incompatible Professional Qualification | [40, 35, 51, 56] | 4 | Employee Turn Over | [19, 21, 53] | 3 |
| Lack of Motivation | [19, 53, 58] | 3 | Team Growth and Competition | [40, 53] | 2 |
| Lack of Time | [40, 53, 60] | 3 | Lack of Rewards and Recognition | [40, 57] | 2 |
| Low Awareness of Self Possessed Knowledge | [40] | 1 | | | |
| **Technological Barriers** | | | **Cultural Barriers** | | |
| Lack and Improper Utilization of KS Tools | [19, 40, 44, 52, 53, 57, 33] | 7 | Language Difference | [19, 39, 40, 52, 57, 20, 40, 41, 44, 49, 51, 32] | 12 |
| Technological Knowledge Gap | [19, 39, 45, 52, 57, 59, 62, 20] | 8 | Cultural Norms Difference | [32, 34, 39, 41, 43, 45, 48, 56, 58, 63 49 35] | 12 |
| Lack of Central Knowledge Repository and Standardized Templates | [22, 52, 19, 51] | 4 | **Geographical Barriers** | | |
| Contextual Difference | [57, 19, 36, 45, 52] | 5 | Geographical Distance | [36, 47, 57, 33, 53, 41, 40, 20] | 8 |
| Lack of Trainings | [36, 40] | 2 | Time Zone Difference | [34, 44, 52, 56, 19, 41, 20, 32] | 8 |

| Identified Facilitators | Studies | Frequency | Identified Facilitators | Studies | Frequency |
|---|---|---|---|---|---|
| **Individual Facilitators** | | | **Organizational Facilitators** | | |
| Social Interaction | [31, 41, 55, 51, 38] | 5 | Organizational Support | [19, 20, 34, 46, 50, 51, 53, 57, 58, 44, 56, 21, 45] | 13 |
| Trust | [34, 57, 50, 19, 38, 58] | 6 | Team Communication | [19, 56, 57, 43, 53, 50, 58, 32] | 8 |
| Motivation | [21, 50, 57, 51, 49] | 5 | Rewards, Incentives & Recognition | [21, 38, 19, 20, 53] | 5 |
| Individual Participant's Satisfaction | [46] | 1 | Trainings and Workshops | [44, 53, 19, 48] | 4 |
| Manageable Workload | [49] | 1 | Job Security | [53] | 1 |
| Professional Qualification | [41] | 1 | | | |
| **Technological Facilitators** | | | **Cultural Facilitators** | | |
| Technological Support | [34, 44, 57,, 33, 53, 34, 39, 41, 20, 39, 19, 46] | 12 | Relocation of Members Between Remote Sites | [34, 50, 55, 44, 53] | 5 |
| Centralized Libraries, Knowledge Repositories and Maps | [19, 39, 44, 53, 20, 21, 57, 50] | 8 | Cultural Exchange Programs and Workshops | [44, 57, 20] | 3 |
| Technical Infrastructure | [20, 34, 53, 50] | 4 | Visits | [19, 20, 30, 33, 43, 56] | 6 |
| User Innovation | [51] | 1 | Intercultural Communication | [33, 56, 41, 63] | 4 |
| | | | **Geographical Facilitators** | | |
| | | | Overlapping Hours/Shifts | [57] | 2 |

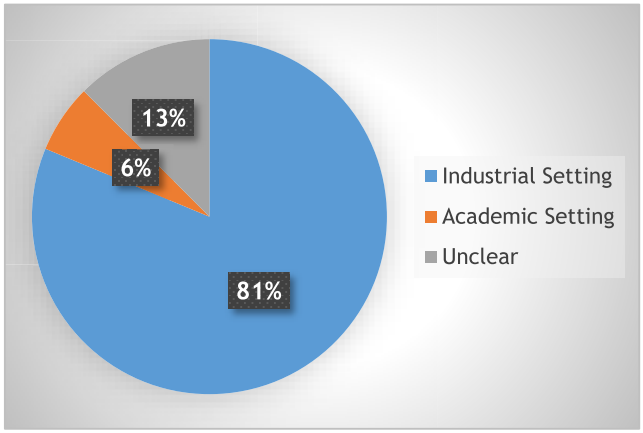


**FIGURE 19.** Study setting.

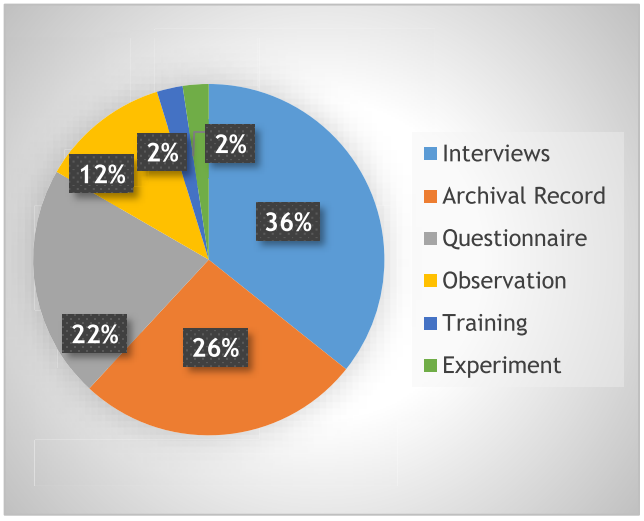


**FIGURE 20.** Data collection method.

five studies used "observation" for data collection. "Training" and "experiment" were used in one study each. It can be noted that some studies have used more than one data collection approach. Because of these multiple data collection approach, the sum of studies in this section (42) exceeds the number of the selected studies (33).

## VIII. SLR ISSUES AND LIMITATIONS

Meta-analysis has been sometimes criticized as an unsuitable exercise of uniting "apples" and "oranges" because it involves combining of various studies. Also, if the research method, data analysis, data collection method etc. are so heterogeneous, then statistically combining them can yield misleading conclusions. In this type of situation, meta-analysis can be considered inappropriate. To overcome this issue, in the current study results have been presented in summarized form consisting of "summary tables" and "concept maps". Most of the selected studies identified in this SLR were self reported and used "case study" as a research method which may be subject to publication bias.

## IX. CONCLUSION, PRACTICES AND FUTURE WORK

The identified factors can serve as a guideline in streamlining the overall KS process of any GSDO. The literature about KS factors in GSD context is characterized by diverse and heterogeneous research findings. The findings from this study can provide benefits by providing potential useful insights of knowledge sharing factors to GSDOs. Understanding KS factors that drive and hinder KS in GSDOs is a necessity for allowing team members to understand KS process. 42 KS factors are identified and classified in this study. The classification of factors using concept maps provides a rich picture of facilitators and barriers and facilitates continued investigation for future studies with visual representation.

Our aim in the current SLR was to provide GSDOs with a body of knowledge that can help them to identify KS facilitators and barriers. Based upon the analysis of the KS factors with highest frequencies, we suggest that the GSDOs should focus on the following practices to enhance KS culture:

- GSDOs should provide sufficient organizational support to the software developers whenever required. The significance of organizational support implies that software developers consider the support provided by GSDOs to facilitate KS to be an important element.
- By assigning "*cultural ambassadors*" who can interpret communication and actions of individuals working at remote sites, the cultural norms differences can be resolved in GSDOs. Efficient use of cross-cultural individuals can provide an environment and baseline for organizations with an aim to enhance the KS culture in GSDOs. Further, cultural exchange programs help in understanding the behavior, work practices and attitudes of individuals working from different location with various cultural backgrounds.
- To overcome language differences, GSDOs can make use of "*cultural awareness*" programs by assigning "*information gatekeeper*" as they have skills of understanding and translating knowledge into more meaningful way for their locally oriented colleagues.
- Culturally marginal people can be assigned for mediating roles between different team members, as they have common understanding of both cultures. Without such pre-emptive measures, KS is destined to fail between software developers.

GSD literature is increasing rapidly, and the usage of agile methodologies and open source development is also on increase. Accordingly, as new areas of research emerge, future research can be done to identify the KS factors with respect to different software development methodologies. The influence of these factors on individual roles (software coder, software tester, software designer and software analyst) working in GSDOs can to be explored further. There is also a need for exploring the influence of KS factors as per project and team needs.

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**RAYHAB ANWAR** is currently pursuing the master's degree in computer science with Universiti Tunku Abdul Rahman, Kampar, Malaysia. Her research interests include knowledge sharing, knowledge transfer, and global software development.

**MOBASHAR REHMAN** received the Ph.D. degree in information technology (knowledge management) from Universiti Teknologi Petronas. He is currently an Assistant Professor with the Department of Information Systems, Universiti Tunku Abdul Rahman, Kampar, Malaysia. His research interests include knowledge management, knowledge sharing, and human factors in software engineering and cyber-psychology.

**KHOR SIAK WANG** received the Ph.D. degree in information retrieval from Universiti Putra Malaysia. He is currently an Assistant Professor with the Department of Information Systems, Universiti Tunku Abdul Rahman, Kampar, Malaysia. His research interests include information retrieval, advanced image technology, and advanced information management.

**MANZOOR AHMED HASHMANI** received the Ph.D. degree in communication networks from the Nara Institute of Science and Technology, Japan. He currently an Associate Professor with the Department of Computer and Information Sciences, Universiti Teknologi Petronas. He is also a member of the High Performance Cloud Computing Centre and the Centre for Research in Data Science. His research interests include computer communications (networks), artificial neural networks, and artificial intelligence.