# Distributed Software Development Process, Initiatives and Key Factors: A Systematic Literature Review

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***Abstract*— Geographically Distributed Software Development (GSD) process differs from Collocated Software Development (CSD) process in various technical aspects. It is empirically proven that renowned process improvement initiatives applicable to CSD are not very effective for GSD. The objective of this research is to review the existing literature (both academia and industrial) to identify initiatives and key factors which play key role in the improvement and maturity of a GSD process, to achieve this goal we planned a Systematic Literature Review (SLR) following a standard protocol. Three highly respected sources are selected to search for the relevant literature which resulted in a large number of TOIs (Title of Interest). An inter-author custom protocol is outlined and followed to shortlist most relevant articles for review. The data is extracted from this set of finally selected articles. We have performed both qualitative and quantitative analysis of the extracted data to obtain the results. The concluded results identify several initiatives and key factors involved in GSD and answer each research question posed by the SLR.**

***Keywords*— Global Software Process Improvement, Distributed Software Development, Systematic Literature Review, Process Improvement Initiatives and Outsourcing**

## I. INTRODUCTION

A software development process can be defined, managed and measured. Any process which is defined and measured can be improved continuously [1]. The quality of software systems is dependent on the quality of process followed to develop it. SPI (Software Process Improvement) has become the primary approach for improvement of software quality [2].

An improved process can be defined in terms of its capability and maturity. Capability can be defined as the predictability of the process and its outcomes, or the range of expected results that can be achieved by following a process. Maturity can be defined as the growth in process capability.

An improvement initiative (related to capability and maturity) can be defined as a well-defined evolutionary path toward achieving a mature process where each maturity level solidifies the foundation for continuous process improvement.

Achieving each of this level of maturity in defined initiative means an increase in the process capability [3].

This SLR is carried out with the following goals and objectives,

*Primary Objective* – the main goal is to study to-date literature to find out all the initiatives (models, frameworks, techniques and applications) from the capability and maturity perspective. All the initiatives are considered either just proposed or empirically validated and whether came from industry or academia.

*Secondary Objective* – identification of all the factors (either motivators or barriers) involved in GSD.

*Ternary Objective* – the data collection, synthesis and analysis based on both quality and quantity (i.e., quantitative and qualitative analysis), which could prove to be helpful for the future researchers and practitioners in this field.

This paper represents the work done in the first phase of our project. The project is to design and develop a distributed model for small-medium scaled organizations involved in software outsource development in Pakistan. The primary objective is to make sure that all the related work to-date has been studied and well understood prior to conducting a field study to gather data.

Next section covers the background and motivation behind this research. The definitions (found in the literature) of some important terminologies related to our topic are stated. Research Methodology followed for the systematic review is outlined in section 3. The synthesized information brewed from extracted data is presented in section 4 as the results. A detailed discussion of the results compiled in fourth section is provided in section 5. The limitations of the review both internal and external along with validity of the process are outlined in section 6. The paper is concluded in section 7 and future work is covered in section 8. References are followed by an Appendix, listing all the articles reviewed in the final phase of this SLR.

## II. BACKGROUND AND MOTIVATION

It is evident from the literature that international competition in outsourcing business, vendor companies need to improve the quality of their processes [4]. Process quality in SME's (Small and Medium Enterprises) is very rare and not easily adopted [5]. Most of the organizations providing outsource services in software development belongs to developing countries like Bangladesh, India, Pakistan and Vietnam. These organizations can be ranked as SMEs and that is a driving factor for us to conduct this research. SMEs in these countries are reluctant to adopt SPI initiatives because of the time and costs attached with them. The research community has to change this mindset through development of cost and time affective and productive initiatives applicable in SMEs.

How can we define improvement on a general scale, it is understood as a negotiated process of change occurring through a structuring process [6]. SPI can help to reduce defects and increase the quality of the software [7]. Process modeling is used as a main initiative for process improvement which is defined in literature as, a set of practices or a set of standard steps (or stages) that were successfully followed in the past by individuals, projects teams, or organizations, and were documented as practices capable of adoption by other peers [3].

The successful completion of a distributed project depends upon the quality of collaboration and communication among the stakeholders [8]. The success of any project can be broadly categorized on the quality of the final product and the completion within estimated cost and time [9]. Taweel. A. et.al [10] has discussed the issues related to communication challenges in knowledge and coordination management, based on an informed case study. Babar. A. et.al has empirically evaluated the role of groupware applications in evaluation of software architecture [11]. Hashmi. S. I. et al [12] have presented a new idea to use the service oriented architecture in solving the challenges of GSD. The idea is to use GSD as a service on the cloud.

Taweel. A and Brereton. P has floated a term 'Sequential Collaborative Software Engineering (SCSE)' for software development across different time zones [13]. The paper presents a mathematical model estimating the development time based on overheads related to the distributed development pattern. In [14] authors have summarized a set of commercial tools used for global software development. These tools are specific for requirements engineering, code management and project management. Smite. D et.al has presented a classification scheme to report empirical studies in the area of global software engineering [15]. Jablokow and Myers [16] have suggested a factor known as cognitive diversity which plays its part in distributed software development. Cognitive Diversity can be elaborated as the dissimilarity in the ways in which people solve problems.

## III. RESEARCH METHODOLOGY

An SLR can be defined as a methodological way to investigate and answer a set of specific research questions [17], [18] and [19]. This SLR follows the following model and steps involved in it, which are further explained in the sub sections.

- Outline Research Questions
- Define a Literature Search Strategy
  - Define Key words and Key Phrases
  - Select Sources
- Define a homogeneous literature selection protocol. This protocol is based on three literature selection phases, i.e., primary, secondary and final study selection.

The above steps are categorized as a *pre-review* phase. The following steps constitute our systematic review.

- Data Extraction
- Data Analysis & Synthesis
  - Quantitative Analysis
  - Qualitative Analysis
- Results Documentation

### *A. Outline Research Questions*

To get the right answers, we have to ask the right questions. The following guidelines are used to outline the research questions,

- Categorize the area of interest in population, intervention and outcome relevance.
  - All the organizations and institutions involved in GSD constitutes the population
  - The initiatives and factors are interventions
- To outline the industrial challenges through exploration of industrial research literature.
- Challenges identified by researchers through hypothetical and empirical research.
- The research foot prints leading to the development of internationally renowned standards.

The research questions drafted out with the help of these pointers are listed in Table 1. The fourth question is unorthodox but is critical for our research as we focus on distributed process in small to medium sized organizations.

TABLE I
UNITS FOR MAGNETIC PROPERTIES

| *ID* | *Research Question* | *Aim* |
|---|---|---|
| RQ1 | What are the current global software process improvement initiatives? | Classification of the current initiatives (in the literature) used for standardization of global software process improvement. |
| RQ2 | Are Collocated Software Process Initiatives applicable in the context of Global Software Development? | Collocated software development process is much matured domain and initiatives in this domain can be found at different levels of implementation. It will be very effortless if these initiatives can be used for global processes. The purpose of this question is to look for any empirically proved evidence in the literature which suggests likewise. |
| RQ3 | Do the improvement initiatives really affect the maturity of the process? | The objective here is to find empirical or hypothetical evidence regarding the effectiveness of improvement initiatives. |
| RQ4 | Does the SPI Initiative follow the fit for all approach? | An important question to ask is that whether we can use an SPI initiative for all sizes of organizations i.e., if an initiative is successfully implemented in a large scale organization will it fit a small scale organization? |

### B. Literature Search Strategy

The search strategy is based on the following steps,
a. Contextualize search terms based on the research questions
b. Look for closest Synonyms
c. Use of Boolean operators

*Results for a (Contextualize search terms based on the research questions)*

Global Software Development Process, Global Software Engineering, Systematic Literature Review, Software Process Improvement, Factors, Initiatives, Business Process Outsourcing, Offshore Outsourcing. The terms 'Systematic Literature Review', 'Factors' and 'Initiatives' are not constructed from the research questions. These terms are general but are related to the field of interest.

*Results for b (look for closest synonyms)*

*Global Software Development Process:* ("Global Software Development" OR "Distributed Software Development Process" OR "Information Systems Development Process" OR "IT Development Process" OR "Global Software Methods")
*Global Software Engineering:* ("Global Software Engineering" OR "Global Software Manufacturing" OR "GSE projects" OR "Distributed Engineering Methodologies" OR "Global Information Systems Engineering" OR "GIS Development")
*Systematic Literature Reviews:* ("Systematic Literature Reviews" OR "Literature Reviews" OR "Industrial Reports" OR "Field Study" OR "Case Study" OR "Academic Report")
*Improvement:* ("Improvement" OR "Betterment" OR "Enhancement")
*Factors:* ("Motivators" OR "Barriers" OR "Impact Factors" OR "Risk Factors")
*Initiatives:* ("Models" OR "Frameworks" OR "Tools" OR "Methodologies" OR "Techniques")
*Process:* ("Criteria" OR "Procedure" OR "Method")
*Offshore:* ("Offshore Outsourcing" OR "Offshore Insourcing")
*Outsourcing:* ("Business Process Outsourcing" OR "Vendor-Sourcing" OR "Intra-Organizational Process").

*Results for c (Use of Boolean/Logical operators)*
(("Global Software Development" *OR* "Distributed Software Development Process" *OR* "Information Systems Development Process" *OR* "IT Development Process" *OR* "Global Software Methods") *OR* ("Global Software Engineering" *OR* "Global Software Engineering" *OR* "Global Software Manufacturing" *OR* "GSE projects" *OR* "Distributed Engineering Methodologies" *OR* "Global Information Systems Engineering" *OR* "GIS Development")) **AND** (("Systematic Literature Reviews" *OR* "Literature Reviews" *OR* "Industrial Reports" *OR* "Field Study" *OR* "Case Study" *OR* "Academic Report") *OR* ("Improvement" *OR* "Betterment" *OR* "Enhancement") *OR* ("Factors" *OR* "Motivators" *OR* "Barriers" *OR* "Impact Factors" *OR* "Risk Factors") *OR* ("Initiatives" *OR* "Models" *OR* "Frameworks" *OR* "Tools" OR "Methodologies" *OR* "Techniques") OR ("Process" *OR* "Criteria" *OR* "Procedure" *OR* "Method")) **AND** (("Offshore" *OR* "Offshore Outsourcing" *OR* "Offshore In-sourcing") *OR* "Outsourcing" *OR* "Business Process Outsourcing" *OR* "Vendor-Sourcing" *OR* "Intra-Organizational Process")).

### C. Selecting Primary Sources

To narrow down the scope, a small scale study was conducted for the resources to be searched and for validation of selected search terms. The study helped us in the selection of resources and search phrases. The search phrases were categorized broadly under two key phrases i.e. "Global Software Process Improvement" and "Global Software Development". The list of selected papers for the final review is tabularized in appendix A under these two categories. The final selected literature sources and the number of articles selected from each source is summarized in table 2.
These sources were searched with different phrases comprising primarily of two already mentioned key phrases and other phrases selected from search terms contextualized in section 3.2.

TABLE II
ARTICLES ON EACH PHASE OF SELECTION PROCEDURE

| Resource | Total Found | Primary Selection | Secondary Selection | Final Selection |
|---|---|---|---|---|
| IEEE | 1350 | 349 | 57 | 54 |
| Science Direct | 627 | 136 | 31 | 17 |
| Springer | 972 | 193 | 44 | 24 |
| Google Scholar | 388 | 54 | 19 | 04 |
| Total | 3337 | 732 | 151 | 99 |

### D. Literature Selection Protocol

To select relative literature we have devised a protocol. The protocol is a top-down three phase selection process having a set of criteria (selection filters) for each phase. The first two (primary and secondary) phases are carried out by first author and the third (final) phase is carried out by both authors. The first phase started with the search of selected sources against the contextualized search phrases to produce a list of articles. These articles are then filtered on the basis of abstract and metadata (Title, Year of Publication, and Reputation of publishing source).

The secondary phase prioritizes the list returned from primary phase, based upon a set constructs and their relative weights as listed in table 3. The priority of the article is calculated using equation 1.

$$Total\ Weight, W = \sum_{c=1}^{7} w_c \quad \ldots\ldots\ldots (1)$$

An article is assigned a priority level from minimum, average and maximum based on the value of its total weight. It's not necessary that each article meets definition of all seven constructs i.e., if an article does not reflect a construct then its weight is assigned zero ($w_c = 0$). Equation 2 shows the range of weights and relative priority value.

$$priority, p = \begin{cases} Minimum, & 14 \leq W < 20 \\ Medium, & 20 \leq W < 28 \\ Maximum, & 28 \leq W \leq 34 \end{cases} \quad \ldots\ldots (2)$$

TABLE III
Characterization constructs with prioritization scale

| *Construct, c* | *Definition* | | | | *Weight, $w_c$* |
|---|---|---|---|---|---|
| Publication Source | Journal | | | | 5 |
| | Conference | Highly Reputed | | | 3 |
| | | Non Reputed | | | 1 |
| Paradigm Focus | Process: *explains the challenges in the process itself* | | | | 5 |
| | People: *aspects of process improvement tied to the stake holders involved* | | | | 4 |
| | Project: *aspects of process improvement tied to the complexities of project* | | | | 3 |
| | Organization | Inter: *inter-organizational issues effecting process improvement* | | | 2 |
| | | Intra: *internal issues effecting process improvement of a project* | | | 1 |
| Research Outcome | Initiative | Validated: *the initiative proposed in the article is empirically validated* | | | 5 |
| | | Proposed: *the article just presents a hypothesis* | | | 3 |
| | Industrial Guidelines: *the article lists out a set of guidelines for practitioners based on the research* | | | | 2 |
| | Research Guidelines: *the article stones a milestone for the new researchers to provide a checkpoint from where new researchers can begin* | | | | 3 |
| Target Audience | Researcher: *The article's content is targeting academia and research community* | | | | 4 |
| | Practitioner: *The article's content is mainly targeting a practitioner audience* | | | | 3 |
| Publication Type | Empirical Research: *the data is collected through case studies, questionnaires, field studies or interviews* | | | | 5 |
| | Hypothetical Research: *the results are outcome of experiments or focus groups* | | | | 3 |
| Development Process | Distributed | Offshore | Outsourcing: *focus is on global outsourcing across companies* | | 5 |
| | | | Insourcing: *focus is on global outsourcing within organization* | | 3 |
| | | | | Onshore | Outsourcing: *focus is on outsourcing within borders* | 4 |
| | | | | | Insourcing: *focus is on developing within an organization at different physical locations within same borders* | 2 |
| Publication Level | Research Article | | | | | 5 |
| | Book Chapter | | | | | 3 |
| | Report | | | | | 2 |

The final phase of literature selection is carried out by both the authors using the inclusion/exclusion criteria stated below,

*Inclusion/Exclusion Criteria*

- The article should answer at least one of the research questions, listed in table 1 otherwise its excluded.
- The articles with low priority are excluded.
- Articles that discuss any aspect of software process improvement in global context are included.
- The articles focusing on challenges and motivators in global software engineering are included.

### *E. Publication Quality Assessment*

The outcome of an SLR depends upon the quality of the selected literature. In our case this quality depends upon the authenticity of the literature selection protocol (used in secondary phase) and the final selection phase. The selection protocol is authenticated by inter-rating technique i.e. both authors randomly selects a fix number of articles from the output of secondary phase and apply the protocol. The protocol is valid if the results from both authors match. The authenticity of the final phase is based on the selection constructs (used for characterization) and the inclusion/exclusion criteria.

### *F. Data Extraction*

The following footprints are used for data extraction during the review process,

- Initiative taken for distributed software process improvement
- Factors (Barriers and Motivators) involved in global software development
- Software engineering paradigm
- Identification of research relevant information (e.g. research methodologies, data collection methods, outcomes, data analysis methods)
- Information related to quantitative analysis.

### G. Data Synthesis

The extracted data is synthesized in useful information which provides a foundation for the next phase of this research. The following syntheses are performed on the data and the results are summarized in the next section.

- Answer all the research questions
- List down all the factors categorically
- Drafting out the initiatives to have a better understanding of what has already been published
- Characterization of articles based on extracted data
- Listing a set of high quality SLRs as a guideline (a starting point) for researchers and practitioners
- Stating the best definition of different GSD terms found in the reviewed literature

## IV. RESULTS

The extracted and synthesized information reflects dynamic attributes of improvement in globally distributed software development process. The most important yet general observation found is that there are standard and mature initiatives like CMMI [20] and ISO 9001: 2000 [21] for collocated software development process but no such internationally acknowledged initiative could be found for global software process improvement. The research community needs to work on the standardization and validation of such initiatives.

### A. Answers to Research Questions

*Research Answer 1:* The initiatives both empirically validated and hypothetically proposed, found in the literature are listed in table 4. To further strengthen the evidence in favor of this question we found an SLR [3] carried out by Rafael and Jorge which concludes that no appropriate process model for DSD has been agreed upon.

TABLE IV
LIST OF INITIATIVES EXTRACTED FROM SYNTHESIZED INFORMATION

| *Type* | *Classification* | *Ref* | *Remarks* |
|---|---|---|---|
| Frame-work | Process Maturity | [29] | |
| Model | Process Evaluation | [33] | This is a simulation model tailored to examine the performance of GSD projects. |
| Model | Process Quality | [34] | The model analysis the quality of the software process for an organization based on ISO/IEC 9126. |
| Reference Model | Distributed Software Process | [24] | The model is derived from a case study and is validated in the industry. |
| Assessment Tool | Process Improvement | [35] | This tool is used to initiate software process improvement in very small enterprises. |
| Set of Practices | Global Software Process Definition | [22] | The practices are validated empirically and were used to define new processes in a distributed environment based on two geographically distant locations. |
| Simulat-ion Model | Project Planning | [36] | |
| Frame-work | Software Architecture Evaluation | [37] | The framework is designed to support software architecture in GSD. The framework is empirically evaluated and is very applicable in practice. |
| Frame-work | Requirement Elicitation | [38] | The framework improves the communication issues related to requirements elicitation in distributed projects. |
| Frame-work | Offshore Outsourcing | [27] | The framework focuses large scale organizations and is evaluated in one. |
| Tool | Decision Support | [28] | The model presents Global Teaming Decision Support System (GT-DSS) for distributed development process. |
| Tool | Task Distribution | [39] | A light tool for task distribution in global settings. The tool is implemented in a predefined scenario and meets its benchmark. |
| Mathemati cal Model | Development Time Estimation | [13] | The model is used to estimate the development time. |
| Collaborat ive Environm ent | Distributed Extreme Programming | [32] | The proposed environment supports a distributed team in instantiation and implementation of a Distributed Xtreme Programming process in GSD projects. |
| Model | Process Integration | [40] | |
| Model | Project Planning | [41] | The model is applied to the project analysis and the initial results presented in the article shows a reasonable improvement. |
| Model | Agile Methodology | [42] | The model is validated and has proved its effectiveness. The model is developed in an academic environment. |
| Research Frame-work | Scrum Practices | [43] | This framework can be used in industry as reference guide. |
| Frame-work | Knowledge Sharing | [44] | |
| Frame-work | Process Quality | [45] | The framework focuses on a large global service provider. The results are plausible for a large organization. |
| Tool | Process Quality Assurance | [46] | The tool is developed with PHP, MySQL and Apache Server. |
| Technique | Micro-Estimation (Coordination ) | [47] | Task estimation is performed by using a micro-estimation technique. |
| Tool | Collaboration | [48] | It is a social network tool designed and built to address the common challenges of collaboration. |
| Frame-work | Performance Measurement System | [49] | |
| Model | Temporal Cultural Differences | [50] | The model is proposed based on a questionnaire based survey |
| Model | Risk Management | [51] | The initiative models relationship between high-level goals and risk factors to access risks upfront. |
| Reference Model | Process Maturity | [52] | The model is elaborated in detail but is not empirically validated. |
| Frame-Work | Offshore Quality Assurance | [53] | The framework supports vendors to comply with ISO 9001:2008 and is validated through a web application. |
| Frame-work | Requirements Prioritization and Integration | [54] | This is a Correlation-Based Priority Assessment framework (CBPA). The initiative plays is vital role in software process improvement. |

*Research Answer 2:* The answer to second research question is ***'NO'***. Analysis of synthesized data from the research literature clearly specifies that we can't use the initiatives used for collocated software process in the context of globally distributed software development process. We have concluded to this answer based on the following supporting evidence from the reviewed literature:

- Herbsleb. J.D. [23] in orchestrating global development has clearly stated that the practices, organizational formation and techniques used for collocated development are often not adequate for GSD.
- Global software development challenges the techniques of traditional software engineering and requires new solutions [1], [4], [24].
- The practices, organizational structures and initiatives used for collocated development are often not ample for GSD projects [25].
- Werner et.al has conducted an industrial comparison for process descriptors and has stated that resource planning in GSD is different from common resource planning [26].
- Andreas stated 'No' [27].
- Sarah et al. [28], processes that work for collocated environments do not necessarily scale up for distributed environments.
- Rafael and Jorge [3] have supported this argument through an extensive literature review that the best practices required for DSD are different from those used in collocated environments.
- Generic process frameworks like CMM lack KPAs (key process area) that address the capabilities for managing globally distributed projects [29].
- Ebert. C. et al. [4] have conducted an extensive case study on validation activities in the industry and have concluded that GSD challenges, the incorporation of traditional techniques.
- Hansen. M. T. and Baggesen. H. have carried out an industrial studied stretched over four years and two continents [30]. They tried to apply CMMI at two sites to ensure process maturity but the results show that it was not very successful as it created a stretch between the teams.
- Salger. F. [31] has argued that distributed development just not intensifies the problems of collocated development but also poses some new challenges.
- Reeves and Zhu [32] have started their proposal with an argument that new methodologies and techniques have to be designed and deployed for the challenges of distributed development.

*Research Answer 3:* The answer is ***'Yes'***, which is deduced from the following resources:

- A survey result presented in [55] states that only 4% practitioners have the opinion that SPI initiatives in their organizations have not provided the desired results. This rate is further reduced in South Asian countries. McLoughlin and Richardson [56] have strongly argued that the literature shows that the initiatives in process improvement have worked in recent years for organizations in increasing their productivity and quality.

*Research Answer 4:* The answer is **'*No*'**, an improvement initiative does not follow the fit-for all approach.

- Sune et.al [57] has strongly supported that the application of an initiative to multiple perspectives is unreal.
- Lamersdorf and Munch have argued that characteristics of software development process can widely differ between organizations [39].
- Weerd.I. et al in [58] have presented a retrospective case study on software product management in a global environment. In their final analysis they have stated that same increment which can be successful in a large organization may not work in a medium or small sized organization.

### *B. Critical Factors*

One goal of this review is to list all the critical factors which affect the effectiveness of any software development process. Table 5 lists these factors with the impact they have on the process improvement and also the research methodology used for data extraction. An important parameter here is the frequency of each factor i.e., the number of times each factor is discussed in a different study. The frequency can tell us the criticalness of a factor i.e. higher frequency means the factor is more critical and vice versa.

TABLE V
FACTORS IDENTIFIED IN THE STUDY
Impact of SPI initiative can have three values i.e.
Positive (+), Negative (-), Both (+/-)
Research Method has values i.e.
Empirical Study (ES), Literature Review (LR), Case Study (CS)

| Factors | Frequency | Impact on SPI Initiative | Paradigm | Research Method |
|---|---|---|---|---|
| Shared win-win motivation | 2 | + | People | ES |
| Risk Sharing | 4 | + | Organization | LR |
| Ownership and Responsibility | 1 | + | People | ES |
| Understanding Cultural Differences | 4 | + | People | ES |
| Limited Vision of Domain | 1 | - | Inter-Organization | LR |
| Differing technical and domain vocabularies | 1 | - | Process | ES |
| Tools and Other Initiatives | 1 | + | People | ES |
| Lack of Tools | 3 | - | Process | CS |
| Communication (Internal, External, Infrastructure) | 8 | - | Organization | LR |
| Number of Participants in communication | 1 | +/- | People | CS |
| Personnel Communication Skills | 3 | + | People | ES |
| Time Difference | 3 | - | Organization | LR |
| Skilled Human Resources | 3 | + | People | LR |
| Staff Involvement and Experience | 1 | - | Organization | LR |
| Staff Motivation | 1 | - | Organization | LR |
| Mentoring | 1 | - | Organization | LR |
| Training | 1 | + | People | ES |
| Knowledge Exchange | 6 | + | Organization | LR |
| Different Knowledge Levels | 2 | - | Organization | LR |
| Knowledge of Client's Culture | 4 | + | Process | LR |
| Allocation of Resources | 1 | - | Organization | LR |
| Less Project Visibility | 2 | - | Project | LR |
| Efficient Project Management | 1 | + | Organization | LR |
| Distribution of workload/Tasks | 7 | +/- | People | ES |

| | | | | |
|---|---|---|---|---|
| SPI Awareness | 5 | +/- | People | CS |
| Lack of Trust, Fear | 2 | - | Project | LR |
| Language Difference | 6 | - | Organization | LR |
| Perceived Loss of Control | 1 | - | Inter-Organization | LR |
| Perceived Loss of Constituent Support | 2 | - | Inter-Organization | LR |
| Internal conflicts | 1 | - | Inter-Organization | LR |
| Power Differences | 1 | - | Inter-Organization | LR |
| Shared Business Goal | 2 | + | People | ES |
| Metrics | 2 | - | Organization | LR |
| Management Involvement in Development process | 1 | - | Organization | LR |
| Following Best Practices in Management & Engineering | 3 | + | People | ES |
| Formal and Structured Planning, Procedures and Policies | 4 | - | Organization | LR |
| Use of Process Experts | 1 | - | Organization | LR |
| Cognitive Diversity | 1 | - | Process | LR |
| Tracking and control | 1 | - | Organization | LR |
| Inertia – Laziness | 1 | +/- | People | CS |
| Conflicting Expectations | 1 | +/- | Process | CS |
| Lack of standards | 1 | - | Organization | LR |
| Notification of Organizational Changes | 1 | +/- | Organization | LR |
| Distribution Overhead and Effort Loss | 1 | - | Organization | CS |
| Platform Heterogeneity | 1 | - | Project | LR |
| Managing Distributed Dependencies | 1 | - | Project | LR |
| Process Mismatch | 3 | - | Process | ES |
| Managing Social Networks | 1 | + | People | ES |
| Distributed Performance Monitoring | 1 | + | People | ES |
| Managing Complexity | 1 | + | People | ES |
| Absence of Work Units | 1 | - | Process | LR |
| Inter/Intra Organizational Politics | 1 | +/- | Organization | CS |
| Team Dynamics (Size, Spirit, Strength) | 2 | +/- | People | ES |
| Belief and Willingness | 1 | + | People | ES |
| Quality of Products and Services | 1 | + | Organization | LR |
| Implementation Methodology | 1 | +/- | Process | CS |
| Different Mindsets | 1 | +/- | People | CS |
| Content Completeness | 1 | + | People | ES |
| Zero transmission loss | 1 | + | People | ES |
| Nurturing and Leveraging Core Competencies | 1 | + | People | ES |
| Conflicting Assumptions | 1 | - | Process | ES |
| Product Owner Effectiveness | 1 | - | Scrum Project | LR |
| Continuous Integration | 1 | - | Scrum Project | LR |

### C. *Analysis of Synthesized Data*

The most important and critical foundation of any distributed environment is $C^3$ (i.e., Communication, Coordination and Collaboration). The research in GSD focuses on any combination of these three at one instance. The trend in the research suggests that most work has been done for the improvement of coordination in a distributed project. Table 6 shows the number of studies carried out in each component categorized by the research methodology.

TABLE VI
Number of articles categorized in $C^3$

| *Component* | *Field Study* | *Case Study* | *Survey* | *Hybrid Method* |
|---|---|---|---|---|
| Communication | 6 | 4 | 4 | 6 |
| Coordination | 5 | 6 | 4 | 19 |
| Collaboration | 0 | 0 | 0 | 2 |

The analysis of literature unveils another important fact about the research in GSE i.e. the validity of research. The more beneficial research is the one which is empirically validated and supported by clear and comprehendible results. However, the hypothetical or non-validated research also plays its part in the development of new ideas. Table 7 quantifies the number of studies that are supported by valid results and the ones only proposing GSD initiatives.

TABLE VII
Number of studies focused on type of research

| *Initiatives* | *Total* |
|---|---|
| Implemented | 11 |
| Proposed | 22 |

*Quantitative Analysis of Data*

The quantitative analysis of the extracted data presents information about different aspects of GSE. Software engineering has four important paradigms which are people, process, organization and project. Each aspect plays its part in the development and maturity of software process. Figure 1 shows the frequency of articles we found in the SLR for each of these components. We can conclude that most of the research has focused on process and organization.

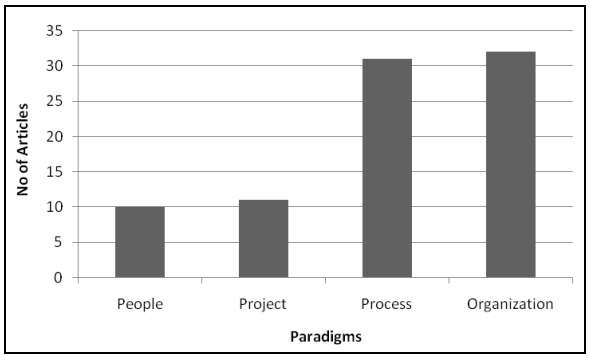


Fig. 1. Number of studies categorized according to software paradigms

In software engineering, mostly research is empirically conducted and the common and effective data collection methods are case study, field study, archived data, focus groups, interviews and questionnaires. Figure 2 shows the number of studies based on each of these methodologies. The highest number of studies has used the combination of these methods.

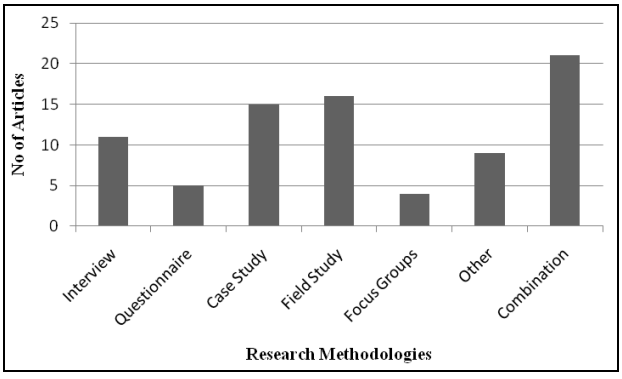


Fig. 2. Frequency of Data Collection Methodologies

There are two basic data analysis techniques used, known as quantitative and qualitative data analysis. Figure 3 shows that majority of the studies have used both analysis techniques. Some have used quantitative analysis and some have used qualitative analysis while a high number of studies have not used any of these techniques. The studies which have not used these techniques have relied upon alternate data analysis methods.

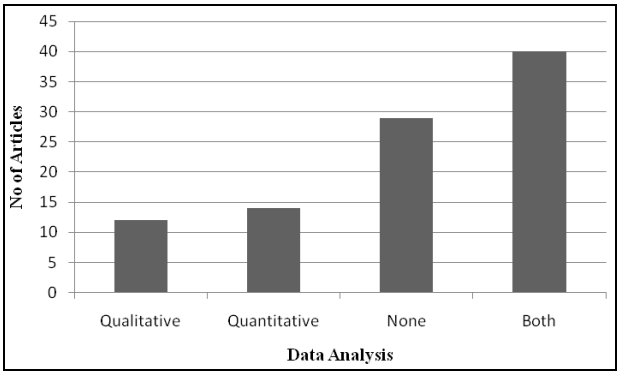


Fig. 3. Frequency of Data Analysis Methodologies

## V. RESULTS DISCUSSION

### A. Initiatives

We have found around 30 initiatives in the literature focusing different aspects of software process which play their roles in its improvement. One third of these initiatives are frameworks and most of the rest are models (2 reference models, 1 simulation model and 1 mathematical model). One article has presented an assessment tool which can be used in small enterprises for the initiation of process improvement. In [22] a set of practices have been defined and empirically validated for the definition of new small processes which are used in software process improvement. Precise estimation of development time has a critical role in its success and a mature process has always an accurate time estimation line for time line estimation, authors have presented a mathematical model [13]. The continuous improvement can only be achieved if the quality of the process is assessed periodically and is embedded as an integral part of process improvement. There are a few initiatives regarding process quality measurement which are worth inking down i.e., [46], [52], [45], [29], [34]. In distributed environment 'Task Distribution' has large influence on success. An empirically validated and benchmarked tool is presented in [39].

### B. Factors

The factors are categorized motivators and barriers when a factor improves a process it's referred to as motivator and is referred as barriers when impediments the process. The most commonly discussed factor is the 'Communication Infrastructure' of an organization. The success of a distributed project depends upon the maturity of this factor. The second equally discussed motivator is the 'Knowledge Sharing'. Usually organizations have a distributed knowledge repositories to provide a common platforms for all the stakeholders to share their knowledge. This factor has an indirect effect on the capability of the distributed software development process. This builds an environment where all stakeholders have a greater depth of knowledge therefore the process executed by these people have an integrated sense of maturity. 'SPI Awareness' is another factor which can improve the process maturity intuitively. The stakeholders should be aware of all the aspects of SPI to extract full benefits of it. The barrier most widely discussed in the literature is 'Cultural Differences'. This factor can affect a project in a number of ways, for instance professionals from two different continents have different work ethics. A mature process must have a pre-defined environment which can bring people from different cultures to work as a single unit. 'Language' is another important aspect of this barrier which is mostly handled separately in the literature. The global language to communicate is English but still the variation in accents makes it difficult. A closely related motivator found in research is 'Personnel Communication Skills'. This motivator can be developed through personal and organizational training. 'Risk Sharing' is a motivator as all the stakeholders working on offshore sites should be given a sense of responsibility in terms of sharing the risk. The essence of a team is a central sense of sharing the outcome of their efforts. As the process improvement initiative the organization and the management are responsible to develop this sense in their distributed teams. 'Time Difference' is another barrier which is widely discussed in the literature. The success of any distributed project depends on ramping of this barrier. 'Process Mismatch' is another barrier which reflects the heterogeneity in two globally distributed sites. Two barriers are critical for process improvement which are 'Lack of Trust' and 'Fear'. The fear is present on both sides i.e. the fear related to job security for people working on central sites to lose their job to an equally talented but less paid colleague based in a developing country and team members located at distributed sites feel the fear of being left out of decision making. Similarly, they feel lack of trust especially in cases where their designation does not match their skills and experience. A mature process should handle these fear and trust issues. Justified 'workload distribution' can also build the trust among distributed teams and management. Another factor in trust building is 'Notification of Organization Changes'. All the stakeholders must be made aware of any change (minute or immense).

There are factors which are common to collocated and distributed development processes and equally important as well e.g. Skilled Human Resources, Lack of Tools, Staff Motivation, Training, Allocation of Resources, Metrics, Tracking and Control, Lack of Standards, Implementation Methodology and Team Dynamics.

### C. Synthesized Information

This section is focused on summarization of information useful for researchers and practitioners. We will highlight few high quality SLRs found during the review which are work of some highly reputed professionals in this area. Unterkalmsteiner et al. [59] have written a comprehensive

SLR on software process improvement. Kitchenham. B. et al have conducted a tertiary study of all the systematic literature reviews published over a period of ten years in software engineering [1]. Khan, S. et al. have conducted SLR in offshore outsourcing [17]. These articles [7], [3], [9], [15], [18], [19], [25], [56], [57], [61] - [66] are useful literature reviews in the field of software engineering.

## VI. LIMITATIONS

The validity of our results is dependent on internal and external validity of the extracted data and synthesized information.

***Internal Validity***, the main threat to internal validity is the publication bias to which all the self-reported studies are subjected to, which cannot be overcome. This bias is based on the fact that most of the reporting studies do not state the underlying rationale.

Another limitation is the absence of relevant information i.e. the region where research has been conducted and other is the size of the enterprise. Only 8 papers specified the geographical locations of their onshore and offshore sites. Similarly 12 out of 97 papers reported the size of organization. The metric used for size in these 12 papers also varied in terms of number of employees and the volume of their fiscal growth.

***External Validity***, the main threat to external validity is the limitation of access to all the digital resources. We have used only well renowned digital resources which were accessible to us. There are resources like ACM and Scopus that we could not include. However, we have covered enough literature to generalize our findings.

To minimize the researcher's bias we used the inter-rater technique where the second author randomly choose some articles and applied the same systematic review method to match the results.

## VII. CONCLUSION AND FUTURE WORK

We have listed a set of articles highlighting different types of process improvement initiatives in GSE. A collocated environment is different from a distributed setup [67] therefore the techniques applicable to a collocated process for maturity and quality are not necessarily applicable to a distributed environment. An SPI initiative implemented in its spirit can really improve the quality of a process and product however, the total success or partial failure of an SPI initiative is reliant on the size of the organization [68].

We have listed a set of critical factors (motivators and barriers) in distributed software process improvement. The strength of an organization's communication infrastructure plays a critical role in success of its distributed software development. Knowledge sharing is a motivator which is equally affective in distributed as well as collocated development and definitely needs a bit more research and development effort in future. The management has task distribution challenges among distributed team members, keeping under consideration the load and the skill set of each offsite team member. An unjustified work load distribution can cause a project level failure. 'Language Difference' has appeared as the most common barrier in DSD.

It has been observed that a high percentage of research in GSE has been carried out in Europe. The favourable outsourcing locations are developing countries like Vietnam and Bangladesh. Figure 4 illustrates a timeline sketched over a period of 6 years showing the number of publication in GSE including the journal and conference papers only. It is conclusive that the research interest in GSE has increased over time with the advancement in globalized corporate environment.

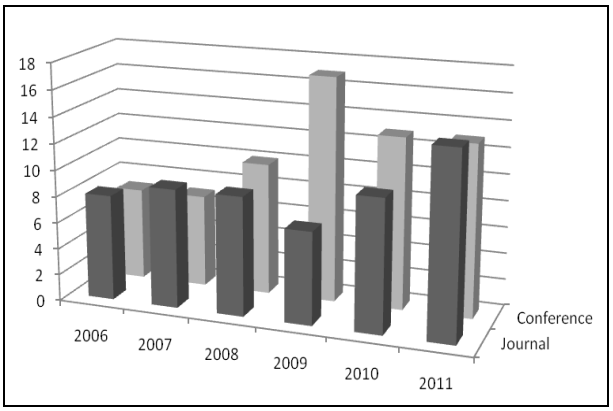


Fig. 4. SPI Research Timeline over last 6 years

This SLR is conducted to provide a foundation for development of a DSPI framework specific for small-medium sized organizations. The framework is targeted for the maturity and capability of enterprises providing offshore development services. A questionnaire based study is lined up to learn the key factors, process and people aspects in the small to medium sized organizations.

## APPENDIX

TABLE APPENDIX
LIST OF SELECTED ARTICLES FOR FINAL REVIEW PHASE
*Database:* IEEE (I), Elsevier (E), Springer (S)
*Content Type:* Conference Paper (C), Journal paper (J), Research Proposal (RP), Book Chapter (BC)
*Priority:* High (H), Medium (M), Low (L)
*Final Status:* Excluded (E), Included (I)

| | Title | Database | Content Type | Year | ID | Priority | Final Status |
|---|---|---|---|---|---|---|---|
| **Key Phrase: "Global Software Process Improvement"** | | | | | | | |
| 1. | Process improvement in four small software Companies | I | C | 2001 | SI-1 | M | E |
| 2. | Global Software Engineering: The Future of Socio-technical Coordination | I | C | 2007 | SI-2 | H | I |
| 3. | Leveraging global resources: a process maturity framework for managing distributed | I | J | 2005 | SI-3 | H | I |

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| | development | | | | | | |
| 4. | Improving Distance Mentoring: Challenges and How to Deal with them in Global Development Project Courses | I | C | 2010 | SI-4 | H | I |
| 5. | Improving Productivity of Local Software Development Teams in a Global Software Development Environment | I | C | 2006 | SI-5 | M | I |
| 6. | Evaluation and Measurement of Software Process Improvement – A Systematic Literature Review | I | J | 2011 | SI-6 | H | I |
| 7. | Agile Practives in Global Software Engineering – A Systematic Map | I | C | 2010 | SI-7 | H | I |
| 8. | Improving Global Software Development Project Performance Using Simulation | I | C | 2007 | SI-8 | H | I |
| 9. | Teaching Requirements Elicitation within the Context of Global Software Development | I | C | 2009 | SI-9 | M | I |
| 10. | Research directions in software process improvement | I | C | 2004 | SI-10 | H | I |
| 11. | Six Sigma and Software Development Process: DMAIC Improvements | I | C | 2006 | SI-11 | M | E |
| 12. | The application of a new process quality measurement model for software process improvement initiatives | I | C | 2011 | SI-12 | H | I |
| 13. | Reporting empirical research in global software engineering: a classification scheme | I | C | 2008 | SI-13 | H | I |
| 14. | Continuous Improvement through Iterative Development in a Multi-Geography | I | C | 2008 | SI-14 | H | I |
| 15. | Improving validation activities in a global software development | I | C | 2001 | SI-15 | M | I |
| 16. | A Framework to Enable Offshore Outsourcing | I | C | 2010 | SI-18 | H | I |
| 17. | Transitioning to Distributed Development in Students' Global Software Development Projects: The Role of Agile Methodologies and End-to-End Tooling | I | C | 2010 | SI-19 | H | I |
| 18. | Implementing Software Process Improvement Initiatives: An Analysis of Vietnamese Practitioners' Views | I | C | 2008 | SI-21 | H | I |
| 19. | Improving Global System Development and Collaboration across Functions: Experiences from Industry | I | C | 2010 | SI-22 | H | I |
| 20. | Crafting a Global Teaming Model for Architectural Knowledge | I | C | 2010 | SI-23 | H | I |
| 21. | Analysis of software process improvement efforts in Pakistan | I | C | 2010 | SI-24 | H | I |
| 22. | A Framework for Model-Based Continuous Improvement of Global IT Service Delivery Operations | I | C | 2008 | SI-25 | H | I |
| 23. | Does Software Process Improvement Reduce the Severity of Defects? A Longitudinal Field Study | I | J | 2012 | SI-26 | H | I |
| 24. | Software quality and IS project performance improvements from software development process maturity and IS implementation strategies | E | J | 2007 | SE-4 | M | E |
| 25. | From integration to composition: On the impact of software product lines, global development and ecosystems | E | J | 2010 | SE-10 | M | E |
| 26. | Essential communication practices for Extreme Programming in a global software development team | E | J | 2006 | SE-11 | M | E |
| 27. | Behavioral characterization: finding and using the influential factors in software process simulation models | E | J | 2001 | SE-15 | M | E |
| 28. | Systematic literature reviews in software engineering – A tertiary study | E | J | 2010 | SE-30 | H | I |
| 29. | Priority assessment of software process requirements from multiple perspectives | E | J | 2006 | SE-29 | M | E |
| 30. | Systematic literature reviews in software engineering – A systematic literature review | E | J | 2009 | SE-31 | H | I |
| 31. | Managing the business of software product line: An empirical investigation of key business factors | E | J | 2007 | SE-32 | M | E |
| 32. | An experimental investigation of the impact of individual, program, and organizational characteristics on software maintenance effort | E | J | 2000 | SE-33 | M | E |
| 3 | Design rationale capture | S | J | 20 | SS-1 | M | E |

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| 3. | for process improvement in the globalised enterprise: an industrial study | | | 11 | | | |
| 34. | A reference framework for process-oriented software development organizations | S | J | 2005 | SS-2 | M | E |
| 35. | Requirements Tracing On target (RETRO): improving software maintenance through traceability recovery | S | J | 2007 | SS-3 | M | E |
| 36. | RE challenges in multi-site software development organizations | S | J | 2003 | SS-4 | M | E |
| 37. | Towards Progressive and Load Balancing Distributed Computation: A Case Study on Skyline Analysis | S | J | 2010 | SS-5 | M | E |
| **Key Phrase: "Global Software Development"** | | | | | | | |
| 38. | Risk Management in Global Software Development Projects: Challenges, Solutions, and Experience | I | C | 2011 | SI-26 | M | I |
| 39. | A Decision Support System for Global Software Development | I | C | 2011 | SI-27 | H | I |
| 40. | Using the Cloud to Facilitate Global Software Development Challenges | I | C | 2011 | SI-28 | H | I |
| 41. | A Comparison of Industrial Process Descriptions for Global Custom Software Development | I | C | 2010 | SI-29 | H | I |
| 42. | TAMRI: A Tool for Supporting Task Distribution in Global Software Development Projects | I | C | 2009 | SI-30 | H | I |
| 43. | Exploring the Role of Instant Messaging in a Global Software Development Project | I | C | 2011 | SI-31 | H | I |
| 44. | Global Software Development and Delay: Does Distance Still Matter? | I | C | 2008 | SI-32 | H | I |
| 45. | Communication, Knowledge and Co-ordination Management in Globally Distributed Software Development: Informed by a scientific Software Engineering Case Study | I | C | 2009 | SI-33 | H | I |
| 46. | How Globally Distributed Software Teams Can Improve Their Collaboration Effectiveness? | I | C | 2011 | SI-34 | H | I |
| 47. | Architecture-Centric Global Software Processes | I | C | 2006 | SI-35 | H | I |
| 48. | Technology Selection to Improve Global Collaboration | I | C | 2006 | SI-36 | M | I |
| 49. | Fostering a High-Performance Culture in Offshore Software Engineering Teams Using Balanced Scorecards and Project Scorecards | I | C | 2011 | SI-37 | H | I |
| 50. | An empirical study of speed and communication in globally distributed software development | I | J | 2003 | SI-38 | H | I |
| 51. | Cultural Differences in Temporal Perceptions and its Application to Running Efficient Global Software Teams | I | C | 2006 | SI-39 | M | I |
| 52. | Goal and Risk Factors in Offshore Outsourced Software Development from Vendor's Viewpoint | I | C | 2009 | SI-40 | H | I |
| 53. | Delegation in Global Software Teams: Leading or Managing? | I | C | 2009 | SI-41 | H | I |
| 54. | Improving Contextual Skills in Global Software Engineering: A Corporate Training Experience | I | C | 2008 | SI-42 | H | I |
| 55. | Governance Mechanisms in Global Development Environments | I | C | 2011 | SI-43 | H | I |
| 56. | Process-Based Collaboration in Global Software Engineering | I | C | 2009 | SI-44 | H | I |
| 57. | Successful Global Development of a Large-scale Embedded Telecommunications Product | I | C | 2007 | SI-45 | M | E |
| 58. | A reference model for successful Distributed Development of Software Systems | I | C | 2007 | SI-46 | H | I |
| 59. | Challenges of Globally Distributed Software Development – Analysis of Problems Related to Social Processes and Group Relations | I | C | 2008 | SI-47 | H | I |
| 60. | How Do Distribution and Time Zones Affect Software Development? A Case Study on Communication | I | C | 2011 | SI-48 | H | I |
| 61. | New Angles for Global Software Engineering Research? - Keynote Summary | I | C | 2010 | SI-49 | M | I |
| 62. | Managing Cognitive and Cultural Diversity in Global IT Teams | I | C | 2010 | SI-50 | M | I |
| 63. | Critical Success Factors for Offshore Software Development Outsourcing Vendors: A Systematic Literature Review | I | C | 2009 | SI-51 | M | I |
| 6 | Globally Distributed | I | C | 20 | SI- | H | I |

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| 4. | Software Process Engineering | | | 11 | 52 | | |
| 65. | Descriptive Analysis of Fear and Distrust in Early Phases of GSD Projects | I | C | 2009 | SI-53 | H | I |
| 66. | Offshore QA - A Framework for Helping Software Development Outsourcing Companies Comply with ISO 9001,2008 | I | C | 2010 | SI-55 | H | I |
| 67. | A Framework for Training Skills for Global Software Development | I | RP | 2010 | SI-56 | M | I |
| 68. | From CMMI and isolation to Scrum, Agile, Lean and collaboration | I | C | 2009 | SI-59 | H | I |
| 69. | A framework for supporting the software architecture evaluation process in global software development | I | C | 2009 | SI-60 | H | I |
| 70. | A reference model for global software development: findings from a case study | I | C | 2006 | SI-61 | M | I |
| 71. | Using SCRUM in global software development: A Systematic Literature Review | I | C | 2009 | SI-62 | H | I |
| 72. | Process models in the practice of distributed software development: A systematic review of the literature | E | J | 2010 | SE-34 | H | I |
| 73. | Assigning tasks in a 24-h software development model | E | J | 2006 | SE-35 | M | E |
| 74. | Design guidelines for software processes knowledge repository development | E | J | 2011 | SE-36 | M | I |
| 75. | Barriers in the selection of offshore software development outsourcing vendors: An exploratory study using a systematic literature review | E | J | 2011 | SE-37 | M | I |
| 76. | Modeling software development across time zones | E | J | 2006 | SE-38 | M | I |
| 77. | Sociomaterial bricolage: The creation of location-spanning work practices by global software developers | E | J | 2011 | SE-39 | M | I |
| 78. | Incremental method evolution in global software product management: A retrospective case study | E | J | 2010 | SE-40 | H | I |
| 79. | An empirical study of groupware support for distributed software architecture evaluation process | E | J | 2006 | SE-41 | M | I |
| 80. | Motivation in Software Engineering: A systematic literature review | E | J | 2008 | SE-42 | M | E |
| 81. | Characterizing software architecture changes: A systematic review | E | J | 2010 | SE-43 | M | E |
| 82. | A framework for the design and verification of software measurement methods | E | J | 2009 | SE-44 | M | E |
| 83. | An empirical study of the effect of knowledge integration on software development performance | E | J | 2004 | SE-45 | M | E |
| 84. | Software Process Improvement as organizational change: A metaphorical analysis of the literature | E | J | 2010 | SE-46 | H | I |
| 85. | Factors influencing clients in the selection of offshore software outsourcing vendors: An exploratory study using a systematic literature review | E | J | 2011 | SE-47 | H | I |
| 86. | Initiating software process improvement in very small enterprises: Experience with a light assessment tool | E | J | 2008 | SE-48 | H | I |
| 87. | Evaluating the relationship between process improvement and schedule deviation in software maintenance | E | J | 2009 | SE-49 | H | I |
| 88. | Effectively utilizing project, product and process knowledge | E | J | 2008 | SE-50 | M | E |
| 89. | A holistic approach to managing software change impact | E | J | 2009 | SE-51 | M | E |
| 90. | De-motivators for software process improvement: an analysis of practitioners' views | E | J | 2003 | SE-52 | M | I |
| 91. | Software process improvement as emergent change: A structurational analysis | E | J | 2007 | SE-53 | H | I |
| 92. | Verification framework and algorithms for integrating information distribution systems | E | J | 2006 | SE-54 | M | E |
| 93. | Priority assessment of software process requirements from multiple perspectives | E | J | 2006 | SE-55 | H | I |
| 94. | Evaluating Collaboration Platforms for Offshore Software Development Scenarios | S | BC | 2007 | SS-6 | H | I |
| 95. | Moomba – A Collaborative Environment for Supporting Distributed Extreme Programming in Global Software Development | S | BC | 2004 | SS-7 | H | I |
| 9 | Software Process | S | BC | 20 | SS-8 | M | E |

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| 6. | Modeling Socio-Technical Perspectives | | | 04 | | | |
| 97. | Optimized Software Process for Fault Handling in Global Software Development | S | C | 2008 | SS-9 | H | I |
| 98. | Towards the Competitive Software Development | S | BC | 2011 | SS-10 | M | E |
| 99. | Using grounded theory to study the experience of software development | S | BC | 2011 | SS-11 | M | E |
| 100. | Applying Multi-Criteria Decision Analysis to Global Software Development with Scrum Project Planning | S | BC | 2011 | SS-12 | H | I |
| 101. | Collaboration in Distributed Software Development | S | BC | 2009 | SS-13 | H | I |
| 102. | Synchronous Communication Media in the Software Requirements Negotiation Process | S | BC | 2009 | SS-14 | M | E |
| 103. | A Comparison of Commonly Used Processes for Multi-Site Software Development | S | BC | 2010 | SS-15 | H | E* |
| 104. | Communications in Global Software Development: An Empirical Study Using GTK+ OSS Repository | S | BC | 2011 | SS-16 | H | I |
| 105. | Increasing Awareness in Distributed Software Development Workspaces | S | BC | 2004 | SS-17 | M | E |
| 106. | Collaboration in Global Software Engineering Based on Process Description Integration | S | BC | 2009 | SS-18 | H | I |
| 107. | Ten Strategies for Successful Distributed Development | S | BC | 2006 | SS-19 | H | I |
| 108. | Dealing with Scalability in an Event-Based Infrastructure to Support Global Software Development | S | BC | 2007 | SS-20 | M | E |
| 109. | Defect Detection Effectiveness and Product Quality in Global Software Development | S | BC | 2011 | SS-21 | M | E |
| 110. | Scrum Practices in Global Software Development: A Research Framework | S | BC | 2011 | SS-22 | H | I |
| 111. | A Lightweight Approach for Knowledge Sharing in Distributed Software Teams | S | BC | 2008 | SS-23 | H | I |
| 112. | Benefits of Global Software Development: The Known and Unknown | S | BC | 2008 | SS-24 | H | I |
| 1 | Global Software | S | RP | 20 | SS- | M | E |

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| 13. | Development Project Management – Distance Overcoming | | | 04 | 25 | | |
| 114. | Toward Visualization and Analysis of Traceability Relationships in Distributed and Offshore Software Development Projects | S | BC | 2007 | SS-26 | M | E |
| 115. | Meeting the Challenge of Communication in Offshore Software Development | S | BC | 2007 | SS-27 | H | I |
| 116. | On the Use of Handover Checkpoints to Manage the Global Software Development Process | S | BC | 2009 | SS-28 | H | I |
| 117. | A Software Inspection Process for Globally Distributed Teams | S | BC | 2010 | SS-29 | H | I |
| 118. | Critical Success Factors for Offshore Software Development Outsourcing Vendors: An Empirical Study | S | BC | 2010 | SS-30 | H | I |
| 119. | Achieving Better Collaboration in Global Software Design with Micro Estimation | S | BC | 2007 | SS-31 | H | I |
| 120. | Awareness Support in Global Software Development: A Systematic Review Based on the 3C Collaboration Model | S | BC | 2010 | SS-32 | H | I |
| 121. | Software Architecture Evaluation in Global Software Development Projects | S | BC | 2009 | SS-33 | M | E |
| 122. | Analyzing Collaboration in Software Development Processes through Social Networks | S | BC | 2010 | SS-34 | H | I |
| 123. | Distributed Information System Development: Review of Some Management Issues | S | BC | 2009 | SS-35 | M | E |
| 124. | Multi-site Distributed Software Development: Issues, Solutions, and Challenges | S | BC | 2007 | SS-36 | H | I |
| 125. | The Rosetta Stone Methodology – A Benefits Driven Approach to Software Process Improvement | S | BC | 2010 | SS-37 | H | I |
| 126. | Product Line Architectures for Global Software Development | S | BC | 2004 | SS-38 | M | E |
| 127. | A Case Study: Coordination Practices in Global Software Development | S | BC | 2005 | SS-39 | H | I |
| 128. | Maintainability through Architecture Development | S | BC | 2004 | SS-40 | M | E |
| 129. | Safety Critical Software Process Improvement by Multi-objective Optimization | S | BC | 2007 | SS-41 | M | E |

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|---|---|---|---|---|---|---|---|
| | Algorithms | | | | | | |
| 130. | Logical Time in Distributed Software Systems | S | J | 2002 | SS-42 | M | I |
| 131. | A framework to improve communication during the requirements elicitation process in GSD projects | S | BC | 2010 | SS-43 | H | I |
| 132. | Design rationale capture for process improvement in the globalised enterprise: an industrial study | S | J | 2011 | SS-44 | H | I |

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