Received: 17 May 2018 | Revised: 22 June 2018 | Accepted: 12 July 2018

DOI: 10.1002/smr.1988

SPECIAL ISSUE PAPER

WILEY Journal of Software: Evolution and Process

GSEPIM: A roadmap for software process assessment and improvement in the domain of global software development

Arif Ali Khan[1] | Jacky Keung[2] | Mahmood Niazi[3] | Shahid Hussain[4] | Mohammad Shameem[5]

[1] College of Computer Science and Technology, Nanjing University of Aeronautics and Astronautics, Nanjing, China

[2] Department of Computer Science, City University of Hong Kong, Kowloon Tong, Hong Kong

[3] Information and Computer Science Department, King Fahd University of Petroleum and Minerals, Saudi Arabia

[4] COMSATS University, Islamabad, Pakistan

[5] Department of Computer Science and Engineering, IIT (ISM), Dhanbad, India

Correspondence
Arif Ali Khan, College of Computer Science and Technology, Nanjing University of Aeronautics and Astronautics, Nanjing, China.
Email: arif.khan@nuaa.edu.cn

Funding information
Nanjing University of Aeronautics and Astronautics research, Grant/Award Number: 1015-YAH18056

Abstract

Software development firms have begun adopting the practice of global software development (GSD). The main reason for the shift toward globalization is the various benefits received by software development firms. However, there are several issues faced by GSD organizations, particularly those associated with software process improvement (SPI). It has been noticed that a formal process improvement approach could assist in successfully executing development activities in GSD. The core objective of this research work is to develop a global software engineering process improvement model (GSEPIM) to assess and improve software process activities in a GSD environment. The proposed model will be developed based on existing models in other domains, an empirical study conducted with GSD practitioners, and an understanding of critical success factors and challenges of SPI. In this study, the first step in the development of GSEPIM is completed by identifying the challenges of SPI in GSD and presenting a solution in the form of a robust framework.

KEYWORDS

global software development, GSEPIM, software process improvement, SPI challenges, systematic literature review

1 | INTRODUCTION

Global software development (GSD) is the practice of developing software systems across geographical, socio-cultural, and temporal boundaries.[1] A large number of firms are globalizing development activities in order to receive the benefits of low labor cost, a skilled workforce, and round-the-clock development.[2] The development teams face various challenges due to cultural differences, time differences, language barriers, and different social norms and values.[1]

The concept of GSD is growing fast and has been adopted by the majority of software development firms. The main reason behind the acceptance of GSD is the economic factor, which is the most motivating factor for software development organizations.[2,3] Herbsleb[3] reported that business profits, low cost and time, a high percentage of productivity, a skillful workforce, and innovative concepts are the benefits that make GSD a good choice for software development organizations.

Basides various benefits, software quality becomes an enormous issue in the domain of GSD, as evidenced by the disappointing results of various big projects.[4] Attarzadeh and Ow[5] conducted a survey and reported that 31.1% of GSD projects were terminated before completion. Software development firms have recognized that the main reason for poor software quality is the failure to efficiently organize the development process.[6]

Different techniques and methods have been developed to manage and implement software development processes, and the most effective approach is software process improvement (SPI). Zahran[7] defined SPI as "the discipline of defining, characterizing, improving, and measuring software management, better product innovation, faster cycle time, greater product quality, and reduced development costs simultaneously."

Various software process management and improvement standards and techniques have been developed. In particular, capability maturity model integration (CMMI) was developed to assess the process improvement capabilities of an organization and provide best practices.[8] Similarly, ISO/IEC 15504 was developed by the International Standards Organization (ISO)[9] as part of the software process improvement and capability determination (SPICE) project. The aim of SPICE development is to assess and publish process improvement models.[9] Currently, the ISO/IEC 15504 standard has been changed to ISO/IEC 330XX, which is more advanced and can be used to evaluate deployed processes in an organization as well as process maintenance, process improvement, and change management.[10] Furthermore, the government of the UK has developed the information technology infrastructure library (ITIL) framework in order to support IT services.[11] ITIL consists of best practices to create policies for assessing and improving IT-related activities.[11]

However, the distributed nature of process improvement activities has been ignored, and little work has been done to develop techniques that could manage SPI programs in a GSD environment.[12] It is important that SPI practitioners working in GSD environments have clear concepts and a thorough understanding of process improvement activities.[12-14]

Nevertheless, the challenges associated with SPI are quite different in GSD organizations, and practitioners should focus on issues regarding process improvement in a GSD environment.[12] The deployment of process improvement programs in GSD environments is more challenging compared with collocated or single-site development.[12] Existing literature does not examine in detail the implementation of process improvement programs in GSD.[13-15]

Little attention has been given to conducting empirical studies and examining ways to efficiently execute SPI programs in GSD environments. Moreover, existing research has not focused on developing SPI standards and models that could be used to execute process improvement activities in GSD. In this regard, we have proposed a model that could support GSD organizations by providing a robust framework for the assessment and improvement of SPI implementation activities. The proposed model could help GSD organizations to effectively manage process improvement programs.

The rest of the paper is organized as follows: Section 2 highlights the motivation and novelty of the work. The limitations of existing models and standards are reported in Section 3. The research questions and methodology are provided in Sections 4 and 5, respectively. The structure of the proposed research model is given in Section 6, and Section 7 describes the assessment criteria selected for the model. The preliminary findings of the study are briefly reported in Section 8. Mapping of SPI manifesto is given in Section 9, and the comparison of the existing work with the proposed model is provided in Section 10. Future research directions and the planned progress of the study are discussed in Section 11.

2 | MOTIVATION AND NOVELTY

Software process improvement research has been conducted for many years in the areas of information systems and software engineering.[12,16] Ramasubbu[13] discussed how existing studies have reported the significance of process improvement in the domain of collocated software development but ignored the importance of SPI activities in GSD.

Niazi[17] highlighted that the deployment of SPI activities is a long-term approach and requires significant time and resources.[18] Even software development organizations that can provide all the necessary resources do not always accomplish the expected outcomes. Ngwenyama and Nielsen[19] reported that the failure rate of SPI programs is as high as 70%, and the root cause of process improvement failure is the lack of attention given to the issues associated with SPI activities.

Richardson et al[20] revealed that in GSD, team members are physically separate due to geographical and temporal distances, which decreases opportunities for direct communication. Similarly, cultural conflicts in a GSD environment negatively impact the views and opinions of the dispersed team members.[15] Existing SPI models and standards (ie, CMM, CMMI, and ISO/IEC 15504) can effectively manage SPI activities in a collocated environment but do not explicitly describe the process of deploying SPI activities in a distributed environment.[20] Kuhrmann et al[21] conducted a systematic mapping study of process improvement in GSD and reported that little work has been done by the researchers to scale SPI implementation activities in the domain of GSD. They further reported that available studies were critical of implementing the existing SPI models (ie, CMM, CMMI, and ISO/IEC 15504) in the domain of GSD. Presently, the GSD phenomenon is expanding toward the improvement of all the phases of the software development cycle instead of just focusing on financial benefits.[17]

Ramasubbu[13] reported that the geographical, socio-cultural, and temporal distribution of team members makes it challenging to successfully execute SPI activities. He further discussed how the geographical distribution of team members causes various other issues related to SPI activities, eg, developing and implementing practices for process improvement, formulating a strategy to shape a strong and positive relationship among the dispersed team members, overcoming time differences, and addressing cultural challenges. In order to effectively implement these challenges, it is important for SPI team members to have comprehensive knowledge and understanding of the designing and deployment of process improvement activities.[16]

To summarize, despite the importance of SPI programs, no mechanism has been identified in order to competently execute process improvement activities in a distributed environment. There is a pressing need to develop a technique that could help GSD firms successfully assess and execute SPI-related activities.

3 | LIMITATIONS OF EXISTING MODELS AND STANDARDS

We have reported the limitations of the available SPI models and standards in the following subsections.

3.1 | Capability maturity model (CMM)

The main objective of CMM is to assess and improve the organizational processes. CMM consists of five maturity levels (initial, repeatable, defined, managed, and optimizing).[22] Level 1 of CMM refers to the lowest maturity state of an organization, whereas level 5 refers to the highest maturity level. Each maturity level consists of different key process areas. CMM is an effective model for process improvement with defined maturity levels, key process areas, and key practices. However, it does not provide any information regarding the effective implementation strategies and deployment of key practices. The CMM model does not discuss issues related to human nature, such as employee motivation, hiring, and selection.[23]

3.2 | Capability maturity model integration (CMMI)

The structure of CMMI is based on the core components of CMM and the information collected from various other models and real-world experiences of organizations that had adopted CMM for years. CMMI also has five maturity levels (initial, managed, defined, quantitatively managed, and optimizing).[8] In comparison with CMM, CMMI provides an innovative view of maturity levels, key practices, and process areas. However, the CMMI model does not provide detailed information about the implementation of key practices and also does not recommend any implementation strategies.[23]

3.3 | SPICE (ISO/IEC 15504)

The ISO and the International Electrotechnical Commission (IEC) developed ISO/IEC 15504 for SPI under the SPICE program.[9] Process and process capability are the key dimensions of SPICE (ISO/IEC 15504).[7] The process dimension involves the measurable aims and objectives of each process, while the capability dimension consists of the attributes of each process.[7] It can be measured using capability levels. Zahran[7] define a capability level as “a set of attributes that work together to enhance capability to perform a process. Each level provides a major enhancement of capability in the performance of the process.” SPICE integrates existing process improvement methodologies, but it does not provide an explicit process improvement path.

3.4 | International Standards Organization (ISO) 9000/9001

ISO 9000 detailed a series of standards for certifying the quality of systems implemented in firms.[24] Software systems can be assessed using this standard irrespective of the size and type of the organization or the complexity of its products or services. ISO 9001 consists of guidelines to implement standard organizational management systems. It assists organizations in fulfilling customer needs and the needs of any other involved parties based on the suggested quality management principles. It provides complete guidelines for organizations to assess the quality of their management systems.[14,15] ISO 9001 is a generic standard that mainly focuses on the manufacturing and service aspects of different types of organizations, instead of just the software industry.[25] It is also a quality management standard and does not explicitly explore the process improvement aspects of software systems.

3.5 | Implementation maturity model (IMM)

Niazi[23] developed a maturity model to assist process improvement practitioners in order to effectively manage SPI activities. IMM is based on the key concepts of CMMI.[8] The structure of IMM consists of three core components (factors, assessment, and implementation). IMM provides detailed information about the deployment of key practices and recommend implementation strategies. The human-related aspects of SPI implementation are explicitly discussed in IMM. However, IMM does not differentiate between collocated and distributed software development organizations.

4 | RESEARCH CONTRIBUTION AND RESEARCH QUESTIONS (RQS)

A brief survey of the literature clarifies that there is a need for a framework or model that can contribute to effectively performing process improvement activities in a GSD environment. The core objective of this research is to empirically examine the views of process improvement practitioners in order to develop a model that could assist GSD firms in assessing and implementing SPI programs.

The model will be developed on the basis of key SPI concepts discussed in existing literature and an industrial study conducted in GSD organizations. The focus of our study is to fill the research gap between process improvement in academic research and industrial practices. The following research questions have been developed in order to address the reported problem of this study:

RQ1: What are the factors identified in the literature and industrial study that could have a negative impact on the implementation of process improvement programs in GSD?

RQ2: What are the factors identified in the literature and industrial study that could have a positive impact on the implementation of process improvement programs in GSD?

RQ3: What are the significant differences between the factors identified in the literature and industrial study?

RQ4: What are the practices to address the identified factors?

RQ5: What would be the characteristics of a model that could assist GSD firms in effectively implementing process improvement activities?

5 | RESEARCH METHODOLOGY

The proposed model will be developed based on a thorough literature review and empirical study conducted with SPI practitioners working in GSD organizations. We will also conduct case studies in GSD organizations in order to assess the effectiveness of the model in a real-world environment.

- A systematic literature review (SLR) study will be conducted in the first phase of this research project in order to identify the factors that could have a positive or negative impact on SPI programs in GSD environment. Best practices will also be devised in this phase to address the identified factors.
- The findings of the SLR study will be empirically validated in the second phase of this study using the survey questionnaire approach. We will also report additional new factors and practices suggested by the survey respondents.
- We will develop a global software engineering process improvement model (GSEPIM) based on the findings of the literature study and the empirical study.
- The project will be completed by conducting case studies in GSD organizations in order to assess GSEPIM in a real-world environment.

The complete research process is presented in Figure 1.

5.1 | Data collection

We have selected the SLR and questionnaire survey techniques to collect data from existing literature and the industry. The selected research techniques have been chosen because these methods are considered to be suitable for the type of data involved in this research.[23,26]

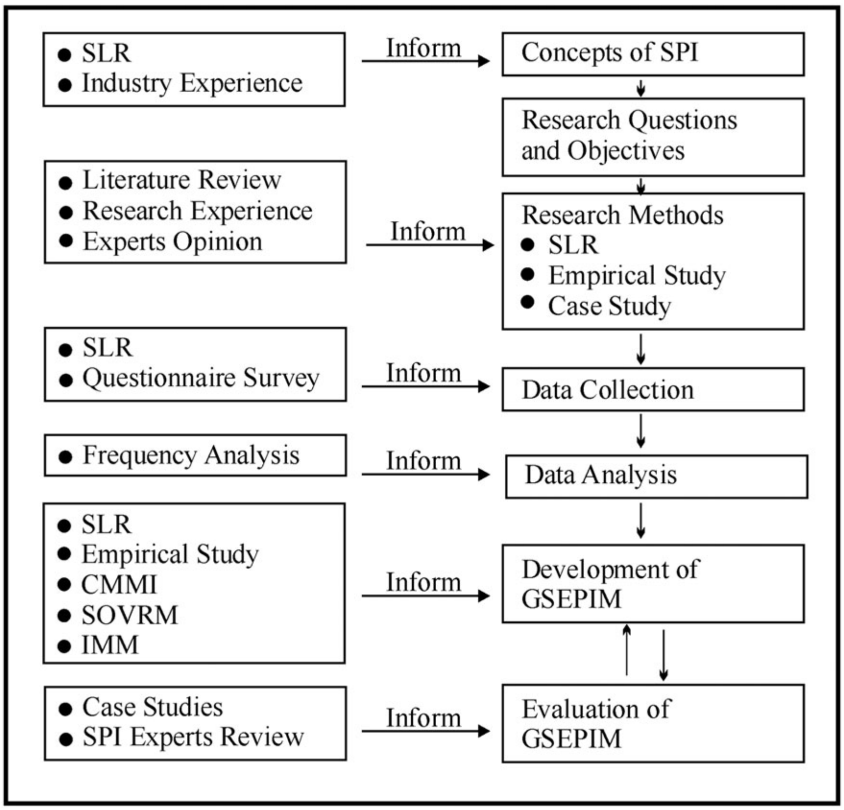

FIGURE 1 Research process

5.1.1 | Systematic literature review

Kitchenham et al[27] define SLR as a methodical way of mining, analyzing, and reporting the findings of existing literature associated with any research field and questions of interest. The key objective of this SLR study is to conduct a formal literature review to explore the maximum number of articles related to the proposed research questions.[27] We have followed the three core phases of the SLR approach (ie, planning, conducting, and reporting).[27] All the three phases of SLR are briefly discussed in our previous articles.[14,15,28]

5.1.2 | Empirical data collection

The selection of the empirical research method should be based on the research problem, required data and information, existing resources, and the capability of manipulating the given variables.[29]

We will develop a survey questionnaire in order to validate the findings of the SLR and identify additional factors and practices related to process improvement in the domain of GSD. The questionnaire approach could assist in collecting large amounts of data and information from a large-scale targeted population.[1] This study will be conducted in the domain of GSD, and the survey questionnaire will assist in collecting data from SPI practitioners working across geographical boundaries. Using the survey approach, it is easy to obtain information regarding people's attitudes. It is difficult to collect such information using observational practices.[1]

5.2 | Data analysis

We will use the frequency data analysis technique to analyze the questionnaire survey data and conduct case studies to evaluate the proposed model (GSEPIM).

5.2.1 | Frequency analysis

The frequency analysis approach assists in comparing data across variables or groups of variables.[26] Frequency analysis can be used to analyze ordinal, numeric, and nominal types of data. In this study, we will follow the frequency analysis approach in order to statistically compare the identified factors and practices. The comparative analysis of the identified factors will help calculate the relative significance of each success factor. In the same way, the frequency-based analysis of the identified practices will highlight the relative importance of each practice.

5.2.2 | Case study analysis

We have selected the case study approach to evaluate the practical implications of the proposed model (GSEPIM). The case study method is the most controlled assessment approach that provides real-world results and information.[30] This technique could be a good choice for this research study as GSEPIM is intended to be implemented in real-world GSD organizations.

6 | STRUCTURE OF PROPOSED MODEL (GSEPIM)

The core components of GSEPIM will be developed based on the factors and practices identified during the SLR and industrial study. The components will be structured using the identified factors, practices, and concepts of existing models and frameworks, namely CMMI,[8] IMM,[23] and SOVRM,[26] in order to develop GSEPIM (Figure 2). The relationships between the key components of GSEPIM are depicted in Figure 2. It highlights how the results of existing models, SLR, and industrial study have been used to develop the key components of the proposed model.

The three core components of GSEPIM are (Figure 2):

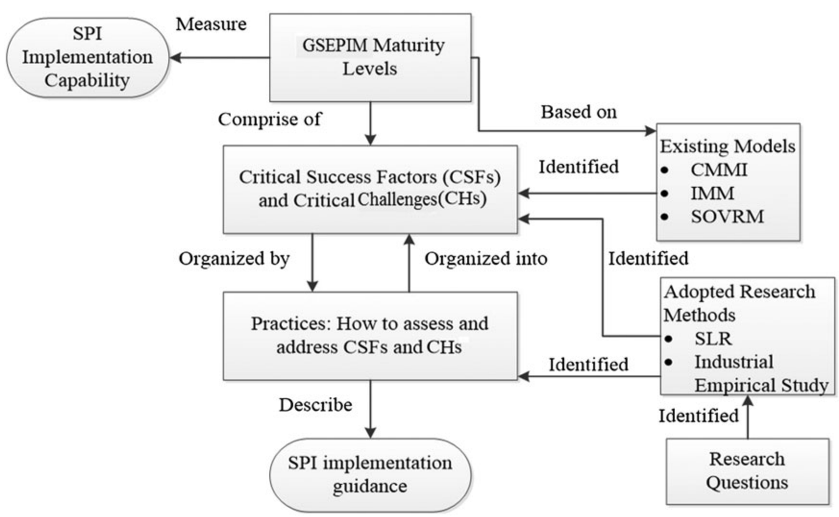

FIGURE 2 Architecture of GSEPIM

- Maturity level component
- Critical success factors (CSFs) and critical challenges (CHs) component
- Practices component

6.1 | GSEPIM maturity level component

The maturity levels of GSEPIM will be developed based on the stage representation of CMMI.[8] It is important to make several adjustments to the structure of CMMI in order to consider its process improvement implementation characteristics.

6.2 | GSEPIM factors (CSFs and CHs) component

The five maturity levels of CMMI consist of various process areas (PAs). The concepts of CSFs and CHs could be used to develop the maturity levels instead of using the PAs of CMMI.[31] CSFs and CHs have also been previously used by other researchers.[31,32] They have used CSFs and CHs rather than CMMI PAs. The importance of using CSFs and CHs has been discussed by other researchers.[31,33] Therefore, we can justify the use of CSFs and CHs concepts.

6.3 | GSEPIM practices component

Using the SLR and empirical study approach, different practices will be identified in order to address the CSFs and CHs of the factors component. The practices identified during the SLR study will be empirically evaluated and used to identify additional practices from SPI experts using the survey questionnaire technique.

7 | GSEPIM ASSESSMENT DIMENSION

We have adopted the Motorola assessment tool[34] in order to evaluate GSEPIM, as detailed in Appendix 1. The Motorola assessment tool has been used by various other researchers in order to evaluate their proposed maturity models.[26,31,32] It has been selected in this study for various compelling reasons. It can assist in identifying those areas of organizations that need further consideration and improvement.[34] The following are the criteria of the three assessment dimensions of the Motorola instrument (Appendix 1).

- Approach: Emphasize the top management's commitment to the implementation of specific practice.
- Deployment: Focus on the consistent and uniform implementation of the practice across all the project areas.
- Results: Assess the breadth and consistency of the results of deployed practice across different project areas.

7.1 | Assessment criteria of GSEPIM

The following criteria have been selected in order to assess the effectiveness of GSEPIM in a real-world environment:

- **Ease of use:** The key objective of this criterion is to assess how easily the GSD organization can understand and adopt the proposed model (GSEPIM).
- **User satisfaction:** The GSEPIM should fulfill the requirements of end users, and they need to be satisfied with its results.
- **Structure of GSEPIM:** This criterion focuses on the evaluation of the key GSEPIM components. Further, it emphasizes the distribution of the identified CSFs and CHs across different maturity levels of GSEPIM.

The assessment criteria are based on the studies conducted by other researchers in various other domains.[26,30-32] The selected criteria can assess the quality and effectiveness of the product and could help highlight those areas that contain any deficiencies and need further improvements.[26]

8 | PRELIMINARY RESULTS

We conducted a thorough SLR study and identified different challenges that could impact the SPI process in GSD. The complete SLR process is briefly discussed in our previously published articles.[28,35,36] The identified challenges could contribute to only one component of the proposed model, ie, GSEPIM factors (CSFs and CHs).

8.1 | Identified SPI challenges

In this study, we have considered the 20 primary studies selected in our previously published studies.[14,36] A total of 17 factors were identified as given in Table 1 and Figure 3. The given factors could negatively impact the SPI process, and their frequency and percentage are provided in Table 1 and Figure 3.

CH7 (lack of communication) was considered by 90% of SLR studies as the most significant challenge. Communication becomes a vital issue in a GSD environment due to the geographical boundaries between the team members.[3] Team members working in a distributed environment are scattered and can seldom meet each other, which introduces misunderstandings and possibly distrust among the distributed teams. Conchúir et al[2] further claimed that the lack of face-to-face communication could easily lead to challenges in coordination and control.

CH5 (budget constraints) was cited as the second most common challenge by 85% of the selected primary studies. Top management may strive to successfully implement SPI programs, but budget constraints make it difficult to hire an outside consultant for SPI activities.[37] It also becomes challenging for small-size organizations to set a big budget for SPI programs due to such budget constraints.[38]

The SLR results show that CH17 (poor SPI understanding) was cited in 80% of the articles, as shown in Figure 3. Kautz and Nielsen[39] carried out an industrial empirical study and tried to find the underlying reasons for unsuccessful SPI implementations in that particular company, coming to the following conclusion: “the technical director and staff had poor understanding of key SPI concepts and they have experienced various hurdles during the SPI implementation.” Lack of a proper understanding of SPI concepts is one of the key reasons for the failure of SPI programs.[35]

CH8 (lack of implementation standards) was discussed in 70% of the selected articles. Niazi et al[12] highlighted the need to adopt proper tools for SPI implementation and motivate team members to have sufficient knowledge about those tools. Besides, one of the reasons for the failure of

TABLE 1 Identified SPI challenges in a GSD environment

S. No	Challenges	Frequency (*N* = 20)	Percentage, %
CH1	Lack of conflict management	11	55
CH2	Lack of trust	9	45
CH3	Lack of experienced staff	13	65
CH4	Cultural differences	6	30
CH5	Budget constraints	17	85
CH6	Organizational politics	13	65
CH7	Poor communication	18	90
CH8	Lack of implementation standards	14	70
CH9	Poor technological infrastructure	4	20
CH10	Lack of staff involvement	10	50
CH11	Work pressure	7	35
CH12	Poor organizational commitment	5	25
CH13	Lack of SPI training	3	15
CH14	Time zone differences	5	25
CH15	Lack of resources	10	50
CH16	Lack of knowledge sharing	12	60
CH17	Poor SPI understanding	16	80

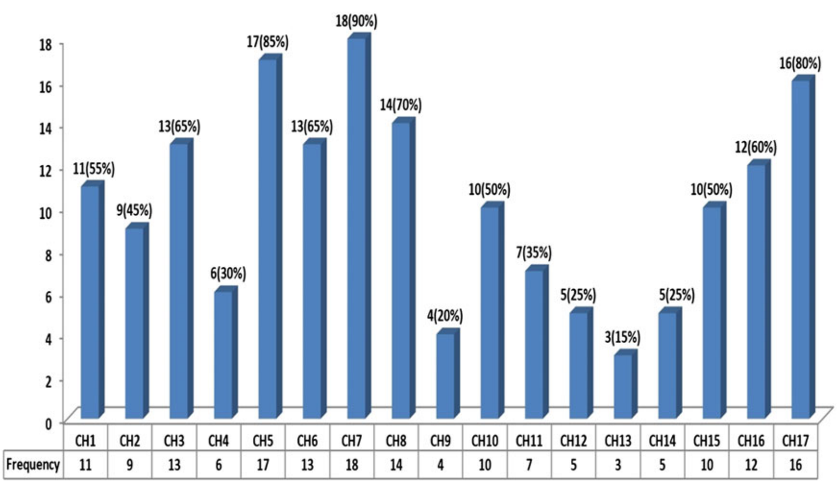

FIGURE 3 Frequency distribution of identified challenges

SPI is the lack of tools and standards for process improvement activities.[23] Lack of tools might be the superseding problem for the success of SPI in the absence of any other barriers.[23]

Besides the above four significant challenges, we have also highlighted other important factors, ie, CH6: organizational politics (65%), CH3: lack of experienced staff (65%), CH16: lack of knowledge sharing (60%), and CH1: lack of conflict management (55%).

8.2 | Challenge categorization

The identified challenges were further classified into different categories as the same factor-based classification was performed by other researchers.[40-42] Noll et al[40] conducted an industrial empirical study to develop a framework that shows the relationship between the autonomy and motivation level of distributed agile team members. Their findings highlighted the fact that autonomy is one of the motivating factors but not sufficient to elevate the motivation level of team members.[40] In another study, Hernández-López et al[43] developed a formal model for building trust in GSD teams by considering the influence of each factor on the trust level of team members. The factors of the proposed model could help develop a trust-based understanding between distributed teams. The authors further found that there is a need for a maturity model that can assess the trust level of GSD teams.[43] Zafar et al[41] identified a list of challenges using SLR and an empirical study that could cause integration failures in GSD environments. The identified challenges were presented in the form of a taxonomy by classifying them into eight core categories of integration failure. Colomo-Palacios et al[42] identified the challenges of packaged software release planning in the domain of GSD. The identified challenges were classified into two different categories, ie, general challenge ranking and specific GSD challenge ranking.[42] The findings concluded that personnel and human resource management challenges are the top challenges in packaged software release planning.[42] In other study, Ramasubbu proposed a framework to classify process improvement activities in GSD environments. The framework consists of six key categories: project administration, coordination, software methodology, human resource management, knowledge integration, and technology factors. Ramasubbu[13] classified SPI activities across the reported categories. Due to the similar nature of both studies, we have used the concepts of the framework developed by Ramasubbu[13] and mapped all the identified challenges into the aforementioned categories. All the authors participated in the challenge categorization (Figure 4).

The categorization of the identified challenges provides a framework that has both industrial and research implications. It will assist researchers and practitioners in focusing on a specific category of challenges rather than reviewing all the challenges. Each category represents a critical area of SPI challenges that could negatively impact process improvement activities in GSD. Such categorical classification of challenges will assist in the development of efficient SPI policies and strategies.

9 | SPI MANIFESTO MAPPING

A group of experts working in the domain of software process improvement developed the SPI manifesto, which can assist in the effective initiation of a process improvement program.[44] The manifesto consists of three core values: people, business, and change (Figure 5). It also presents 10 different principles (Figure 6) organized around the core values that could assist process improvement practitioners to consider their decisions in the context of the problem.[44]

We have tried to map the identified challenges in the SPI manifesto by considering its values and principles. The results given in Table 1 show that CH7 (poor communication), CH12 (poor organizational commitment), CH13 (lack of SPI training), and CH15 (lack of resources) are in line with the SPI manifesto to motivate the team members of process improvement. Similarly, CH2 (lack of trust), CH3 (lack of experienced staff), CH4 (cultural differences), CH10 (lack of staff involvement), and CH11 (work pressure) are in agreement to one of the key values of the manifesto (people).

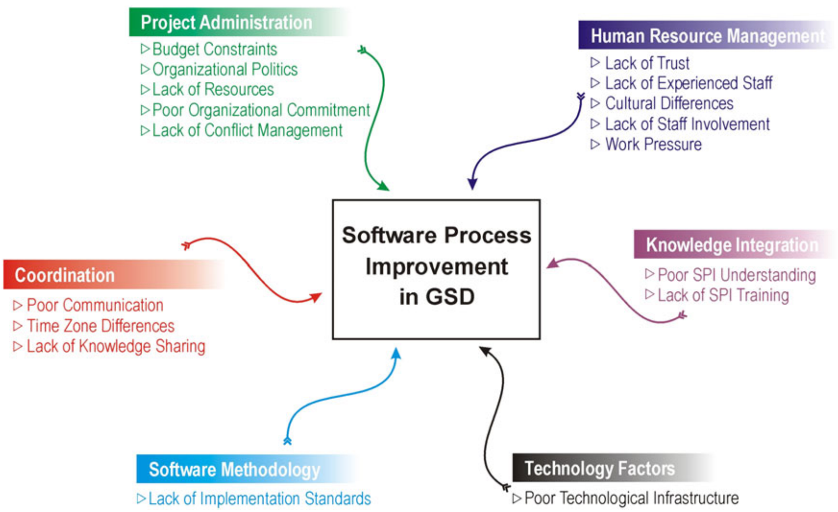

FIGURE 4 Categorical classification of identified challenges

FIGURE 5 Values of the SPI manifesto[44]

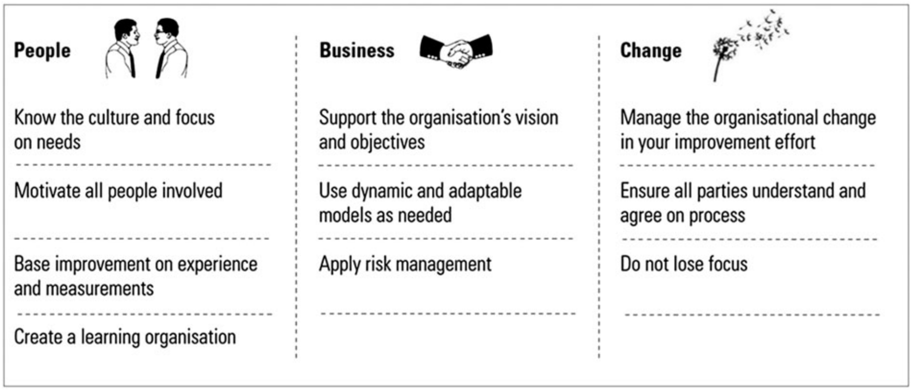

FIGURE 6 Principles of the SPI manifesto values[44]

The other factors, namely CH4 (cultural differences), CH8 (lack of implementation standards), CH9 (poor technological infrastructure), and CH16 (lack of knowledge sharing) are mapped to the business values of the SPI manifesto. The given mapping provides a detailed understanding of GSD process improvement challenges in the domain of the standard SPI manifesto.[44] They can be used to focus on the reported challenges related to each specific value of the manifesto.

10 | PROPOSED MODEL COMPARISON

The preliminary results of this study are based on our previously published articles.[15,36] We have conducted an SLR and empirical study to develop the factor component of the proposed model.[15] In this study, the key challenges (barriers) of SPI were extracted from the existing literature and validated in the domain of GSD. The challenges were further classified in the context of client-vendor organizations in order to provide insight into the types of GSD (client and vendor). We also conducted an SLR study to identify the success factors of an SPI implementation.[36] This study contributes to the factor component of GSEPIM by considering the positive impact factors. The reported factors will further be evaluated through expert opinion by conducting an industrial empirical study with SPI practitioners and researchers working in the domain of GSD.

The key findings of our published articles[15,36] are the initial input to the factor component of the model (GSEPIM). These factors present the key areas of SPI that need further consideration. The remaining components (maturity level and practices) of the model will be discussed in future research.

11 | CURRENT PROGRESS AND FUTURE STUDY DIRECTIONS

We have conducted the following research so far:

- Conducting a thorough overview of the literature to identify research problems
- Developing research questions and objectives

- Finalizing the complete research process
- Research methods selection
- Developing the structure of GSEPIM based on existing models
- Selecting the GSEPIM assessment criteria
- Identifying the challenges and success factors of SPI in GSD using SLR

We have completed the literature study and presented the results of the literature review in the context of SPI challenges. We have only answered RQ1 in this study, and the rest of the research questions (RQ2 to RQ5) will be addressed in future studies.

ACKNOWLEDGEMENT

This research work is supported by the Nanjing University of Aeronautics and Astronautics research grant: 1015-YAH18056.

ORCID

Arif Ali Khan http://orcid.org/0000-0002-8479-1481
Mahmood Niazi http://orcid.org/0000-0001-7318-7644
Mohammad Shameem http://orcid.org/0000-0002-6055-5345

REFERENCES

1. Khan AA, Basri S, Dominic PDD. A proposed framework for communication risks during RCM in GSD. *Procedia Soc Behav Sci*. 2014;129:496-503.
2. Conchuir OE, Olsson H, Agerfalk P, Fitzgerald B. Benefits of global software development: exploring the unexplored. *Soft Process: Improv Practice*. 2009;14(5):201-212.
3. Herbsleb JD. Global software engineering: the future of socio-technical coordination. Proceedings of the International Conference on Future of Software Engineering 2007:188-198.
4. Carmel E, Espinosa JA, Dubinsky Y. "Follow the sun" workflow in global software development. *Manag Inform Syst*. 2010;27(1):17-38.
5. Attarzadeh I, Ow HS. Project management practices: the criteria for success or failure. *Communications of the IBIMA*. 2008;1:234-241.
6. Unterkalmsteiner M, Gorschek T, Islam MA, Cheng KC, Permadi BR, Feldt R. Evaluation and measurement of software process improvement—a systematic literature review. *IEEE Trans Soft Eng*. 2012;38(2):398-424.
7. Zahran S. Software process improvement: practical guidelines for business success. *J Soft Mainten: Res Pract*. 1999;11(4):285-291.
8. SEI. *CMMI® for Development, version 1.3 (CMU/SEI-2010-TR-033, ESC-TR-2010-033)*. Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University; 2010.
9. ISO. ISO/IEC 15504-4. Information technology—Process Assessment—Part 4: Guidance on use for process improvement and process capability determination. International Organization for Standardization 2004.
10. ISO. ISO/IEC 33001. *Information Technology—Process Assessment—Concepts and Terminology*. Geneva, Switzerland: International Organization for Standardization; 2015.
11. Cartlidge A, Rudd C, Smith M, et al. *An Introductory Overview of ITIL® 2011*. London: The Stationery Office; 2012.
12. Niazi M, Babar MA, Verner JM. Software process improvement barriers: a cross-cultural comparison. *Inform Soft Tech*. 2010;52(11):1204-1216.
13. Ramasubbu N. Governing software process improvements in globally distributed product development. *IEEE Trans Sof Eng*. 2014;40(3):235-250.
14. Khan AA, Keung J. Systematic review of success factors and barriers for software process improvement in global software development. *IET Soft*. 2016;10(5):125-135.
15. Khan AA, Keung J, Niazi M, Hussain S, Ahmad A. Systematic literature review and empirical investigation of barriers for software process improvement in global software development: client-vendor perspective. *Inform Soft Tech*. 2017;87:180-205.
16. Bayona S, Calvo-Manzano JA, San Feliu T. *Review of Critical Success Factors Related to People in Software Process Improvement. Systems. Software and Services Process Improvement*. Germany: Springer Berlin Heidelberg; 2013:179-189.
17. Niazi M. A comparative study of software process improvement implementation success factors. *Software: Evol Process*. 2015;27(9):700-722.
18. Khan AA, Basri S, Dominic PDD, Amin FE. Communication risks and best practices in global software development during requirements change management: a systematic literature review protocol. *Appl Sci, Eng Tech*. 2013;6(19):3514-3519.
19. Ngwenyama O, Nielsen PA. Competing values in software process improvement: an assumption analysis of CMM from an organizational culture perspective. *IEEE Trans Eng Manag*. 2003;50(1):100-112.
20. Richardson I, Casey V, Burton J, McCaffery F. *Global Software Engineering: A Software Process Approach. Collaborative Software Engineering*. Springer Berlin Heidelberg; 2010:35-56.
21. Kuhrmann M, Diebold P, Munch J, Tell P. How does software process improvement address global software engineering. IEEE International Conference on Global Software Engineering 2016:89-98.
22. Paulk M, Curtis B, Chrissis BM, Weber C. *Capability Maturity Model for Software, Version 1.1. CMU/SEI-93-TR-24*. Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University; 1993.
23. Niazi M. A framework for assisting the design of effective software process improvement implementation strategies, PhD thesis, University of Technology Sydney, 2004.

24. ISO. ISO 9000. Quality management systems—fundamentals and vocabulary. Technical Report ISO 9000:2005, International Organization for Standardization, 2005.

25. Chrissis MB, Konrad M, Shrum S. *CMMI: Guidelines for Process Integration and Product Improvement*. Boston: Addison Wesley; 2003.

26. Khan SU. Software outsourcing vendors' readiness model (SOVRM), PhD thesis, Keele University, UK, 2011.

27. Kitchenham B, Pearl Brereton O, Budgen D, Turner M, Bailey J, Linkman S. Systematic literature reviews in software engineering—a systematic literature review. *Inform Software Tech*. 2009;51(1):7-15.

28. Khan AA, Keung J, Niazi M, Hussain S. Towards a hypothetical framework of humans related success factors for process improvement in global software development: systematic review, Proceeding of the 32nd ACM Symposium on Applied Computing (SAC), Morocco, 2017, DOI: https://doi.org/10.1145/3019612.3019685.

29. Bryman A. *Social Research Methods*. Oxford: Oxford University Press; 2012.

30. Yin KR. *Case Study Research: Design and Methods*. Sage publications; 2013.

31. Niazi M, Wilson D, Zowghi D. A maturity model for the implementation of software process improvement: an empirical study. *J Syst Soft*. 2005;74(2):155-172.

32. Ali S, Khan SU. Software outsourcing partnership model: an evaluation framework for vendor organizations. *J Syst Soft*. 2016;117:402-425.

33. Khandelwal V, Ferguson J. Critical success factors and the growth of IT in selected geographic regions. 32nd Hawaii International Conference on System Sciences, 1999.

34. Daskalantonakis MK. Achieving higher SEI levels. *IEEE Soft*. 1994;11(4):17-24.

35. Khan AA, Keung J, Hussain S, Niazi M, Tamimy MMI. Understanding software process improvement in global software development: a theoretical framework of human factors. *ACM SIGAPP Appl Comput Rev*. 2017;17(2):5-15.

36. Khan AA, Keung J, Hussain S, Niazi M, Kieffer S. Systematic literature study for dimensional classification of success factors affecting process improvement in global software development: client-vendor perspective. IET Software 2018.

37. Mishra D, Mishra A. Software process improvement methodologies for small and medium enterprises. *Product-Focused Soft Process Improv*. 2008;273-288.

38. Niazi M, Babar AM, Katugampola MN. Demotivators of software process improvement: an empirical investigation. *Software Process: Improv Pract*. 2008;13(3):249-264.

39. Kautz K, Nielsen PA. Implementing software process improvement: two cases of technology transfer. 33rd Annual Hawaii International Conference on System Sciences 2000:1-10.

40. Noll J, Razzak AM, Beecham S. Motivation and autonomy in global software development: an empirical study. In Proceedings of the 21st International Conference on Evaluation and Assessment in Software Engineering (EASE'17). Karlskrona, Sweden 2017:394-399.

41. Zafar AA, Saif S, Khan M, et al. Taxonomy of factors causing integration failure during global software development. *IEEE Access*. 2018;6:22228-22239.

42. Colomo-Palacios R, Soto-Acosta P, García-Peñalvo FJ, García-Crespo A. A study of the impact of global software development in packaged software release planning. *J Univ Comput Sci*. 2012;18(19):2646-2668.

43. Hernández-López A, Colomo-Palacios R, García-Crespo A, Soto-Acosta P. Trust building process for global software development teams. A review from the literature. *Int J Knowl Soc Res*. 2010;1(1):65-82.

44. Pries-Heje J, Johansen J. SPI Manifesto. Version A.1.2.2010; 2010. Available at http://www.iscn.com/Images/SPI_Manifesto_A.1.2.2010.pdf.

How to cite this article: Khan AA, Keung J, Niazi M, Hussain S, Shameem M. GSEPIM: A roadmap for software process assessment and improvement in the domain of global software development. *J Softw Evol Proc*. 2019;31:e1988. https://doi.org/10.1002/smr.1988

APPENDIX 1

See Table A1.

TABLE A1 Motorola assessment instrument[34]

Score	Key Activity Evaluation Dimensions		
	Approach (score range: 0, 2, 4, 6, 8, 10)	**Deployment (score range: 0, 2, 4, 6, 8, 10)**	**Results (score range: 0, 2, 4, 6, 8, 10)**
"Poor (0)"	• "no management recognition of need" • "no organizational ability" • "no organizational commitment" • "practice not evident"	• "no part of the organization uses the practice" • "no part of the organization shows interest"	• "ineffective"
"Weak (2)"	• "management begins to recognize need" • "support items for the practice start to be created" • "a few parts of organization are able to implement the practice"	• "fragmented use" • "inconsistent use" • "deployed in some parts of the organization" • "limited to monitoring/verification of use"	• "spotty results" • "inconsistent results" • "some evidence of effectiveness for some parts of the organization"
"Fair (4)"	• "wide but not complete commitment by management" • "road map for practice implementation defined" • "several supporting items for the practice in place"	• "less fragmented use" • "some consistency in use" • "deployed in some major parts of the organization" • "monitoring/verification of use for several parts of the organization"	• "consistent and positive results for several parts of the organization" • "inconsistent results for other parts of the organization"
"Marginally qualified (6)"	• "some management commitment; some management becomes proactive" • "practice implementation well under way across parts of the organization" • "supporting items in place"	• "deployed in some parts of the organization" • "mostly consistent use across many parts of the organization" • "monitoring/verification of use for many parts of the organization"	• "positive measurable results in most parts of the organization" • "consistently positive results over time across many parts of the organization"
"Qualified (8)"	• "total management commitment" • "majority of management is proactive" • "practice established as an integral part of the process" • "supporting items encourage and facilitate the use of practice"	• "deployed in almost all parts of the organization" • "consistent use across almost all parts of the organization" • "monitoring/verification of use for almost all parts of the organization"	• "positive measurable results in almost all parts of the organization" • "consistently positive results over time across almost all parts of the organization"
"Outstanding (10)"	• "management provides zealous leadership and commitment" • "organizational excellence in the practice recognized even outside the company"	• "pervasive and consistent deployed across all parts of the organization" • "consistent use over time across all parts of the organization" • "monitoring/verification for all parts of the organization"	• "requirements exceeded" • "consistently world-class results" • "counsel sought by others"