

# SOFTWARE QUALITY ATTRIBUTES IN GLOBAL SOFTWARE DEVELOPMENT: INITIAL RESULTS

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**ABSTRACT:** *Global Software Development (GSD) is a fast growing software engineering paradigm in developing software across the geographical borders in order to save cost and get high quality software products. Software Quality ensures the success of GSD software products and promotes trust between vendor and customer organization. To identify different Software Quality Attributes (QAs), which play a vital role in the success of software products in GSD, we have used a Systematic Literature Review. Snowballing technique has also been used to enhance the SLR search phase. We have identified 'Reliability', 'User satisfaction', 'Performance, Efficiency, Functionality (PEF)', and 'Maintainability' as the most important attributes for software quality in GSD. High quality of software ensures GSD vendors to be successful in global software industry. Therefore, the GSD vendor organizations have to pay more attention to address the identified attributes in order to improve the quality of software in GSD projects.*

**KEYWORDS:** *Global Software Development; Software Quality; Quality Attributes; Vendors*

## 1.0 INTRODUCTION

Global Software Development (GSD) is getting popular among software customers for its many advantages. GSD is the new approach in which software is being developed in a distributed environment. GSD is also known as an offshore software development and global software work [1]. The reasons behind the rapid expansion of GSD are its low-cost and time saving advantages [2]. GSD makes it possible to access the expertise of others at a reasonable price [2].

Globalization guarantees the customers to develop software according to their needs and demands across the globe. The success of an organization working in GSD environment depends on the quality of their software product. The customers terminate their contract with vendors if the delivered software product does not fulfill their needs and demands [3]. Therefore GSD vendors need to pay more attention towards the quality of software to gain trust of customers and reputation in the market.

GSD is the reality that ensures customers that they can develop according to their budgets and requirements at reasonable prices [4, 5]. A number of challenges in GSD have been reported by academicians and industry practitioners [5, 6]. The most commonly reported challenges in GSD projects are coordination and communication, contract management, cultural problems and software quality issues [7]. The quality of software in the GSD is more critical than ordinary software development because the vendor and customer are dispersed across different geographic locations [8].

Software quality can be defined according to the customer's needs and demands. It is a common belief that a single definition of quality cannot express what quality is meant by all the people. It is in fact the standard that customer demands from vendors. Software quality is a complex concept and it can be better understood when quality is defined in its attributes [9]. Quality of the software represents the skill and expertise of vendors, which help them to survive in the global market. In this research paper, we represent the preliminary results of a Systematic

Literature Review (SLR). This identifies Software Quality Attributes (QAs), which can improve the quality of the overall software product. Further, by addressing these attributes can yield in customer's satisfaction.

It cannot be argued that normally customers look for vendors that develop high quality software products at reasonable price [7]. Software quality is the standard through which software systems are evaluated by customers. Improving the quality of software ensures vendor organizations to be competitive in the software industry. In software industry different quality models are employed to express quality attributes and its sub-attributes [10]. Quality of software that is developed in GSD environment is complicated due to development of team dispersion [11]. Currently, in GSD industry, there is no specific quality model that represents which software quality attributes are critical for GSD vendors for producing quality products. Our research project will develop a model that will assess the quality of software by defining important QAs for GSD. The model will also give help to select the most appropriate software quality metric for each QA. Real world practice for QAs and software quality metrics will assist GSD vendors to develop a high quality software product. This paper is based on the findings of the following research question.

**RQ1.** What are the different software quality attributes, as identified in the literature, to be considered by GSD vendors, for measuring the quality of the software products?

## 2.0 BACKGROUND LITERATURE

GSD is becoming dominant in software industry for its benefits with the passage of time [6]. Customers that don't have experts to develop regardless of because of time or latest technology, are engaged in GSD. Researchers have explored many issues related to GSD benefits and problems [15]. A case study indicated that many firms terminate their contracts with vendors due to the unsatisfied quality of products that are delivered [4]. Customers demand for high quality at reasonable price from GSD vendors. GSD makes it possible to access the latest technology and skilled people

at low cost, but its main challenge is to provide high quality software products to gain trust of customers [4, 12].

In the beginning of GSD, customers try to find cost benefits, but today it's not only the cost, but also quality that compels customers to develop their products in GSD environment. Providing high quality software to the customer is the aim of GSD. Software Quality has multiple definitions; it is the desirable properties that a customer wishes to be present in his/her software [10]. Marcelo presented different factors that impact software quality [13]. Tobias Kuipers presented the idea of how to monitor outsourced software quality. He used ISO/IEC 9126 standard to express quality of software [14]. Leonardo Pilatti stated that competitive cost and high quality of software products are the advantages that lead the customers to develop their product in a distributed environment [15].

Researchers have explored the quality and its issues in different aspects. Still, there is a need to define quality and its attributes for GSD by using empirical software engineering methods. Quality issues become critical when working in a distributed environment as distribution affects quality of software [9]. Vendor organizations have to maintain a clear quality picture to develop and deliver software products according to their customer's needs and expectations.

### 3.0 RESEARCH METHODOLOGY

We have used Systematic Literature Review (SLR) process for the identification of QAs in GSD. SLR is comparatively fair and unbiased way to gather all the relevant literature related to a specific research question or research area [16].

To further enhance the SLR search phase we have performed snowballing technique. SLR protocol and research proposal for this research project have been published [17, 18]. A similar approach of using SLR has been used by other researchers [19].

We have used the following search string in most of the libraries as mentioned in Table 1;

("Software quality factors" OR "Software quality" OR "Software standard" OR "Software Quality Management" OR SQM OR "Software Quality Assurance" OR "Application quality" OR SQA OR "Software rank" OR "Software ability" OR "software caliber") AND (Characteristics OR aspects OR factors OR features OR components OR parameters OR drivers OR motivators) AND ("Global software development" OR GSD OR "Offshore software outsourcing" OR "Information systems outsourcing" OR "Information technology outsourcing" OR "IS outsourcing" OR "IT outsourcing" OR "CBIS outsourcing" OR "Computer-based information systems outsourcing" OR "Distributed Software Development" OR "Multi-site Software Development" OR OSDO)).

For those libraries where the lengthy string cannot be processed for searching, we have divided the string into smaller substrings. Details are given in our published protocol [17]. Table 1 is based on the result of identified papers and resources to be searched during the searching process. Table 2 and Table 3 are based on finally selected publications after applying inclusion and exclusion criteria [17]

**Table 1: SLR Result**

S.NO	Database	Total No of Papers	Primary Selection	Final Selection
1	ACM	441	47	13
2	CiteSeer	500	46	6
3	IEEE	529	132	14
4	Science Direct	111	29	12
5	SpringerLink	114	19	11
6	Google Scholar	1277	710	31
7	Emerald	68	7	1
<b>Total Papers</b>				<b>88</b>

**Table 2: Snowballing Result**

S.NO	Database	Finally Selected Papers
1	Google Scholar	19
2	SpringerLink	1
3	IEEE	6
4	Science Direct	5
<b>Total Papers</b>		<b>31</b>

**Table 3: Finally Selected Papers**

S. No	Total Number of Finally Selected papers
SLR	88
Snowballing	31
<b>Total Number of Papers</b>	<b>119</b>

**Table 4:** Software Quality Attributes for GSD

S.NO	Software Quality Attributes	Frequency n =119	Percentage
1	Reliability	77	65.8%
2	PEF (Performance, Efficiency, Functionality)	61	51.3%
3	Maintainability	57	47.9%
4	User satisfaction	47	39.5%
5	Complexity	31	26.1%
6	Modularity	23	19.3%
7	Competitive Cost	14	11.8%
8	Reusability	13	10.9%
9	Effectiveness	6	5.0%
10	Greenness	2	1.7%

During the Initial selection of the primary sources, we have reviewed the title, keywords and abstract. The rationale behind this is to select only relevant literature. After selecting papers we studied full text paper and select only those which fulfilled our inclusion criteria. The same approach is used by other researchers as well [20]. We have measured the quality of publication during the process of data extraction by considering the following questions.

- Is the methodology in the paper clearly mentioned?
- Is it clearly mentioned in the paper, how software quality were measured/evaluated in GSD projects?
- Is the sample size of the study clearly mentioned in the paper?

Each of the above factors is marked as 'YES' or 'NO' or 'N.A'. We accumulated data from finally selected papers. The data extraction process was conducted by the primary reviewer and the secondary reviewer and as a result provided gaudiness in each step. The extracted data has been stored in MS-Word format and entered in SPSS to perform different analyses based on various variables.

#### 4.0 RESULTS

In order to answer the research question; the below table represents different Quality Attributes along with their frequencies and percentages.

The identified Software QAs, given in Table 4, are explained as follow:

**Reliability:** Our results show that "Reliability" is the most important attribute which guarantee the success of software products in GSD projects. Research indicates that most customers terminate their software contracts due to poor or unsatisfied quality of products [4]. We suggest that vendor organizations should give more attention to the reliability of software in order to gain trust of their customers in GSD projects.

**PEF:** We have combined three different quality attributes "Performance, Efficiency and Functionality" as a single attribute "PEF". The reason is that these are related to the output and resource utilization of computer system. Customers consider software to be more efficient if its performance and functionalities are according to their needs and expectations.

**Maintainability:** Maintainability of software helps customer to use it for a long time according to their needs. Maintainable software works better and for a long time, therefore develops trust between GSD vendors and customers. In GSD, organizations spend their capital to make software highly maintainable according to software engineering rules.

**Customer's Satisfaction:** Customer's satisfaction is the standard by which software is measured. It is customer's satisfaction that makes vendors more confident to work in GSD environment. Customer's satisfaction is the degree in which it measures how vendor organizations understand the requirements and expectations of their customers. If customers are satisfied with the delivered software, it indicates that the software developed by GSD vendor is of high quality.

**Complexity:** Complex software makes it hard to be maintainable and less understandable. Vendors should make the complexity of software as much less as possible. This is because if the software is more complex it needs more documentations and explanations at each stage.

**Modularity:** Software modularity is very important for GSD vendors as it helps them to make their software flexible, reusable and more understandable. In modular approach of software development, software is developed component by component. The quality of each component ensures the quality of final deliverable product.

**Competitive Cost:** Low-cost is one of the motivators of GSD, therefore cost should be reasonable and hidden costs should be controlled by vendor organizations. It will help to develop long lasting relationship between customers and vendors. By software cost we don't only mean its development cost, but also its maintenance cost. Delivering high quality software products in a cost effective manner is the goal of GSD.

We have also identified that 'Reusability', 'Effectiveness', 'Greenness' is also important for the success of a software product. Software reusability helps vendor organizations to save their time, cost and efforts. Effectiveness of software is optimized by GSD vendors to deliver high quality software products. They make the proper decisions to make software more effective for their customers [21]. Development of

green software is a new emerging area which ensures the development of environment-friendly and sustainable software.

## 5.0 CONCLUSION AND FUTURE WORK

The findings of our study show that GSD vendors have to focus on addressing the identified list of quality attributes in order to deliver high quality software.

Our results show that GSD vendor organizations should try their best to improve the reliability. The distributed environment is considered more risky for software development therefore GSD vendors should make their software products more reliable for customers [8]. Our aim of this research project is to develop a model that assess the quality of GSD software products and provide most appropriate metrics for the identified QAs. Software Quality Assessment Model for Global Software Development (SQAM-GSD) will also provide real world practices for vendors. This paper is a signal component of our proposed research model SQAM-GSD. Our future plan is to conduct an empirical study like we did in our previous work [22], to achieve the following goals;

- Identify real world practices for each of the identified QAs
- Analyze the identified QAs based on continent/country, company size, decade ,study strategy etc
- Identify the co-relational analysis of identified QAs and Software Quality Metrics for QAs
- Perform SWOT Analysis for Software Quality Metric

## 6.0 LIMITATIONS

This paper is a single component of our research project; due to page limitations we are unable to give further analysis of the identified QAs, however we will present further analyses of the identified quality attributed in future. The findings are based on the literature review which needs validation from industry practitioners, and we plan to conduct empirical study in future.

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