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# Using Quality Measures During the Software Development Process: Case Study of Cameroonian Software Industry

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**Abstract**

Many studies on software quality use a variety of techniques and tools to assess quality in IT organizations. However, it is still difficult to ensure the proper use of measures to guarantee software quality. Cameroon, like many developing countries, faces a number of challenges in its software industry including limited market size, poor infrastructure, and lack of software engineering best practices. This study evaluates the software quality measurement practices in Cameroon and identifies potential areas of improvement. This study conducted a questionnaire survey of 30 companies by identifying five main categories and nine research questions. 57% of the companies surveyed consider that the impact of the measures on the success of the project is significant, and the measurement findings are, by large, accessible to executives as well as to the staff concerned. Furthermore, the adoption of a measurement tool can improve the monitoring and management of software projects.

## A. Introduction and Background

Evaluating the quality of software involves measuring the different aspects of the software. Quality evaluation is an important activity that gives developers, architects, and engineers the possibility of apprehending the quality of their products and, consequently, to highlight their choices. However, it is still difficult to ensure the proper use of measures to guarantee software quality. To collect evidence and identify potential areas of improvement, it is important to study the quality measurement practices, methods used, and factors influencing the adoption of quality measurement in today's industry. The evaluation of quality practices in software projects generally includes the use of software metrics [1]. These measurements were used in different phases of software development life cycle. The results of these evaluations can be used by several stakeholders [1] to identify what needs to be improved and how. Data collection and analysis of quality metrics can be automated to help developers assess the quality of their software systems faster, at low cost, and with little effort. Several static measurement tools are available for this purpose. It is important to know the current situation of current practices in terms of quality in software development because the techniques for evaluating software quality, software development process, and factors are influenced by the adoption of the methods and quality evaluation tools in today's software industry.

Cameroon, like many developing countries, faces a number of challenges in its software industry including limited market size, poor infrastructure, and lack of software engineering best practices. These challenges can make it difficult for Cameroonian software companies and developers to reach their full potential. The use of quality measures in the Cameroonian software industry is still at an early stage.

This study presents an analysis of the software quality measurements practices in Cameroon's software industry. Several factors motivated the investigation of the Cameroonian software industry.

1. To the best of our knowledge, no investigation had been conducted so far into the current practices of software quality evaluation in the Cameroonian software industry even though this industry plays an important role in local software development.
2. Making the results available is beneficial to startups and the digital economy and could improve the products they supply; these results can also be used in computer education and student training.
3. An overview of the relationships among the business environment, development technologies and processes, and the quality of software developed by companies constitutes a good database.
4. An overview of the factors that influence the adoption of software quality measurement methods and the factors that lead to the low use of software-based quality evaluation methods can help overcome the poor use of quality measurement practices.

The aim of this study is to identify the factors of acceptance, adoption, and areas of potential improvement, and to provide suggestions on how to improve software quality evaluation methods and processes. The remainder of this paper is organized as follows. Section B presents related research, and Section C describes

the research approach and the data collection process. Section D presents the survey results. Section E deals with the issue of validity, and Section F concludes the paper with a summary of key findings and directions for future work.

## B. Related Work

The development of software goes through several technical stages. The major classic phases in the software development process are planning, requirements analysis, design, implementation, testing, production and, maintenance. The execution order of these phases depends on the software development cycle models. Software is of high quality when it respects certain criteria. Measuring the quality of the software comes down to formalizing these criteria and determining whether the software meets them. Quality models are composed of a set of metrics and rules to assess the software quality. Several quality models have been proposed in the literature, most of which are the ISO 9126 [2], SquaRE [3], and FURPS [4] models. However, in this work, we are not particularly interested in a specific set of quality metrics, but rather in quality measurement practices in the Cameroonian software industry, with what types of tools, by whom, and for what purposes.

**Software measurement in the project**

The concept of measurement has several definitions in software engineering literature. According to Oliviera [5], measurement is defined as the process by which numbers or symbols are assigned to attributes of entities in the real world in such a way as to describe them according to clearly defined rules. In this definition, two essential concepts are presented: entities and attributes. An entity can be an object, such as a software specification, a conceptual element of the source code, or even an event in the software product development phase. An attribute is a property of the entity to be measured (e.g., number of lines of code), functionality (in the case of software specification), or even the duration of a test phase. Generally, a measurement should produce meaningful and usual values. For example, in software engineering, instead of saying that an application is large, it can be said that it contains a million lines of code. According to the principles of metrology as described in [6], the term "measurement" refers to "measurement method," "application of a measurement method," and "measurement results". Measuring a software product is a very important activity that gives developers, architects, and quality engineers, the possibility of apprehending the quality of their products, and consequently, to highlight their choices. One of the problems with measurements that can prevent their adoption is accuracy. Several studies [1], [5], [7] have examined the accuracy of certain measurements in software engineering and some investigated the validity of these measurements [8].

In this study, we analyzed the extent and distribution of software metrics in the Cameroonian software industry. We also explored possible causes of non-measurement.

**Adoption and uses of software measurements and the importance of quality evaluation**

Previous surveys [8, 9] in China and Norway have shown that most projects use similarity or expert judgment to evaluate quality. Researchers have reported

many possible reasons for the low rate of use of software quality measurements in industry, including:

1. Many companies do not collect enough data to allow the construction of such models;
2. The type of tools used in companies would be a weakness;
3. Many of the software quality models are not detailed enough;
4. The cost related to software measurement was not negligible as the evaluation tools were not mastered [8].

As the project life cycle progresses, companies typically have different amounts of information for measuring software quality and may use different evaluation techniques at different stages of development. Regnell et al. [10] introduced an analytical model of requirement selection in product software development using a survey involving product managers and system engineers. The survey revealed that most of the respondents incorrectly selected the product requirements. To deliver the software product in conformity with customers' actual needs, Thitisathienkul and Prompoon [11] proposed a method to assess the quality of software requirements specification artifacts considering document content and structure. They argued that their model could be used to improve the quality of software development life cycle documents and support software development to meet customers' actual needs. Kaur and Kaur [12] explored the relationship between object-oriented metrics and fault proneness of an Open Source project, namely EMMA, using machine learning techniques. They found that Random Forest models performed well in fault prediction. Sahraoui et al. [13] investigated the impact of a measurement program in an industrial context by analyzing data collected on 44 industrial systems of different sizes using a set of nine variables including six quality factors (maintainability, evolvability, reusability, robustness, testability, and architecture quality), corrective-maintenance effort, code complexity, and the presence of comments. Their findings indicated a positive impact on the set of used variables and they concluded that a measurement program can have a significant positive impact on the quality of software systems when combined with decision-making procedures and corrective actions. Rothenberger et al. [14] investigated the impact of the development quality on the development productivity and product quality by analyzing data collected from Indian software projects using a set of six factors including design resources, development standards, project complexity, personnel capability, project size, and tool capability. They highlighted that the improvement of development quality leads to increase development productivity and product quality. A systematic mapping study by López et al. [15] on quality measurement in agile and rapid software development identified 61 studies published from 2001 to 2019. They observed that there is no consensus regarding quality requirement measurement and suggested that practitioners should improve quality measurement with a focus on security and usability. As the quality of a software product is strongly related to the quality of software requirements specifications (SRS), Ramesh and Reddy [16] redefined the IEEE standard metrics' measuring approaches, namely completeness, correctness, unambiguity, understandability, traceability, modifiability, verifiability, and consistency, to improve SRS quality assessment. Gong et al. [17] proposed an improvement of software quality

measurement based on the ISO SQuaRE series standards in order to improve the quality of software. The authors replicated their study by analyzing the relationships between the quality model, quality measurement, quality requirement, and evaluation process using the ISO/IEC SQuaRE Series Standards [18]. Tahir et al. [19] identified 14 basic measurement practices and proposed a model of 18 success factors for implementing the measurement process based on measurement theories found in their previous study [20]. Their model was validated using a survey of 200 software professionals in the Pakistani software industry. They found that only 10% of software companies followed any measurement model, 75% of companies did not follow any measurement standard, and 80% of software companies did not use any measurement tool. For Pakistani software professionals, synchronization between the measurement process and software process improvement, use of software measurement standards, and use of measurement tools leads to the successful implementation of a measurement process and, therefore, will improve quality prediction, monitoring, and management of software projects.

In summary, while there are many studies on quality measures, the use of quality measures in the Cameroonian software industry is still at an early stage. To increase the companies and developers' awareness of the importance of quality measure, this study investigates the critical role of measurement to the success of the software process and product project and the level of satisfaction of software professionals with the current measurement costs in the Cameroonian software industry context. To our best knowledge, there is still no investigation into why quality evaluation methods are not used; therefore, we have not attempted to explore this question.

### C. Methodological approaches to software quality and the survey

The main methodological approach consisted first to identify the major challenges in the software quality literature. Next, we contextualized survey questions to the Cameroonian environment. We identified five main categories and nine research questions (RQ):

1. Quality measurement in the stages of software development (RQ1);
2. Software quality measurement tools (RQ1, RQ2 and RQ3);
3. Impact of quality measures (RQ4 and RQ5);
4. Monitored activities and frequency of measurements (RQ6 and RQ7);
5. Actors and Authors of quality measures (RQ8 and RQ9).

The nine RQ are:

- RQ1: During the project life cycle, at which development stages is quality measurement conducted?
- RQ2: What types of tools are used for software quality measurements?
- RQ3: What important characteristics guided your choice of the tool?
- RQ4: How important is quality measurement to the success of the project / Process / product?
- RQ5: How would you describe the influence of the use of software metrics on the overall quality of the project / process / product?
- RQ6: How often are software quality metrics are used by project stakeholders?

- RQ7: What activities are monitored / controlled by the quality measures?
- RQ8: Who uses the quality measures?
- RQ9: Who has access to measurement results?

Research questions require different types of information; for example, RQ1 requires objective data from actual and completed projects and RQ5 requires subjective opinions. Most of the respondents could not provide all of the information in the questionnaire. For example, when the respondent is a developer, he cannot know whether top management uses measures.

Therefore, we also designed telephone interviews, besides the survey questionnaire, as another method of data collection. It should be noted that the survey method by online distribution of the questionnaire can cover more companies than face-to-face interviews.

**Performing a question-and-answer survey**

We distributed the questionnaire online to collect the data with the support of the University and the Ministry of Higher Education. The results of this research can contribute to the improvement of the software development process in Cameroon and teaching. With the support of the Ministry of Finance, we had access to 599 companies. Figure 1 indicates the distribution of these identified companies. We distributed the questionnaire through the e-mail addresses and WhatsApp contacts obtained from the taxpayer file of the Directorate General of Taxes. Then, telephone interviews took place. The companies selected covered different sizes, fields of activity, and levels of maturity.

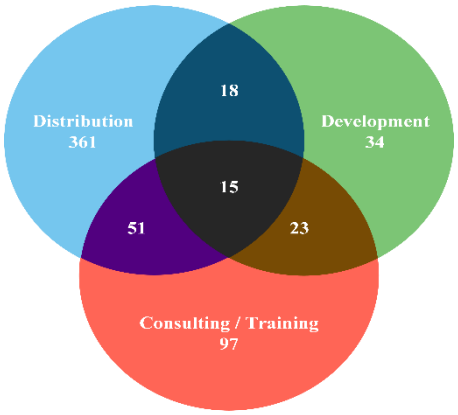


**Figure1.** Domains and distribution of companies working in the software industry in Cameroon

The process chosen to collect data during a survey by online distribution of the questionnaire is that of the SEI Guideline of Survey Design [21]. Table 1 presents seven steps of the SEI Guideline of Survey Design.

**Table 1.** SEI Guideline of Survey Design [21]

| No. | Stage | Explanation / Observation |
|---|---|---|
| 1) | Identify research objectives | Discover the tools, the actors, the users of quality measures in software projects. Get information on the adoption of evaluation methods and tools. |
| 2) | Identify and characterize the target audience | Successful organizations or concerned with improving their products and software processes. |
| 3) | Design the sampling plan | 100 organizations chosen from the list of software development companies provided by the Ministry of Finance. |
| 4) | Design and write the questionnaire | We designed most of the questions after a pre-survey as closed questions, so they are easy to complete within a limited time frame. |
| 5) | test the questionnaire | Pilot study in three software development organizations and validation of the feasibility of this investigation. The pilot study asks respondents how they understand and answer each question. Respondents rated the questions as easy to understand and answer. |
| 6) | Distribution of the questionnaire | We distributed 100 questionnaires. |
| 7) | Analyze the results and write a report | During the final survey by online distribution of the questionnaire, we got 37 respondents out of the 100 organizations, of which 30 are exploitable (6 are part of the same company and 1 is not exploitable). |

### Study environment and sampling

Table 2 summarizes the size of the 30 companies surveyed and we can observe that these software development companies are small, with 50% with less than 5 people. This suggests that software is often developed by individuals in informal businesses without registering as a formal company. The majority of the software industries are informal.

**Table 2.** Presentation of responding companies

| Organization size (people) | Number of companies |
|---|---|
| <5 | 14 |
| 5-20 | 5 |
| > 20 | 11 |
| **Total** | **30** |

In Table 3, we can observe that Center Region which is the administrative heart of Cameroon has the most businesses compared to the Littoral region, with Douala the economic capital where we expected to register more businesses.

**Table3.** Location of responding companies

| Region | Number of companies |
|---|---|
| Center | 14 |
| Far North | 6 |
| Littoral | 8 |
| North | 1 |
| Not identified | 1 |
| **Total** | **30** |

The survey questions used companies as the unit of analysis. For more than one response from a company, we aggregated the data from respondents from that company using the following rule: for the company as a unit of analysis, the responses selected were the responses that were chosen by the majority of respondents from the same company.

## D. Analysis of the survey results

After collecting and analyzing the data, we present a statistical analysis of the responses obtained. The large aggregates constitute the five categories mentioned previously by aligning questions that belong to the same group.

**Quality measurement in the stages of software development**

According to respondents, measurements are primarily conducted during the planning stage, which is somewhat unexpected given that prior research [22] indicates that measurements are typically taken during implementation and tests stages.

*RQ1: During the life cycle of the project, at what stages of development is a quality measurement performed?*

**Table4.** Stages of development affected by a quality measurement

| Steps | # | % |
|---|---|---|
| Planning | 14 | 23 |
| Design | 12 | 19 |
| Implementation | 9 | 15 |
| Test | 13 | 21 |
| Production | 9 | 15 |
| Never | 0 | 0 |
| I do not know | 5 | 8 |
| **Total** | **62 *** | |

*Many possible responses

It is worth noting that none of the respondents answered there were no quality measures. This reflects a certain awareness of the role of quality measures. Almost half (42%) of the respondents reported that both planning and design apply quality measures. It is therefore important to understand that these two steps, which are not yet concerned with the actual codification or testing, are much more abstract and therefore require more meticulous monitoring of standards and methods, while the implementation is more mechanical.

**Software quality measurement tool**

Without going into the exhaustive list of software quality measurement tools, we preferred to group the tools according to the main phases while asking for a specific indicator if there were separate tools. Therefore, the modelling, design, and test phases make it possible to better sequence the responses and experiences acquired in the Cameroonian software industry.

*RQ2: What types of tools are used for software quality measurements*?

To capture software quality in its fullness, it is important to know the types of tools used in the measurements, as the tool can influence the accuracy of the measurement and bias the result.

**Table5.** Types of tools used by the companies

| Tool types | # | % |
|---|---|---|

| | | |
|---|---|---|
| IDE | 11 | 23 |
| Separate measuring tool | 6 | 13 |
| Design | 6 | 13 |
| Modelization | 6 | 13 |
| Test | 11 | 23 |
| No tool | 2 | 4 |
| I do not know | 5 | 11 |
| **Total** | **47 *** | |

*Many possible responses

Excluding the generic IDE tool and the test tool, all phases require the same attention. This shows that the respondents do not have preferred tools for the modeling and design phases. The answer on the test tool aligns with findings from literature, which indicate that tools are primarily used in the test phase.

*RQ3: What important characteristics guided your choice of a tool?*

According to the respondents, the choice of the tool depends on its ability to support several metrics (18%) and its dependence on programming languages (12%) and platforms (12%). The independence of the tool from the programming language is not a determining criterion of choice. According to our interviews, companies use almost the same language for their different projects.

**Table6.** Characteristics guiding the choice of the tool

| **Characteristics** | **#** | **%** |
|---|---|---|
| Platform independence | 7 | 10 |
| Support for some platforms | 8 | 12 |
| Support for particular programming language | 8 | 12 |
| Programming language independence | 4 | 6 |
| Supported some measures | 7 | 10 |
| Support for many metrics | 12 | 18 |
| Visualization of results | 7 | 10 |
| Saving and interpretation of results | 6 | 9 |
| I do not know | 9 | 13 |
| **Total** | **68 *** | |

*Many possible responses

**Impact of quality measures**

37% of respondents believed that the impact of the measures for the success of the project is large, as well as its influence on the quality of the software product. To complete a project and have a product accepted by the customer, it is important to assess the quality of the software during its development.

*RQ4: How important is quality measurement to the success of the project / process / product?*

**Table7.** Importance of quality measurement for project success

| **Importance** | **#** | **%** |
|---|---|---|
| Crucial | 6 | 20 |

| | | |
|---|---|---|
| Big | 11 | 37 |
| Average | 8 | 27 |
| Small | 2 | 7 |
| Insignificant | 0 | 0 |
| Without effect | 0 | 0 |
| I do not know | 3 | 10 |
| **Total** | **30** | |

Apart from the 10% who knew nothing about the quality of the software, everyone else agreed that quality measurement is important for the success of the project. More than half (approximately 57%) attached at least great importance to them. This suggests that quality measurement is not a related requirement in software development; it is at the heart of the concerns of the Cameroonian developers.

*RQ5: How would you describe the influence of the use of software metrics on the overall quality of the project / process / product?*

**Table8.** Influence of the use of software metrics on the overall quality

| **Influence** | **#** | **%** |
|---|---|---|
| Crucial | 5 | 17 |
| Big | 11 | 37 |
| Average | 9 | 30 |
| Small | 1 | 3 |
| Insignificant | 0 | 0 |
| Without effect | 0 | 0 |
| I do not know | 4 | 13 |
| **Total** | **30** | |

In Table 8, 37% of companies believe the measures have a great impact on the project success and, by extension, on the team productivity. Project managers would, therefore, help from promoting a culture of using quality measures to ensure or improve the productivity of their teams.

**Monitored activities and measurement frequencies**

*RQ6: How often are software quality metrics used by project stakeholders?*
*RQ7: What activities are monitored / controlled by the quality measures?*

**Table9.** Frequency of use of quality measures

| **Frequency** | **#** | **%** |
|---|---|---|
| Never | 2 | 7 |
| Rarely | 2 | 7 |
| Sometimes | 10 | 33 |
| Most of the time | 6 | 20 |
| Always | 6 | 20 |
| I do not know | 4 | 13 |
| **Total** | **30** | |

**Table10.** Activities monitored / controlled by quality measures

| **Roles** | **#** | **%** |
|---|---|---|

| | | |
|---|---|---|
| Senior | 7 | 9 |
| Middle manager | 2 | 3 |
| Project Manager | 6 | 8 |
| Business Analyst | 4 | 5 |
| Scrum master | 4 | 5 |
| Leader | 5 | 7 |
| Architect | 3 | 4 |
| Developers | 15 | 20 |
| QA analyst | 4 | 5 |
| Testers | 13 | 18 |
| DevOps | 6 | 8 |
| I do not know | 5 | 7 |
| **Total** | *** 74** | |

*Many possible responses

From Table 10, we can observe that developers and testers are the most interested by quality measures. This is aligned with the data in Table 4, which gives 36% (implementation and test) as the phases in which measurements are performed.

**Users and access to quality measures**

*RQ8: Who use the quality measures?*
*RQ9: Who have access to the measurement results?*

**Table11.** Users of quality measures and measurement results

| Roles | Users of Quality measures (%) | Users of Measurement results (%) |
|---|---|---|
| Senior | 17 (24) | 19 (21) |
| Middle manager | 5 (7) | 9 (10) |
| Project Manager | 15 (21) | 15 (17) |
| Business Analyst | 4 (6) | 4 (4) |
| Scrum master | 7 (10) | 5 (6) |
| Leader | 12 (17) | 14 (16) |
| Architect | 1 (1) | 3 (3) |
| Developers | 3 (4) | 6 (7) |
| QA analyst | 1 (1) | 3 (3) |
| Testers | 1 (1) | 5 (6) |
| DevOps | 0 (0) | 3 (3) |
| I do not know | 4 (6) | 3 (3) |
| **Total** | **70 *** | **89 *** |

*Many possible responses

Table 11 shows that senior managers are the main users of the software measures. However, there are some contradictions such as: from Table 4 'Stages of development concerned by a quality measurement', approximately 21% of quality measurements are made during tests, while only 1% of testers use these measurements and only 6% have access to them. It would therefore be interesting for project managers to democratize access to quality measurement results to increase the productivity of companies.

## E. Study limitations

Limitations refer to influences or shortcomings that are beyond researchers' control and place restrictions on the methodology and analysis of research data

[23]. The main threat to the validity of this study is that the sampling can be biased by companies that do not represent the average size or level of process maturity of the industry. Owing to the small sample size, it was difficult to draw statistically significant conclusions.

The sample size may also not be representative; the source is the Ministry of Finance, which has another objective of checking if the company is developing high-quality software. This can be justified by the limited market size. The surveyed companies were concerned about improving their product and software processes. These companies were more willing to cooperate in the study to improve software development. Perfect probability sampling is hardly possible, as many companies are unwilling to cooperate or lack the necessary capacity. However, we strongly believe that our sample matches our target audience and is consistent with our research objective of exploring potential improvements in software-quality measurement methods and processes. An important factor in the analysis was the accuracy of the answers provided. When generalizing the results, it should be noted that this is a survey of Cameroonian software companies. Cultural issues may also limit the generalizability of the findings.

## F. Conclusion and Future Work

The objective of our research was to study the current situation related to software quality measurement in Cameroon, to identify the factors of acceptance, adoption, and areas of potential improvement, and to provide suggestions on how to improve software quality evaluation methods and processes. The acceptance and use of quality measurement are an important aspect in the present situation and is critical for the future improvement of software quality measurement. To illustrate the current situation, we can now use the unified theory of acceptance and use of technology (UTAUT) [24] to organize our observations on the use of technology, barriers to technology transfer, measurement performance, potential improvement, etc. The following four constructs of the UTAUT model play an important role as direct determinants of user acceptance and usage behavior:

- Performance expectation: the degree to which the system usage is believed to help bring about performance gains.
- Effort required: the degree of ease of use of the system.
- Social influence: the extent to which one believes that “others” believe that one should use the new system.
- Condition facilitation: the extent to which an individual believes that an organizational and technical infrastructure exists to support the use of the system.

Using this UTAUT model, we made the following observations:

1. **Observation 1:** Quality measures are important for the success of projects and stakeholders;
2. **Observation 2:** The actor and author of a measure are not necessarily the same;
3. **Observation 3:** Access to measurement results is mainly reserved for senior executives.

These three key observations from our survey analyzes can stimulate further discussions, future research and prompt improvements in software quality measures. Since quality is transversal, it would be good for all actors to look at the

quality management. Important measures should also be applied regardless of the people involved in the actual development. Further surveys and experiments are required to study the factors that influence the application of quality measurement practices. We also plan to design measures to evaluate data collection and analysis' cost related to quality measures. It would be wise and important for companies that archive measurement data from their projects to monitor software development in Cameroon over time to see deviations and changes in measurement performance and potential improvements. It would be important for companies that archive measurement data from their projects to monitor software development in Cameroon over time to see deviations and changes in measurement performance and potential improvements.

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