Measuring the Quality of the Development Process Academic System with E-GQM Method

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Abstract—In a software development project, aspects of software quality are fundamental; all stakeholders expect high-quality software. To ensure the quality of software products, it is necessary to ensure the software quality process. A software process is essential to be assessed from their quality. In the software development process, the developer needs guidance in carrying out every aspect of it. The goals to achieve and the procedure to measure for each aspect's goals performance must be determined. One method that can be used is the Extended Goal Question Metric method. This method determines what aspects must be achieved for each development process. A few goals to measure are defined for each aspect. For each goal, one or more goals determine one or more relevant questions. For each question, an appropriate metric is determined. The next step is mapping between G to Q and Q to M. The measurement was conducted by calculating the goal value obtained from the metric calculation. From this metric, each goal's value could be obtained, whether it is achieved or not. The tests were carried out on the software process to develop the academic Directorate of Technology and Information System Development of Institut Teknologi Sepuluh Nopember Surabaya, Indonesia. Each goal's value exceeded 0.51 (for a scale of 0-1), which achieved the Software development process's quality. The total average score was 0.889.

Keywords—Quality software; metric; calculation; goal; question; academic.

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I. INTRODUCTION

Along with the development of information technology, more software is being developed to meet various types of fields. In a software development project, aspects of software quality are essential. Software quality includes both the development process and the product. To ensure the quality of the software, it is necessary to measure the software being developed. The measurement process will be useful if it focuses on specific goals. One measurement method that fits this thinking is the Goal Question Metric (GQM) method.

The Goal Question Metric (GQM) methodology is a reference for goal-driven measurement in software engineering. The original formulation by Basili and Weiss [1] defined the foundations of the method as a succession of steps: establish goals, formulate questions from the goals, design and perform data measurements based on the questions. The Goal-Question-Metric (GQM) approach [2] presents a hierarchical structure, starting from a goal. This goal specifies the measurement's objective, the problem to be measured, and the point of view. The software quality measurement system based on GQM works in three stages consists of a definition, data collection, and interpretation stage. In the definition stage, the formation of GQM is carried out. The data collection stage includes the stage of entering software development project data into the database. Then, in the interpretation stage, a comparison is made between the data that has been collected and the baseline. The measurement results report states that a goal is achieved or not achieved. Extended GQM could align the questions conical to a predefined goal, and the answers are put into a metric to be measured later [3].

The Extended Goal Question Metric adds several aspects to limit the possibility of bias in measurement, data collection, and analysis that may occur. These aspects are prioritization and categorization. In preparing goal questions and metrics, the goals defined in the form of requirements and questions are obtained from the evidence of implementing the requirements that must be achieved in ISO 9001: 2000. Simultaneously, the metric is obtained from the questionnaire results and calculated using two ways:
Several previous studies have shown the effectiveness of the method Goal Question Metric in measuring software quality. Kiswinardi used the Extended Goal Question Metric method in measuring the quality of e-government services [5]. Aspects that are measured are the level of user satisfaction, response time, quality, and operation. The research differences associated with this study are different, namely measuring quality in software management processes [6], [7].

A. Goal Question Metric

An approach that assumes that to measure success one must first set goals, both for the organization and for the project itself, then the data that is expected to be able to define these goals operationally must be traced. Until finally, it can provide a framework for interpreting the data stated as goals.

1) Conceptual Level (Goal): Goal is defined for an object, for various reasons that are related to various quality models, from various points of view, related to a particular environment.

2) Operational Level (Question): A set of questions is used to characterize how the assessment/achievement of specific objectives will be shown based on the characteristic model's fulfillment.

3) Quantitative Level (Metric): A data set is associated with each question to answer it quantitatively. The data in question can be objective data or subjective data.

4) Extended Goal Question Metric (E-GQM): E-GQM adds several aspects to limit the possibility of bias in measurement, data collection, and analysis that may occur. These aspects are prioritization and categorization. Priority is selecting goals under the organization; existing goals can also be categorized based on the development organization's needs.

B. Method

The flow stages of this research method process are as follows:

1) Literature Study: Extended Goal Question Metric Method can be used as a method to measure software quality and produce system performance analysis results at high levels, both qualitatively and quantitatively.

2) Mapping goals: questions and metrics formed are made based on the quality management system standard ISO 9001: 2000. Goals defined in the form of requirements and questions are obtained from the evidence of implementing the requirements that must be met in ISO 9001: 2000. The metric was obtained from the questionnaire results and calculated using two methods: dividing the question and dividing it yes/no [8].

3) Questionnaire: To determine the metric's suitability with the question, the Guttman scale questionnaire method is used to measure it. This scale only consists of “Yes” and “No” answers, without any other alternative answers.

4) The calculation: the questionnaire results calculation is subject to obtain a report on the analysis of each selected goal's measurement. The report's content is the average value of the measurement and whether a goal is achieved or not.

5) Evaluation: The questionnaire results are evaluated to analyze the results; the output is a report on the measurement results.

The list of goals is presented in Table I, and the list of questions is presented in Table II below.

| TABLE I | LIST OF GOALS |
|---------|---------------|
| G1      | Shows product conformity with a relevant user and regulatory requirements |
| G2      | Establishing, documenting, implementing, and maintaining a quality management system Improve the effectiveness and efficiency of the system on an ongoing basis according to the requirements of the quality management system |
| G3      | Documents exist to ensure the effectiveness of planning, operating and controlling processes |
| G4      | The available documents are easy to identify and understand with the current revision status; the latest version is available |
| G5      | Top management can provide evidence of the development, implementation, and improvement of the effectiveness of the quality management system on an ongoing basis |
| G6      | Top management can guarantee quality objectives |
| G7      | Planning for the quality management system is well implemented |
| G8      | Top management can define and communicate responsibilities and authorities within the organization |
| G9      | Top management can establish: The appropriate communication channels/media to ensure the effectiveness of the quality management system |
| G10     | Top management conducts reviews of the quality management system at planned time intervals, to ensure its suitability, adequacy, and effectiveness |
| G11     | The organization can provide the resources needed for correction and prevention. (Resources in the form of: employees, work environment, information, suppliers and partners, natural resources, financial resources) |
| G12     | Personnel carrying out work that affects product quality must be competent, based on Education, Training, Expertise and Experience |
| G13     | The organization can determine, provide, and maintain the infrastructure needed to achieve conformity to product requirements |
| G14     | Organizations can plan and develop the processes required for product realization |
| G15     | Organizations can plan and control product design and development |
| G16     | Organizations can monitor information regarding user satisfaction perceptions |
| G17     | Organizations can continuously improve the effectiveness of the quality management system |
| G18     | The organization can take action to eliminate the causes of the nonconformities, preventing repetition according to the effects of the problem |
TABLE II

LIST OF QUESTION

Q1 Does the application run according to its function?
Q2 Is there any contractual evidence of certification from the certification body?
Q3 Is there any non-contractual evidence of a consistent application of the quality management system?
Q4 How many times a month on average the application can run according to its function?
Q5 How many times a month do you on average access the application?
Q6 Does the application create an application business process (in the form of a flowchart) first in the manufacturing process?
Q7 Is the application in accordance with management requirements (management quality standards)?
Q8 Is there a Quality Manual Document?
Q9 Are there any documents required (Procedures, Standard Operating Procedure, standard parameters, etc.) according to customer requirements or the organization's business processes?
Q10 Is the existing document the latest document?
Q11 How many documents can be integrated with other system documents?
Q12 How many documents there are?
Q13 Does Top Management Communicate the importance of user & regulatory requirements?
Q14 Does Top Management carry out a management review?
Q15 How many quality policies were implemented?
Q16 How many times Top management establishes a quality policy?
Q17 Does the application meet the quality objective objectives in each section related to user requirements?
Q18 Is there any evidence regarding the company's performance?
Q19 Are the quality objectives, according to the stipulated timeframe, and is there evidence of supporting data for their achievement?
Q20 Can the company show an organizational structure in accordance with existing conditions?
Q21 Can the organizational structure show job descriptions, especially those related to the management of the quality management system?
Q22 Can top management show information / records and physical activities of internal communication (meetings)?
Q23 Is there physical evidence such as available internal communication media (telephone, fax, e-mail, bulletin, meeting room)?
Q24 Is the system in accordance with process performance and product suitability?
Q25 How many times a month are there corrective actions and risk treatment (errors)?
Q26 How many times a month does the system experience an error (q16)?
Q27 Does the company create and implement a vision-based resource development plan?
Q28 To use non-renewable Resources or consider impacts on the environment?
Q29 Can the company show evidence of employee competency related to quality, such as education, skills, and training?
Q30 Does the company provide facilities such as buildings, workspaces, utilities?
Q31 Does the company provide auxiliary services such as transportation or communication?
Q32 Can the company show proof of product requirements information used as a reference in product realization (e.g., contracts, sample limits, technical drawings, standard parameters) set?
Q33 How many design and development stages?
Q34 Number of design stages verified, validated at each design and development stage?
Q35 Does the company have a record of measuring customer perceptions, including the results of their evaluation?
Q36 How many services can be accessed?
Q37 What is the total number of services?
Q38 What is the number of complaints against specific applications?
Q39 What is the number of complaints against all applications?
Q40 Are there any recommendations for corrective action on conditions related to the quality policy?
Q41 Are there any results of the analysis that recommend continuous improvement action?
Q42 Are there mechanisms/methods for identifying non-conformities, analyzing the causes of non-conformities, and corrective action?
Q43 Is there evidence of corrective action records and verification of the results of corrective actions?
Q44 Is there an evaluation of the need for action to prevent inconsistencies in determining and implementing the actions needed?

III. RESULT AND DISCUSSION

A. Goal Question Metric Mapping

Each Goal mapping with one question will have a metric. Mapping 18 Goals with 42 Questions and their metrics is shown in Table III. For metric, there are two types, namely Yes/ No and Division of 2 Question values.

TABLE III

GOAL QUESTION METRIC MAPPING

| Goal | Question | Metric |
|------|----------|--------|
| G1   | Q1, Q2, Q3 | Yes/No |
| G1   | Q4, Q5    | Q4/Q5  |
| G2   | Q6, Q7    | Yes/No |
| G3   | Q8, Q9    | Yes/No |
| G4   | Q10       | Yes/No |
| G4   | Q11, Q12  | Q11/Q12|
| G5   | Q13, Q14  | Yes/No |
| G5   | Q15, Q16  | Q15/Q16|
| G6   | Q17, Q18  | Yes/No |
| G7   | Q19       | Yes/No |
| G8   | Q20, Q21  | Yes/No |
| G9   | Q22, Q23  | Yes/No |
| G10  | Q24       | Yes/No |
| G10  | Q25, Q26  | Q25/Q26|
| G11  | Q27, Q28  | Yes/No |
| G12  | Q29       | Yes/No |
| G13  | Q30, Q31  | Yes/No |
| G14  | Q32       | Yes/No |
| G15  | Q33, Q34  | Q33/Q34|
| G16  | Q35       | Yes/No |
| G16  | Q36, Q37  | Q36/Q37|
| G16  | Q38, Q39  | Q38/Q39|
| G17  | Q40, Q41  | Yes/No |
| G18  | Q42, Q43, Q44 | Yes/No |
B. Questionnaire

Questionnaires were given to 8 Information Technology (IT) teams in the Directorate of Technology and Information System Development unit. The total number of IT teams is 14 people at the time of filling out this questionnaire and computer-based Written Exam activities so that the team in residence 8 people. Questionnaires are made from the results of literature studies; these eight people answer every question given. There are two types of answers, yes/no and Numbers. The result of the calculation with the answer Yes / No is the number of yes answers divided by the total respondents. As for the calculation of eligibility is with the score obtained is divided by the maximum score.

C. Questionnaire Calculation

The results of filling the questionnaire are then collected and processed using an algorithm following Figure 1 for mapping and Figure 2 for goal value calculation.

```
Input goal id metric
Set str replace[G, " "]
Set str replace[metric id, " "]
Set ide metric = "M.goal id metric"
If (analysis gqmi==0)
   Input baseline min, baselin mid, baseline max;
Else
   Save data to db
   Print "data saved"
End

Fig. 1 Mapping GQM Process Algorithm

Metric calculation algorithm so that the analysis results both quantitatively and qualitatively are shown in Figure 2.

```

Input answer
If (answer==numerator)
   Set sum(answer) as answer, count(answer) as participant,
   sum(answer)/count(participant) as average_numerator
Get average_numerator value
If (average_numerator!=0&&average denominator!=0)
   Calculate average numerator/average denominator
   If the result>baseline mid
      Print analysis result “Achieved”
   Else
      Print analysis result “not achieved”
end

Fig. 2 Goal value calculation

D. Evaluation of Measurement Results

Test data is from its Integra system; the goal is to assess the level of conformity between the goal and the finished product, whether it is under the original goal or not. After the goal selection stage, map the goal to question and question to metric, then the results are shown in Table IV. Pada Table IV, the accumulated value of all questions per goal is fulfilled. From the results of the processing obtained in evaluating which attributes are still to be fixed on the yes answer, which is less than 50%.

IV. Conclusions

Measurement results of the E-GQM method can help developers determine which goals have been achieved and which have not. If it has not been achieved, then improvements can be made. From the Integra system or
educational system's measurement results, all goals have been achieved with a value of > 0.51 for each goal. At the same time, the total average value is 0.89.

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