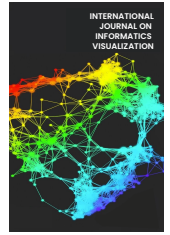




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Measuring the Quality of the Development Process Academic System with E-GQM Method

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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:

dividing, yes/no by using the Guttman scale method. The output of software quality measurement results in quantitatively and qualitatively measuring analysis reports on the software project management process based on the Extended Goal Question Metric method. The academic system requires to be evaluated and measured in quality [4]. Measurement of the quality of this academic system is needed to know the extent of its quality. The evaluation results will be carried out to improve this system on aspects of the goal that have not been met.

II. MATERIALS AND METHOD

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?

TABLE II (CONTINUED)

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, Q16	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 gqm==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%.

TABLE IV
GOAL COUNT RESULTS

Goal Id	Average Value	Analysis Result
G1	0.6875	Achieved
G10	0.875	Achieved
G11	0.875	Achieved
G12	0.875	Achieved
G13	0.9375	Achieved
G14	0.75	Achieved
G15	0.88888889	Achieved
G16	0.8375	Achieved
G17	0.8125	Achieved
G18	0.91666667	Achieved
G2	0.75	Achieved
G3	0.625	Achieved
G4	0.625	Achieved
G5	0.83333333	Achieved
G6	0.6875	Achieved
G7	0.875	Achieved
G8	0.9375	Achieved
G9	0.8125	Achieved

Since the value limit for EGQM is >0.50 , some of the things that there should be improvements are as follows:

- G1 Q2
- G3 Q8
- G4 Q10

However, overall, for the average score, all goals have been achieved. Detailed evaluation explanations and recommendations are described in Table V.

TABLE V
EVALUATION OF MEASUREMENT RESULTS

No	Code G&Q	Recommendation
1	G1 Q2 G1: Demonstrates the suitability of the product to the relevant user requirements and regulations. Q2: Is there any contractual proof of certification from the certification body?	Periodically it is necessary to conduct training on its development teams in the Directorate of Technology and Information System Development both from national and international institutions
2	G3 Q8 G3. Documents exist to ensure the effectiveness of planning, operating, and controlling processes. Q8 Is there a Quality Manual Document?	Quality standard documents are required to assess the results of the PL process developed. This documentation is essential for the guarantee
3	G4 Q10 G4: Available documents are easy to identify and understood with the latest revision status. The latest version is available. Q10: Is an existing Document up to date?	It is necessary to make planning documentation from the SDLC phase to facilitate tracking each stage, whether created, on progress, revision, or closed.

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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