Journal of Electronic Research and Application, 2025, Volume 9, Issue 5
http://ojs.bbwpublisher.com/index.php/JERA
ISSN Online: 2208-3510
ISSN Print: 2208-3502

Research on Quality Assurance and Testing Strategies of Quality Engineers in Software Product Development

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Abstract: Quality engineers play a key role in software product development, covering various stages such as requirements analysis, design, coding, testing, and delivery. Its responsibilities include formulating quality standards, writing test cases, conducting functional and performance tests, and optimizing the product based on feedback. In government procurement projects, quality evaluation focuses on process compliance, security, and functional compatibility. KPI evaluation trees are commonly used for quantitative assessment, and a dynamic adjustment mechanism for indicators needs to be established to cope with complex demands. In addition, risk-driven testing and agile development should be combined to set up quality access control to ensure that each iteration version meets expectations. The multi-dimensional quality assurance and verification scoring mechanism can effectively enhance product reliability and reduce project risks.

Keywords: Quality engineer; Government procurement; Software product quality

Online publication: October 15, 2025

1. Introduction

With the rapid development of information technology, software products are increasingly widely applied in various fields. In government procurement projects, software quality is even more of a concern. The “Measures for Promoting the Development of Small and Medium-sized Enterprises through Government Procurement” promulgated in 2020 emphasizes the fairness and impartiality of the procurement process as well as strict requirements for product quality. Quality engineers undertake multiple responsibilities in the software product development process. From requirement analysis to the final product evaluation, they need to ensure that the quality meets the standards. Meanwhile, in view of the special quality evaluation characteristics of government procurement projects, such as strict acceptance standards, service continuity, and compliance requirements, quality engineers need to establish a reasonable quality assurance system. On this basis, establishing a scientific KPI evaluation tree, a dynamic adjustment mechanism for indicators, and a risk-driven testing strategy, etc., is of vital

importance for ensuring the quality of government procurement software products.

2. Functional positioning of quality engineers and construction of a quality assurance system

2.1. Quality assurance role in software product development

Quality engineers play an indispensable role in software product development, covering the entire process from requirement analysis, design, coding, testing, to delivery. During the requirements analysis stage, they closely communicate with stakeholders, sort out and verify the accuracy and completeness of the requirements, and formulate clear requirements documents to avoid subsequent development problems caused by ambiguous or missing requirements, ensuring that the development direction is consistent with expectations. During the design review stage, quality engineers need to conduct in-depth reviews of the software architecture design, module division, and technology selection to assess whether they meet quality standards and project requirements, and put forward optimization suggestions to enhance the system's maintainability and scalability. During the coding and process auditing stages, they regularly inspect the standardization of the development process, supervise the implementation of coding standards, promptly identify and correct potential issues, and prevent the accumulation of defects. In government procurement projects, the compliance review function of quality engineers is particularly prominent. They need to strictly compare with relevant regulations and standards, and focus on reviewing the performance of software in terms of security, reliability, and functional compatibility to ensure that the products meet the strict requirements of government procurement. They supervise the quality control throughout the project's entire lifecycle by formulating detailed quality inspection checklists and audit plans, ensuring the smooth progress of the project and achieving the expected quality goals. This multi-dimensional and full-process quality supervision and review mechanism not only enhances the reliability and stability of software products but also provides a solid guarantee for the compliance and successful implementation of government procurement projects [1].

2.2. Characteristics of quality evaluation for government procurement projects

The quality evaluation of government procurement projects has unique characteristics and is different from that of commercial projects. In terms of acceptance criteria, government procurement projects have formulated stricter and more detailed regulations, covering clear technical indicators and functional requirements, such as system performance, data security, user experience, etc. Each one needs to be verified to ensure that the product fully complies with the contract agreement [2]. Service continuity is an important evaluation dimension. Government projects usually require suppliers to provide stable and reliable operation and maintenance support over a relatively long period of time to ensure the long-term normal operation of the system and meet the continuity requirements of public services. Compliance requirements are particularly crucial. Projects must strictly abide by relevant laws, regulations, and policies, such as data protection, privacy, security, and the transparency of the procurement process, to ensure the legality and fairness of the implementation process. These characteristics place higher demands on quality engineers, who need to fully integrate these dimensions into the construction of the quality assurance system and design targeted quality control strategies. For instance, by formulating detailed acceptance criteria, establishing a service continuity assessment mechanism, and strengthening the compliance review process, quality engineers can effectively address the specific requirements of government procurement projects. This multi-dimensional quality evaluation system not only ensures the compliance and functional realization of the project, but also enhances the reliability of software products and user satisfaction, providing a solid foundation

for the smooth implementation and long-term operation of government procurement projects.

3. Design of the scoring and rating system for contract performance quality

3.1. Construction of a multi-dimensional evaluation index system

The quality evaluation of contract performance for government procurement of software products needs to establish a multi-dimensional KPI index system, covering four dimensions: functionality, performance, security compliance, and service response, to ensure the comprehensiveness and scientific nature of the assessment. Functional indicators focus on whether the software meets the user's needs, involving the completeness of function realization, the accuracy of operation, and the friendliness of user experience [3]. Performance parameters focus on the operational efficiency of the system. By quantifying response time, throughput, and concurrent processing capabilities, they evaluate the software's performance in real-world scenarios. The security compliance dimension requires software to comply with relevant regulations and technical standards, safeguard data privacy and system security, and prevent potential risks. The service response dimension examines the problem-handling capabilities of suppliers, including the timeliness of fault response and the effectiveness of solutions. The KPI evaluation tree constructed by integrating these four dimensions can objectively reflect the quality level of software products and provide data support for the scoring and rating of contract performance. This system enhances the transparency and fairness of evaluation by refining indicators and conducting quantitative assessment, providing a scientific basis for the quality management of government procurement projects and ensuring that the procurement outcomes meet the expected goals.

3.2. Dynamic weight distribution model

The quality evaluation of contract performance for government procurement of software products should adopt a dynamic weight distribution model to adapt to the characteristics of different project stages. The Analytic Hierarchy Process (AHP) is the core method for constructing this model. By constructing a hierarchical structure, the evaluation indicators are decomposed into multiple levels and factors, and pairwise comparisons are made layer by layer to generate a judgment matrix, calculate the weights of each indicator, and establish the initial weight distribution [4]. This method ensures that the weight settings are scientific and reasonable, reflecting the relative importance of each indicator. In practical applications, the weights need to be dynamically adjusted according to the project stages to highlight the quality priorities at each stage. For instance, in the early stage of development, the accuracy of requirements analysis and design is crucial for subsequent development, and its weight should be appropriately increased. During the testing phase, the coverage rate of test cases and the defect discovery rate directly affect product quality, and corresponding weights need to be added. Through differentiated weight configuration, the evaluation system can accurately reflect the actual situation of performance quality at each stage, enhancing the pertinence and flexibility of the assessment. This model not only enhances the objectivity of quality scoring and rating but also provides a scientific basis for the dynamic management of government procurement projects, ensuring that quality evaluation is closely aligned with project progress [4].

4. Optimization of quality assurance strategies and test plans

4.1. Formulation of test strategies based on rating results

4.1.1. Risk-driven testing priority classification

Identifying key risk domains based on quality rating results is an important basis for prioritizing risk-driven

testing. By conducting quality ratings on each module or function of the software, the degree of risk is clearly defined. For high-risk domains, they often involve core functions, safety-critical parts, and areas where problems frequently occur [5]. Once these areas malfunction, it may have a serious impact on the entire software system. Therefore, for these key risk domains, test resources should be prioritized for allocation, and more comprehensive and in-depth test cases should be designed. Establishing a test case priority matrix is a method to further quantify and standardize the priority division. In the matrix, factors such as the degree of risk, functional importance, and the possibility of problems are comprehensively considered to assign corresponding priority values to each test case, thereby ensuring that the testing work can be efficiently and orderly focused on the key parts, and improving the effectiveness and efficiency of the testing.

4.1.2. Optimization of the automated testing framework

The formulation of test strategies based on rating results should closely revolve around the quality characteristics and risk factors of software products. Based on the dynamic monitoring rating indicators, precisely locate the key test areas and prioritize the allocation of test resources. For high-risk modules, increase the coverage and execution frequency of test cases to ensure that potential problems can be exposed in a timely manner [6].

In terms of optimizing the automated testing framework, emphasis should be placed on enhancing the flexibility and scalability of the framework. Adapt to different software architectures and functional requirements, and be capable of conveniently integrating new testing tools and technologies. Optimize the writing and maintenance mechanism of test scripts, increase the reuse rate of scripts, and reduce testing costs. At the same time, enhance the framework's management capacity for test data to ensure its accuracy and completeness, providing strong support for the reliability of test results.

4.2. Quality assurance under the agile development model

4.2.1. Iterate the quality access control Settings

Under the agile development model, the iterative quality access control setting is a key mechanism to ensure the quality of software products. By embedding a quality rating threshold control system in the Continuous Integration and Continuous Deployment (CI/CD) process, the results of each iteration are strictly evaluated. Quality engineers need to set clear quality standards and thresholds, covering dimensions such as functional integrity, performance, and safety compliance. When the development team submits code to the version control system, the build and testing process is automatically triggered, and quality ratings are conducted based on the test results and predefined metrics. If the iteration results do not meet the threshold requirements, the system will prevent them from entering the next development stage to ensure that only the code that meets the quality standards can be advanced. This mechanism effectively identifies and fixes potential defects, preventing problems from accumulating to subsequent stages and thereby enhancing the overall quality of the software. The quality rating threshold needs to be dynamically adjusted based on the project characteristics and business requirements to adapt to the rapidly changing development environment and enhance the flexibility and pertinence of the assessment. This approach, through automated and quantitative means, strengthens quality control in agile development, providing a solid guarantee for the efficient implementation and reliability of government procurement software projects [7].

4.2.2. Construction of defect prediction model

Under the agile development model, building a defect prediction model is an important strategy for improving software quality assurance. Quality engineers collect historical rating data through the system, covering key

information such as the number, severity, and occurrence stage of defects, and conduct in-depth analysis of the patterns and designs contained in the data. Defect density prediction models are developed by adopting data mining techniques and machine learning algorithms, such as decision trees, random forests, or neural networks. This model accurately predicts the distribution and density of potential defects by using input parameters such as project characteristics, code complexity, and development stage. The prediction results provide a scientific basis for the allocation of test resources, guiding quality engineers to focus on high-risk modules, optimize the design and execution frequency of test cases, and thereby enhance test efficiency and coverage. By identifying risk areas in advance, the model effectively reduces the probability of missed defect detection, lowers the cost of later repair, and enhances the stability and reliability of software products. To adapt to the rapid iteration characteristics of agile development, the model needs to update the training data regularly to ensure that the prediction accuracy is consistent with the actual requirements of the project. This method provides data-driven decision support for the quality management of government procurement software projects, significantly enhancing the pertinence and effectiveness of quality assurance [8].

5. Practice of contract performance in government procurement projects

5.1. Analysis of pain points in contract performance quality evaluation

5.1.1. Lack of quantitative assessments of deliverables

Subjective evaluation issues often exist in the traditional acceptance process, which is particularly prominent in the practice of contract performance for government procurement projects. Due to the lack of objective quantitative assessment standards, acceptance personnel often evaluate the quality of deliverables based on their own experience and subjective judgment, which is very likely to cause disputes. Different acceptance personnel may give different evaluations of the same deliverable, leading to conflicts between the supplier and the purchaser. At the same time, subjective evaluation is difficult to accurately measure whether the deliverables truly meet the contractual requirements, which may allow some products that do not meet the quality standards to pass the acceptance, while some products that meet or even exceed the standards do not receive the recognition they deserve. This situation has seriously affected the fairness and accuracy of the evaluation of contract performance quality and hindered the smooth implementation of government procurement projects [9].

5.1.2. Weak process traceability mechanisms

In the practice of contract performance in government procurement projects, there are weak points in the process traceability mechanism for evaluating the quality of contract performance. On the one hand, the relevant data records are incomplete and cannot comprehensively reflect each link of the performance process, making it difficult to accurately trace the root cause of the problem [10]. For instance, the operation records of some key nodes are missing, which makes it difficult to have a sufficient basis when evaluating quality. On the other hand, the correlation and integration of data are poor. Data at different stages are scattered and lack effective correlation analysis methods, making it impossible to form a complete process traceability chain. This makes it difficult to analyze the causes from the perspective of the entire performance process after quality problems are discovered, and thus, it is impossible to take targeted improvement measures, which affects the accuracy and effectiveness of the evaluation of contract performance quality.

5.2. Implementation of the dynamic quality evaluation mechanism

5.2.1. Milestone node rating system

In the practice of contract performance in government procurement projects, the implementation of dynamic quality evaluation mechanisms is of vital importance, among which the milestone node rating system is a key link. Quantitatively assess the progress of the project by setting clear milestone nodes. For instance, in software product development, the completion of the design phase can be regarded as a milestone. At this node, the design results are strictly reviewed in accordance with the pre-set quality standards. At the same time, link the result of this quality review to the contract payment. If the quality meets the standards during the design stage, normal payment shall be made as stipulated in the contract. If there are quality issues, the payment amount will be adjusted according to the severity of the problem, or the payment will be made after rectification is required. This mechanism prompts suppliers to attach great importance to quality at each milestone, ensuring that the overall quality of the project meets the requirements and guaranteeing the smooth implementation of government procurement projects.

5.2.2. Quality guarantee deposit calculation model

Establishing a dynamic deduction algorithm for the guarantee deposit based on the quality rating coefficient is the key to the quality guarantee deposit calculation model. By quantitatively assessing various quality indicators during the contract performance process of government procurement projects, the quality rating coefficient is determined. This coefficient takes into account multiple factors, such as the functionality, reliability, and ease of use of the product or service, comprehensively. Set the corresponding deposit deduction ratio based on different quality rating results. For instance, when the quality rating is higher, the deduction ratio is lower. When the quality rating is low, the deduction ratio shall be increased accordingly. This dynamic deduction algorithm can motivate suppliers to actively improve the quality of contract performance, ensure the smooth implementation of government procurement projects, and also provide a scientific basis for the reasonable calculation and management of quality guarantee deposits.

5.3. Design of a quality performance feedback system

5.3.1. Construction of supplier quality profile

The construction of supplier quality profiles is an important part of the design of quality performance feedback systems in the contract performance practice of government procurement projects. It is necessary to integrate multi-dimensional data to comprehensively depict the quality of suppliers. On the one hand, collect various indicator data during the contract performance process, including product quality, delivery timeliness, after-sales service, etc. On the other hand, standardize the data to ensure comparability among different indicators. By using data analysis techniques to mine the potential information behind the data, such as the strengths and weaknesses of suppliers. Based on this information, a quality profile is constructed to visually present the quality status of the supplier. Portraits can serve as an important basis for government purchasers to evaluate suppliers, which is conducive to making reasonable procurement decisions. At the same time, it can also prompt suppliers to improve their own shortcomings in a targeted manner and enhance the overall quality level.

5.3.2. Quality improvement decision support

The application of rating data mining technology can conduct an in-depth analysis of the quality and performance of contract fulfillment. By collecting and organizing a large amount of rating data, including multi-dimensional

information such as the product quality, service level, and delivery time of suppliers. By using data mining algorithms, such as association rule mining and cluster analysis, the key factors influencing quality performance and the potential relationships among them can be identified. For instance, it may be found that certain specific supplier characteristics are associated with high-quality performance. Based on these mining results, generate a quality improvement suggestion report. The report elaborates in detail on the identified issues, related factor analysis, and targeted improvement suggestions, providing strong data support and decision-making basis for quality improvement decisions. It helps the purchasing party better manage the contract performance process and enhance overall quality performance.

6. Conclusion

Quality engineers are of vital importance in software product development. In terms of quality assurance, it is necessary to start from multiple dimensions, including precise control of requirements, strict supervision of the development process, and comprehensive assessment of the final product. For testing strategies, it is necessary to comprehensively consider the applicable scenarios of different testing methods, such as the reasonable application of unit testing, integration testing, system testing, etc. Meanwhile, the verification scoring and rating mechanism has practical value in enhancing the transparency of the quality of government procurement projects and strengthening the binding force of contracts, providing references for related fields. Future research directions can focus on building a government-enterprise quality data sharing platform. Quality engineers should also master data analysis skills to better adapt to the new requirements of digital quality management, thereby more effectively ensuring quality and implementing testing strategies in software product development.

Disclosure statement

The author declares no conflict of interest.

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