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# Implementation of Equivalence Partitioning Techniques and ISO/IEC 25010 Functional Suitability Standards for Testing SCM Applications in Small-Scale Automotive Industries

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## Abstract

A Supply Chain Management (SCM) application prototype for PT XYZ has been developed. Before its release, the testing phase is crucial to minimize functional failures. This study aims to conduct comprehensive testing to verify that all functions operate as intended, deliver the expected results, and identify potential errors in the application. Unlike previous research, this study not only uses Equivalence Partitioning as a functional testing technique but also combines it with the ISO/IEC 25010 standard, which guides Functional Suitability and software quality more comprehensively. This approach addresses the limitations of Equivalence Partitioning, which typically focuses only on input class division without ensuring coverage of specific quality standards. Furthermore, integrating testing techniques with the internationally recognized ISO/IEC 25010 standard enhances the relevance and applicability of this research in software development for industries, particularly in supply chain information processing automation. By combining both methods, the testing process becomes more thorough and structured, as evidenced by the 254 test cases generated. Additionally, this study provides quantitative data in the form of valid (83%) and invalid (17%) test case percentages, which can serve as indicators of testing effectiveness and the prototype's quality.



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## INTRODUCTION

The Ministry of Industry encourages companies in the industrial sector to accelerate the implementation of Industry 4.0 through business process automation and information processing automation for both large-scale and small-to-medium enterprises (SMEs). Specifically, in 2021, the Ministry conducted e-commerce training for 13,183 SMEs and organized e-smart SME webinars to support the digital marketing of SMEs (Agustinus, Michael; Selfie, 2021). In addition to support from the ministry, independent efforts from companies are needed to implement automation in their business processes, including information processing. This presents a challenge for industries, especially small-to-medium enterprises, due to their limited resources.

PT XYZ is a small-to-medium private company with 28 interrelated positions and a total of 107 employees. The company operates in the manufacturing industry, producing finished goods by processing raw materials or semi-finished materials using equipment, production machinery, and other tools on a large production scale.

To automate information processing, PT XYZ has developed a Supply Chain Management application. The application has been designed, and a prototype has been produced. This web-based prototype is intended to integrate data from four divisions at PT Ganding Toolsindo: PPIC, Marketing, Production, and Delivery. Its primary function is to balance marketing plans, demand, availability, and procurement of raw materials, production, and distribution.

The Supply Chain Management application prototype is expected to be implemented soon to support the automation of information processing at PT Ganding Toolsindo, particularly in the Supply Chain Management area. In system development methodologies such as the Waterfall model, the development cycle includes Requirements Analysis, Design, Development, Integration and Testing, Verification, and Operation/Implementation. Before the application is put into operation, a testing phase is necessary to minimize the risk of functional failures (Pressman, Roger S.; Maxim, 2015). Several testing methods can be applied, including functional testing of the application's features using the Black Box method (Leloudas, 2023). Typically, the Black Box method offers various techniques to create test cases for application testing, one of which is Equivalence Partitioning (Homès, 2012). The techniques provided by the Black Box method guide the process of constructing test cases for testing the application (Ammann & Offutt, 2016). It does not address the standards required to categorize an application as high-quality, ensuring that all functions operate correctly, yield the expected results, and identify errors in the system. Therefore, there is a need for standardized guidance to design ideal test cases. Combining the Equivalence Partitioning technique with the ISO/IEC 25010 standards is expected to provide a solution. ISO/IEC 25010 is a standard that assesses software quality (Gordieiev et al., 2014). Functional aspects in these standards are based on three sub-aspects, namely Functional Appropriateness, Functional Correctness, and Functional Completeness (ISO org, 2011). In order to effectively judge the quality of a software system, the criteria from ISO 25010 need to be considered (Andreas et al., 2021).

The research "An ISO 25010-Based Quality Model for ERP Systems" aims to develop a quality evaluation model for ERP software in Higher Education Institutions (HEIs). With the ISO/IEC 25010 guideline, this research has succeeded in finding a new model for evaluating the quality of ERP systems in HEIs. This model consists of 8 quality factors and is divided into 34 sub-qualities (Peters & Aggrey, 2020).

The study entitled "Clinical-chatbot AHP evaluation based on 'quality in use' of ISO/IEC 25010" aims to measure the quality of chatbots through the international standard ISO/IEC 25010. This study applies a clinical chatbot comparison method with the Analytics Hierarchy Process (AHP) approach. This study shows that the approach taken provides an effective reference basis for comparing the quality of medical chatbots that comply with the ISO/IEC 25010 standard (Barletta et al., 2023).

The study "Accounting and Smart System: Functional Evaluation of ISO/IEC 25010:2011 Quality Model (a Case Study)" aims to assess the level of functional suitability of smart ERP systems in the SME sector based on the ISO 25010:2011 standard. In addition, this study also aims to produce a high-quality system as evidence of the success of smart ERP implementation automating business processes and integrating data between departments. Testing is limited only to functional suitability characteristics. Based on ISO/IEC 25010:2011 SQuaRE (System and Software Quality Requirements and Evaluation), functional suitability is defined as the degree to which a product (application) or system provides functions that meet user needs when used under certain conditions. Based on the ASQ assessment and ISO 25010:2011 standardization, Odoo accurately performs the automation function of the reporting system as well as the automatic integration of transaction data between the

accounts receivable and accounts payable accounting systems in the form of journal entries. Thus, Odoo has good reporting quality and is worthy of being developed as a smart ERP system for SMEs (Panduwiyasa et al., 2021).

The study entitled "Software Quality Analysis for Halodoc Application using ISO 25010:2011" aims to test the quality of the Halodoc application to determine the quality of the Halodoc application using the model from the International Organization for Standardization (ISO), namely ISO 25010:2011. The test will cover eight characteristics and 29 subcharacteristics. The assessment in this test will use weights, where these weights are determined using the Analytical Hierarchy Process (AHP) method. The testing method is carried out using Black-Box testing, stress testing, and distributing questionnaires to 100 respondents. This research shows that performance efficiency obtained a score of 4,886, usability obtained a score of 4, security obtained a score of 3,549, and portability obtained a score of 3,718. The total assessment results of the Halodoc application obtained a score of 4,515 out of a maximum score of 5 (Pratama & Mutiara, 2021).

The study entitled "Testing of Lecture Monitoring System Application Using ISO 25010 Standard" aims to ensure the quality of the lecture monitoring system to avoid errors and guarantee its features and functionality through testing based on the ISO 25010 standard. The instruments used in the test include a functionality questionnaire, the USE Questionnaire, stress testing, load testing, and the maintainability index. The results of the study indicate that the lecture monitoring system has met the ISO 25010 standard with a score of 100% (good) for functional suitability, 88.53% (very feasible) for usability, 100% (pass) for reliability, 4.2 seconds (acceptable) for performance efficiency, and 100 (very easy to maintain) for ease of maintenance (Mustari S et al., 2024).

The study entitled "Black Box Testing on ukmbantul.com Page with Boundary Value Analysis and Equivalence Partitioning Methods" aims to evaluate the capabilities of the ukmbantul.com platform. This study conducted testing with the Black Box model without seeing/knowing the internal structure of the code or program. The study was conducted using the boundary value analysis and equivalence partitioning methods. The results of the study indicate that the development of ukmbantul.com has considered limitations in data entry. The form used for the data entry process has been validated according to applicable limitations. Through this study, it was concluded that the boundary value analysis and equivalent partitioning indicate a for a correct and proper website. Functionality can be identified. Starting from registration, login, and entering the user dashboard, it has been validated properly and correctly (Sholeh et al., 2021).

The research entitled "Black Box Testing Using Equivalence Partition Method in Sintana Application" aims to reduce the occurrence of bugs and ensure that the application meets user needs. The method applied is equivalence partitioning in the Blackbox testing model. This study shows that there are bug gaps in the application and fixes these gaps so that they can run according to user needs (Melani & Mahmud, 2021).

Research titled "Black Box Testing on the Best Sales System Application Using the Equivalence Partitions Technique" aims to evaluate the program's functional compatibility without knowing the source code used. The research employs the Equivalence Partitions technique. The results of this study conclude that the Equivalence Partitions technique can aid in the test case creation process, and through quality testing, it identifies undetected errors such as typographical mistakes and discrepancies in data editing, where there is a mismatch between the displayed message and the data stored in the database (Ningrum, Fadhila Cahya; Dandi, Suherman; Sita, Aryanti; Handika, 2019).

The next research titled "Testing the Functional Suitability and Performance Efficiency Characteristics of tesadaptif.net." This research aims to present the results of testing two characteristics—functional suitability and performance efficiency—out of the five characteristics defined by ISO/IEC 25010. The data collection technique was conducted using questionnaires. The questionnaire data processing results were then calculated using the feature completeness matrix. Furthermore, performance efficiency testing was carried out using the GTMetrix web tool. The results of the functional suitability characteristic test, based on the feature completeness matrix, provided a score of X = 0.999. This score indicates that tesadaptif.net can function optimally at 99%, although some features are still not functioning as expected (Dako & Ridwan, 2021).

The study titled "Black Box Testing Using Boundary Value Analysis and Equivalence Partitioning on the Batik Raw Material Procurement Application with a Use Case Approach" aims to ensure the application meets the expected functional requirements. The methods used are Boundary Value Analysis and Equivalence Partitioning, with test-case design employing the Use Case approach. The test results show that these methods effectively identify errors

in the application, as evidenced by the DRE score of 0.45, meaning that 45% of the constructed test cases failed the test (I Dewa Made Widia et al., 2022).

The next study is titled "Functionality Testing of the Employee Management Information System Using the Black Box Method." This research aims to anticipate system failures before implementation. The study uses the Black Box method, which tests the system's functionality. The results identified 15 errors based on the test cases that were developed (Nyoman et al., 2021).

The study titled "Testing Functionality, Performance, and Security with Automated Testing Systems on the LIKMI Hub Application," which aims to conduct comprehensive testing of the application using the black box testing method and tools such as Android Studio, Pcloudy, and Immuniweb.com, it was found that all functions work well, and the application performs adequately during use. However, certain aspects of security still need attention (Christina, 2020).

From the literature above, no research has specifically combined the design of test cases in black box testing using the Equivalence partitioning technique with quality aspects guided by ISO/IEC 25010. The expectation of this research is to enhance software testing not only from the perspective of user requirements analysis but also by incorporating software quality characteristics guided by ISO/IEC 25010. This approach addresses the limitations of Equivalence Partitioning, which typically focuses only on input class division without ensuring coverage of specific quality standards. Furthermore, integrating testing techniques with the internationally recognized ISO/IEC 25010 standard enhances the relevance and applicability of this research in software development for industries, particularly in supply chain information processing automation.

## RESEARCH METHODS

This research refers to the basic structure of Black Box Testing using the Equivalence Partitioning technique. The stages can be seen in Figure 1.

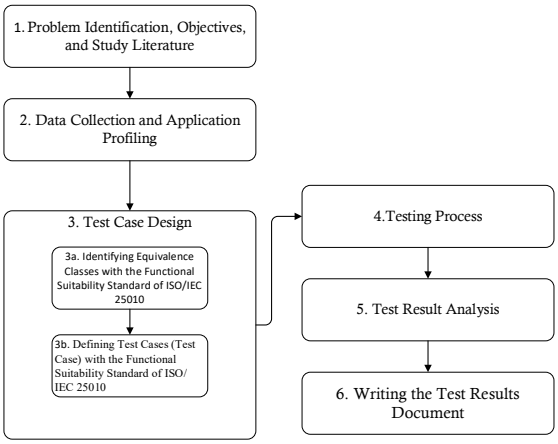


Figure 1. Conceptual framework and research stages

Based on Figure 1, the conceptual framework and research stages, there are six steps to be followed, which are:

1. Problem Identification, Objectives, and Literature Study: In this stage, observations, literature studies, and interviews are conducted to understand the development and issues related to the SCM Application development currently underway at PT Ganding Toolsindo. Observations of the SCM Application being developed, as well as literature reviews of software testing theories and company operational procedure documents related to the use of IS/IT, are carried out.
2. Data Collection and Application Profiling: In this stage, the researcher communicates with developers regarding the application access mechanism, application profile, and the application's user manual.
3. Test Case Design: In this stage, the test cases are designed by following the Equivalence Partitioning technique, starting with identifying the Equivalence Classes, followed by defining the test cases. Both steps are created by referring to the functional suitability standards in ISO/IEC 25010.
4. Testing Process: In this stage, testing is carried out based on the test cases that have been designed.
5. Test Result Analysis: In this stage, the errors found are mapped, and a determination is made as to whether all functions are operating as expected.
6. Writing the Test Results Document: In the final stage, the entire process and test results are documented in the form of a report.

## RESULT AND DISCUSSION

A. Test Case Design

1. Functional Appropriateness

This refers to the measure of features or functions that can complete specific tasks according to their intended purpose. In this case, the tasks are completed by the application. The application's functionality is agreed upon between the developer and the company, as outlined in the application functions in the Use Case diagram. The 12 Use Cases are as follows: Managing Customer Data, Managing Product Data, Printing MRP, Managing Supplier Data, Printing Material Requests, Receiving Materials, Monitoring Material Data, Printing Supplier Delivery Note Reports, Managing and Printing Production Processes, Monitoring Finished Goods Data, Sending FG Product Data, Printing Delivery Note Reports for Finished Goods, and an additional standard feature, the Login Process.

2. Functional Completeness

It is defined as an indicator of a feature or function that can operate or perform its tasks completely without any issues. This is represented by the features established to meet the Use Case requirements, with each page built being equipped with features such as "create, read/view, edit, delete, and search," supported by interface elements like columns, buttons, and dropdowns.

These features are tested to ensure they function as expected, and they are located on the specified pages based on the requirements. These pages include Login, Dashboard, Customer Module, Supplier Module, MRP Module, Purchasing Module, RM Warehouse Module, Production Module, Finish Goods Module, and Delivery Module.

3. Functional Correctness

It is an indicator that can provide its requirements correctly and accurately. The Supply Chain Management application aims to manage supply chain data, which is reflected in the agreed-upon Use Cases, including: User Data, Customer Data, Customer PO Data, Supplier Data, Supplier PO Data, Customer Order Data, Material Receipt Data, Material Shearing Data, Material Pieces Data, Material Coil Data, Material Tube Data, Production Process Data: Process 1–7, Spot Data 1–2, Finished Goods Data, and Finished Goods Shipment Data.

The next step is defining the test cases. After all the standard requirements are outlined, test cases are defined by first comparing the description of the requirements in the Use Case, the features designed to meet those requirements through the modules, and the data expected to align with the needs. These test cases are defined by using the equivalence partitioning model to determine whether the application meets the standards of appropriateness, completeness, and correctness. Based on the ISO/IEC 25010 standard approach, 254 test cases were successfully developed. An example can be found in the Supplier Module test case: the "Add Supplier PO Data" function, which is included in the testing process.

B. Testing Process

A testing process was conducted on 254 test cases by executing the predefined functions. Below is an example of the test result for one of the functions, Supplier Module: “Add Supplier PO Data” function:

Table 1. Test Case and Test Result for Supplier Module: “Add Supplier PO Data” Function

| Test Case ID | External Condition | Valid Equivalence Classes | Invalid Equivalence Classes | Result |
|---|---|---|---|---|
| SKA-130 | Clicking the "Add" Menu on the "Supplier PO" Page | Displaying the "Add Customer PO" Form with Input Functions:<br>• Customer Name<br>• Part Name<br>• Supplier Name<br>• Customer PO Number<br>• Supplier PO Number<br>• PO Date<br>• Order Quantity to Supplier<br>• Material Unit<br>• Price | • Navigating to another page / an undefined page<br>• Does not display the accompanying functions fully. | Valid |

| Test Case ID | External Condition | Valid Equivalence Classes | Invalid Equivalence Classes | Result |
|---|---|---|---|---|
| | | • Material Unit x Price<br>• Submit<br>• Reset | | |
| SKA-131 | Clicking the "Submit" Button on the "Add Supplier PO" Form with Complete Entries, as per the specifications. | • Data saved in the database and displayed on the "Supplier PO Data" page<br>• Displays the message "Supplier PO Data Saved Successfully." | • Data not saved in the database<br>• Does not display the message "Successfully Saved." | Valid |
| SKA-132 | Click the 'Submit' button on the 'Add Supplier PO' form with all fields left empty | • Data not saved in the database<br>• Displays the message "No data was saved" | • An empty record is saved in the database<br>• The message "No data was saved" is not displayed | Valid |
| SKA-133 | Click the 'Submit' button on the 'Add Supplier PO' form with one of the fields left empty | • Data not saved in the database<br>• Displays the message "All fields must be filled" | • Data is still saved in the database<br>• The message "All fields must be filled" is not displayed | Valid |
| SKA-134 | Click the "Select Customer" dropdown in the "Customer Name" column. | The list of customer names appears according to the records in "Customer Data." | The list of customer names entered in the "Customer Data" menu does not appear. | Valid |
| SKA - 135 | Click the selected customer name from the "Select Customer" dropdown | "Nama Customer"<br>The selected customer name appears in the "Customer Name" column | The selected customer name does not appear in the "Customer Name" column | Valid |
| SKA-136 | Click the "Select Customer Part" dropdown in the "Part Name" column. | The list of part names that were previously entered appears | The list of part names that were previously entered does not appears | Valid |
| SKA - 137 | Click the selected part name from the "Select Part" dropdown. | The selected part name appears in the "Customer Name" column | The selected part name does not appear in the "Customer Name" column | Valid |
| SKA-138 | "Click the "Select Supplier" dropdown in the "Supplier Name" column. | The list of customer names entered in the "Data Supplier" menu appears | "Data Supplier"<br>The list of customer names entered in the "Data Supplier" menu does not appear | Valid |
| SKA - 139 | Click the selected customer name from the "Select Supplier" dropdown. | The selected customer name appears in the "Supplier Name" column | The selected customer name doesn't appear in the "Supplier Name" column | Valid |
| SKA-140 | Click the "Select PO Customer" dropdown in | The PO customer number entered in the "Data PO | The PO customer number entered in | Valid |

| Test Case ID | External Condition | Valid Equivalence Classes | Invalid Equivalence Classes | Result |
|---|---|---|---|---|
| | the "No PO Customer" column. | Customer" menu appears as an option. | the "Data PO Customer" menu doesn't appear as an option. | |
| SKA - 141 | Click the selected PO customer number from the "Select Customer" dropdown. | The selected PO customer number appears in the "PO Customer Number" column. | The selected PO customer number doesn't appear in the "PO Customer Number" column. | Valid |
| SKA-142 | The "PO Supplier Number" column is filled with more than 4 characters. | • The input in the column stops once more than 4 characters are entered.<br>• A warning "cannot exceed 4 characters" appears below the column. | • The input in the column does not stop if it exceeds 4 characters.<br>• The warning "cannot exceed 4 characters" does not appear below the column. | Invalid |
| SKA-143 | "Quantity Order" column is filled with non-numeric characters. | • The column input stops text entry if non-numeric input is entered.<br>• A warning "Must be filled with numbers" appears below the column | • The column input does not stop text entry if non-numeric input is entered.<br>• The warning "Must be filled with numbers" does not appear below the column. | Invalid |
| SKA-144 | Click the DateTime button in the "PO Date" column. | A calendar menu appears to select a date. | The calendar menu does not appear to select a date. | Valid |
| SKA-145 | Click the selected date from the calendar menu. | The selected date appears in the "Date Promised" column. | The selected date does not appear in the "Date Promised" column. | Valid |
| SKA-146 | Click the Dropdown "Select Material" in the "Unit Material" column. | The list of previously entered material names appears. | The list of previously entered material names does not appear. | Valid |
| SKA – 147 | Click the selected part from the "Select Material" dropdown. | The selected part name appears in the "Material Name" column. | The selected part name doesn't appear in the "Material Name" column. | Valid |
| SKA-148 | The "Price" column is filled with non-numeric characters. | • The column input stops when non-numeric characters are entered.<br>• A warning "Must be filled with numbers" appears below the column. | • The column input does not stop when non-numeric characters are entered.<br>• No warning "Must be filled with numbers" appears below the column. | Valid |
| SKA-149 | Click the "Select to Multiply" dropdown | The previously entered material names appear as options. | The previously entered material | Valid |

| Test Case ID | External Condition | Valid Equivalence Classes | Invalid Equivalence Classes | Result |
|---|---|---|---|---|
| | In the "Unit Material x Price" column | | names not appear as options. | |
| SKA -150 | Click the selected material unit from the "Select Material" dropdown. | The selected material unit appears in the "Unit Materialxharga" column along with the multiplication result (final price). | • The selected material unit does not appear in the "Unit Materialxharga" column along with the multiplication result (final price).<br>• The multiplication result is incorrect. | Valid |
| SKA-151 | Click the "Reset" button. | The field entries are cleared. | The field entries do not clear. | Valid |

C. Result Analysis

From the overall test cases tested, there is one pattern of error, which is the lack of character limitations in the fields of input. For example, in the "Add Customer Data" function, there is no feature to limit the number of characters. This feature is important for maintaining the quality of the data set and minimizing input errors to ensure data integrity. The ISO 25010 aspect is closely related to the "Correctness" aspect. Figure 2 shows how character input is not restricted.

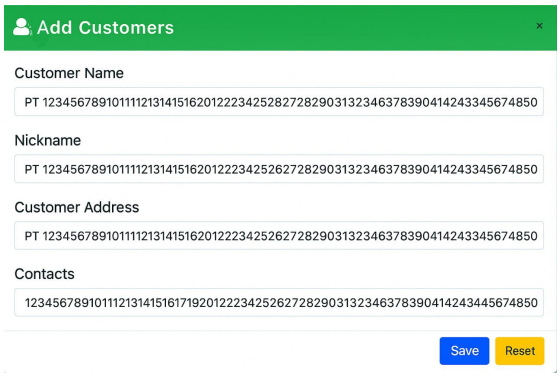


Figure 2. The character limit in the "Add Customer" feature is not restricted

Not only in the 'Add' function, but also in the 'Edit' function, there is no feature to limit the number of characters. This is important for maintaining the quality of the data set and minimizing input errors to ensure data integrity. Figure 3 shows how character input is not restricted.

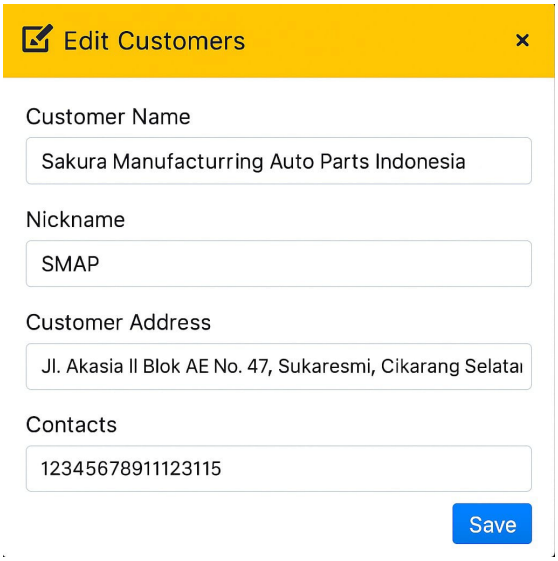


Figure 3. The character limit in the “Edit Customer” feature is not restricted

"This issue occurs in all 'Add' and 'Edit' functions of the SCM application. These functions are distributed across 5 out of the nine modules: Customer, PO Customer, Supplier, PO Supplier, and Production. This happens because the application developers do not master certain formal standards related to application quality, so they tend to overlook the potential for incorrect data to be stored in the database. As a result, of 254 test cases, 42 were declared invalid, while 212 were declared valid. This means that 17% of the features in this application did not perform as expected, while 83% of the features met the expected standards based on the ISO 25010 approach. This is shown in Figure 4.

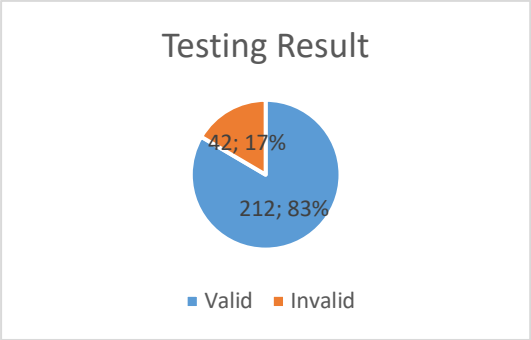


Figure 4. Testing result

This study uses a combination of techniques and standards, i.e, equivalence partitioning and the Functional Suitability Standard ISO 25010, to produce test cases based on three sub-functional aspects of the application according to ISO 25010, while still considering the application functions as agreed upon by users and developers through use case identification. This can be seen in the determination of the first sub-functional aspect, Functional Appropriateness, where use cases are used as the main sub-test cases to determine whether the outputs produced are valid or invalid.

Six previous studies produced test cases with varying numbers of sub-standards in ISO 25010, but it is unclear whether the application functions tested took into account the agreements between users and developers. In addition, studies that only used the ISO 25010 standard could not identify the potential for both desired (valid) and undesired (invalid) outputs.

The other six studies, which only used black box techniques (equivalence partitioning or boundary value analysis) without involving any formal standards, produced test cases only from use cases. As a result, the breadth of the test cases depended on the analytical and design abilities of the software developers regarding the ideal application quality standards when compiling the application's use cases.

## CONCLUSION

1. Using the ISO 25010 approach can help produce more comprehensive test cases, allowing for a more detailed testing process of functions and features.
2. The research successfully developed test cases, resulting in a total of 254 test cases based on the ISO/IEC 25010 approach and the Equivalence Partitioning testing model.
3. Out of the 254 test cases tested, 17% were invalid and 83% were valid, which means 83% of the features met the standards set by ISO/IEC 25010.
4. This study applies only one of the black box testing techniques, i.e, equivalence partitioning, and one formal quality software standard, i.e, the Functional Suitability in ISO 25010:2011. Applying other variations of blackbox testing techniques and formal standards related to software quality may result in different test case models.

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