

Quality Analysis of SMP Islam Dian Didaktika Cbt Application System based on ISO 25010 Standard

Ibnu Hakim

Information System Management Department,
Faculty of Technology and Engineering,
Gunadarma University, Jakarta

Hustinawati

Information System Management Department,
Faculty of Technology and Engineering,
Gunadarma University, Jakarta

ABSTRACT

In order to improve the quality of schools, especially in the field of technology, there needs to be support from various parties, including parents, schools and the government. One important quality improvement is the examination process. Examination is a process carried out to measure the achievement of learner competencies on an ongoing basis in the learning process, to monitor progress, make learning improvements and determine learner learning success. The Computer-Based National Examination (UNBK) which began to be held by the government in 2015-2020 and began to inspire and motivate the implementation of computer-based examinations in schools in Depok and other regions throughout Indonesia. In 2019, SMP Islam Dian Didaktika Depok City began using a webbased examination system or often known as Computer Based Test (CBT) for the implementation of examinations, both Mid-Semester Assessment or better known as PTS, End of Semester Assessment or better known as PAS and School Examinations or better known as US. Approaching 5 years of use, the CBT application system at SMP Islam Dian Didaktika has not been carried out product quality. To find out the quality of the web-based online exam system whether it has met the initial objectives to be achieved, namely making it easier for organizers to carry out the exam process, assessing students' answers and making reports on assessment results, a system evaluation is needed. This study aims to analyze the CBT application system used at SMP Islam Dian Didaktika which is currently used with the ISO 25010 method in the product quality dimension. The objectives to be achieved by this thesis research are to analyze the quality of the CBT application system at SMP Islam Dian Didaktika using the ISO 25010 standard, and to provide input and suggestions for improving the CBT application system at SMP Islam Dian Didaktika. Based on the results of research and discussion that has been carried out using the ISO 25010 standard method, the quality of the CBT application system at SMP Islam Dian Didaktika is declared feasible and meets the criteria of the ISO 25010 standard.

Keywords

ISO 25010, product quality model, CBT application system

1. INTRODUCTION

In order to improve the quality of schools, especially in the field of technology, support from various parties, including parents, schools, and the government, is necessary [1]. One of the key improvements is in the examination process. An exam is a process conducted to continuously measure students' competency achievements during the learning process, to monitor progress, improve learning, and determine the success of students' learning. The Computer-Based National Examination (UNBK), first implemented by the government from 2015 to 2020, has inspired and influenced the

implementation of computer-based exams in schools across Depok and other regions in Indonesia. In 2019, Dian Didaktika Islamic Junior High School (SMP) in Depok began using a web-based examination system, commonly known as Computer Based Test (CBT), for exams such as the Mid-Semester Assessment (PTS), End-of-Semester Assessment (PAS), and School Examinations (US).

Approaching its fifth year of use, the CBT application system at Dian Didaktika Islamic Junior High School has not yet undergone a product quality assessment. The results of the quality assessment of the CBT system at Dian Didaktika Islamic Junior High School are expected to serve as a reference for further development and to meet the general expectations of the school community, ensuring that online exams can be conducted effectively. This is intended to ensure that the system produced aligns with previously defined requirements. Additionally, testing is conducted to ensure the absence of bugs or errors, allowing users to feel satisfied when using the system. The standards for system testing vary and include Performance, Information, Economy, Control, Efficiency, and Service (PIECES) analysis, End User Computing Satisfaction (EUCS), Task Technology Fit (TTF), the Human Organizing Technology (HOT) Fit Model, and ISO 25010 [2].

The ISO 25010 System and Software Quality Requirement and Evaluation method is one of the methods for measuring the quality of online software [3]. This method can be used to assess the quality of an application system by utilizing two dimensions: product quality and quality in use. The product quality dimension refers to inherent aspects of the software and includes several indicators such as functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability [4]. Meanwhile, the quality in use dimension focuses on user aspects and includes indicators like usability in use, flexibility in use, and safety (ISO/IEC-25010:2011). ISO 25010 is used because it emphasizes system quality results based on the existing indicators from ISO 25010 [5]. In this study, only the product quality method is used, as it already encompasses the usability indicator.

Based on the background of the problem described above, the objectives of this study are as follows: First, to measure the characteristics of functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability of the CBT application system at Dian Didaktika Islamic Junior High School using ISO 25010. Second, to analyze the quality of the CBT application system at Dian Didaktika Islamic Junior High School based on ISO 25010.

2. LITERATURE REVIEW

ISO (the International Organization for Standardization) /IEC 25010 is a guideline used for software evaluation, published by the Canadian Standards Association in 2011 [6]. ISO/IEC

25010 is a new model that replaces ISO/IEC 9126-1:2001, which was technically revised (ISO/IEC 25010, 2012) [7]. The ISO/IEC 25010 model provides quality characteristics that can be considered when evaluating software [8]. This model is used for measuring software quality and is divided into two general dimensions: the quality in use model and the software product quality model. The quality in use model relates to the outcomes of human interaction with the software when used in a specific context [9]. On the other hand, the product quality model significantly influences the characteristics selected to assess the attributes of the software product. The quality of the system can be determined by how well the system meets the needs and interests of the key stakeholders involved. The needs of these stakeholders (functionality, capability, security, maintainability, etc.) are what the quality model represents. From this product quality, the system can be categorized into characteristics and sub-characteristics.

Table 1. Characteristics and Sub Characteristics of ISO 25010

Characteristics	Sub Characteristics
Functional Suitability	1. Functional Competence 2. Functional Correctness 3. Functional Appropriateness
Performance Efficiency	1. Time Behavior 2. Resource Utilization 3. Capacity
Compatibility	1. Coexistence 2. Interoperability
Usability	1. Appropriateness Recognisability 2. Learnability 3. Operability 4. User error protection 5. User interface aesthetics 6. Accessibility
Reliability	1. Maturity 2. Availability 3. Fault tolerance 4. Recoverability
Security	1. Confidential 2. Integrity 3. Non-repudiation 4. Accountability 5. Authenticity
Characteristics	Sub Characteristics
Maintainability	1. Modularity 2. Reusability 3. Analyzability 4. Modifiability 5. Testability
Portability	1. Adaptability 2. Installability 3. Replaceability

The process of measurement in ISO 25010 consists of 8 characteristics: Functional Suitability, Reliability, Usability, Performance Efficiency, Compatibility, Security, Maintainability, and Portability [10]. The tools used for measurement are as follows: 1. Functional Suitability: Measurement uses test cases with the black box method, evaluated on a Guttman scale. The results are measured using the feature completeness matrix formula [11]. 2. Reliability: Measurement is done through stress testing using WAPT (Web Application Performance Tool). WAPT applies a load to the software to determine whether it functions properly under pressure. The results are calculated using the Neilsen model

formula, and the scoring uses Telcordia standards. 3. Usability: Usability is measured through a questionnaire distributed to respondents. The sample size of respondents is calculated using the Slovin formula, and the results are evaluated on a Likert scale. 4. Performance Efficiency: This measures the efficiency of the application's performance, conducted using the GTMetrix software. 5. Security: This measurement tests the system's vulnerability using Sucuri SiteHack. The online exam system's link is input into Sucuri SiteCheck, and the application is run. 6. Maintainability: Maintainability is assessed by the researcher directly on the online exam system of SMP Islam Dian Didaktika. The analysis for maintainability uses the Land measurement instrument, covering three aspects: (a) Instrumentation: Alerts and error identification provided by the system in case of failures. (b) Consistency: A consistent design model is used throughout the entire system. (c) Simplicity: Ease of system management, repair, and development. 7. Portability: Portability is measured using cross-browser compatibility testing on both desktop and mobile platforms to ensure the software functions well across different browsers. The tool used for this is LambdaTest. 8. Compatibility: Compatibility is assessed using PowerMapper. The system is run on different browsers to ensure each browser can operate the system without interference [12].

4. METHODOLOGY

In this study, the procedures or steps used begin with the problem identification process, which serves as the initial step in conducting research. Identifying the problem is crucial to formulating appropriate solutions for the issue at hand [13]. Problem identification forms a solid foundation for justifying the need for this research [14]. The study was conducted to obtain research permission from SMP Islam Dian Didaktika. At this stage, the purpose and objectives of the research to be conducted at SMP Islam Dian Didaktika were explained. Once permission was granted, the next step involved familiarizing with the systems and tools used by SMP Islam Dian Didaktika to implement the CBT (Computer-Based Test) application. Data collection in this study was carried out in two phases: distributing questionnaires to students and teachers of SMP Islam Dian Didaktika and testing the exam system based on the ISO 25010 standards. The measurement of the characteristics from ISO 25010 consists of eight characteristics: (1) Functional Suitability: This characteristic is measured using test cases with a black box testing method, evaluated through the Guttman scale. The results are calculated using the feature completeness matrix to determine if the system's functions meet the required criteria, (2) Reliability: The system's reliability is assessed through stress testing using the WAPT (Web Application Performance Tool), which applies a load to the application to test how well it performs under stress, (3) Usability: Usability is evaluated by distributing questionnaires to users (students and teachers). The responses are analyzed using the Likert scale to gauge the user-friendliness and ease of use of the application, (4) Performance Efficiency: This characteristic is measured using GTMetrix, a tool that analyzes the application's loading speed and overall performance efficiency, (5) Security: The security of the application is tested using Sucuri SiteCheck, a tool that identifies any vulnerabilities, malware, or security issues in the web application, (6) Maintainability: Maintainability is directly evaluated by the researchers based on three aspects Instrumentation: The system's ability to provide notifications when errors occur and offer corrective suggestions. Consistency: The use of a unified design model throughout the system. Simplicity: The ease with which the system can be managed, maintained, and updated, (7) Portability: This is measured using LambdaTest, which

performs cross-browser compatibility testing to ensure that the application runs smoothly across different browsers and devices Compatibility using the PowerMapper web tool, (8) Compatibility: PowerMapper is used to test the system's compatibility across various environments. It ensures the system can operate without issues across multiple web browsers. Data analysis was conducted by measuring the ISO 25010 quality standard model, encompassing eight characteristics: Functional Suitability, Reliability, Usability, Performance Efficiency, Security, Compatibility, Maintainability, and Portability. After obtaining values for all measurement aspects, recommendations can be provided with the aim of maintaining and improving the quality of the CBT application system at SMP Islam Dian Didaktika.

The research was conducted at SMP Islam Dian Didaktika, located at Jl. Rajawali Blok F No. 16, Gandul Village, Cinere District, West Java Province, and was carried out during the Mid-Semester Assessment (PTS) in March 2023. The subject of this study is the web-based CBT (Computer-Based Test) application system owned by SMP Islam Dian Didaktika. The measurement of this CBT application system used the ISO 25010 model, which includes eight characteristics: Functional Suitability, Reliability, Usability, Performance Efficiency, Security, Maintainability, Portability, and Compatibility. can be seen in Figure 1. Research Stages.

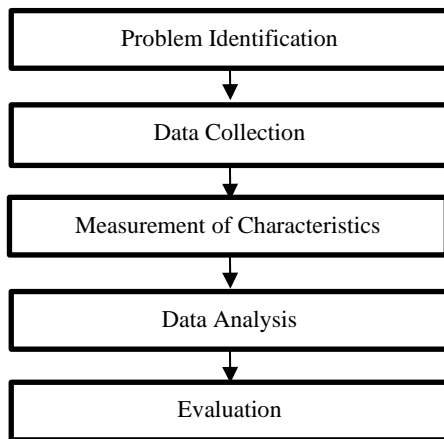


Figure 1. Research Stages.

5. RESULTS AND ANALYSIS

After measuring the CBT application system using the ISO 25010 model with 8 characteristics consisting of: functional suitability, reliability, usability, performance efficiency, security, maintainability, portability, and, compatibility the results are as follows:

5.1. Functional Suitability Measurement Results

The results of this measurement are demonstrated through data presentation in the form of a table. All tested functions are operating correctly with no functions encountering issues or errors. Based on the tested calculations, it can be concluded that the CBT application system of SMP Islam Dian Didaktika is considered adequate or good, as it achieved a value of X = 1, indicating that it meets the functional suitability characteristic.

5.2. Reliability Measurement Results

The measurement of the Reliability characteristic was conducted using the WAPT 10.1 tool with a stress testing scenario involving 20 virtual users over 10 minutes. The results produced a summary with 289 successful sessions, 0 failed sessions, 906 successful pages, 0 failed pages, 6836 successful

hits, and 0 failed hits. This resulted in a reliability value of 100%. According to Telcordia standards, the success rate for software reliability is 95% or 0.95 (Setiawan & Jati, 2017). Thus, the CBT application system of SMP Islam Dian Didaktika meets the reliability characteristic.

5.3. Usability Measurement Results

The measurement of the Usability characteristic was conducted using a questionnaire via Google Forms, which was given to students in March 2023. The participants of the PTS in March 2023 totaled 288 participants. The sample size was calculated using Slovin's formula with a margin of error of 5%, and an additional 26 teachers were included in the population. After obtaining the questionnaire results, calculations were performed to assess the usability characteristic. A summary of the usability characteristic measurement, which reflects the responses of 194 respondents to the CBT application system questionnaire, can be seen in Table 2.

Table 2. Results of Usability Characteristics Measurement

Question	Answer					Score
	Strongly Agree	Agree	Netral	Disagree	Strongly Disagree	
P1	610	240	36	0	0	886
P2	665	192	39	0	0	896
P3	585	264	33	0	0	882
P4	570	252	51	0	0	873
P5	610	224	48	0	0	882
P6	500	304	54	0	0	858
P7	570	184	96	4	0	854
P8	645	196	48	0	0	889
P9	670	208	24	0	0	902
P10	470	288	84	0	0	842
P11	635	200	51	0	0	886
P12	625	204	54	0	0	883
P13	635	212	42	0	0	889
P14	655	208	33	0	0	896
P15	685	184	33	0	0	902
P16	670	196	33	0	0	899
P17	615	212	54	0	0	881
P18	550	240	72	0	0	862
P19	655	212	30	0	0	897
Total	11620	4220	915	4	0	16759

The data obtained from the respondents' answers were then calculated for their percentages. The percentage scores were calculated using the following formula.

Note:

Total Score = Total Score from respondent answers

i = Number of questions

r = Number of Respondents

$$P = \frac{16759}{19 \times 194 \times 5} \times 100\%$$

$$P = 90,93 \%$$

$$P = \frac{Skor\ total}{i \times r \times 5} \times 100\%$$

The percentage result of the usability characteristic measurement is 90.93%. Referring to the score interpretation criteria (Riduwan, 2018), a percentage of 81%-100% is classified as Very Feasible. Therefore, the CBT application system of SMP Islam Dian Didaktika is considered very feasible and meets the usability measurement.

5.4. Results of Performance Efficiency Measurement

The performance efficiency evaluation was carried out utilizing the Gmetrix online tool, with the assessment criteria spanning from grades A to F. This grading system offers a clear and structured method to gauge the efficiency of individuals or systems based on their performance. Grade A represents the highest level of efficiency, while grade F indicates significant room for improvement. By employing Gmetrix, the results can be systematically analyzed to identify strengths and areas that require further development, ensuring a comprehensive understanding of overall performance.

The results of the performance efficiency aspect can be seen in Figure 2.

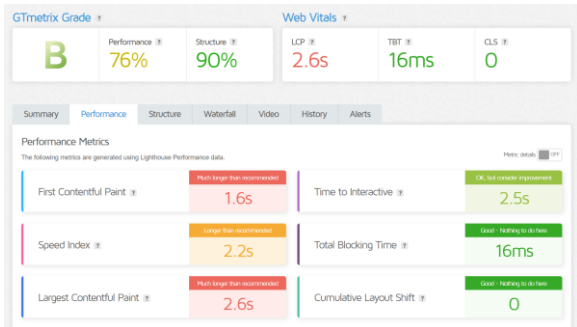


Figure 2. Results of Performance Efficiency Measurement Using GTmetrix

From Figure 2, the performance efficiency measurement results show an overall website score of B, with a performance score of 90%, LCP of 2.6s, TBT of 16ms, and CLS of 0. This measurement was conducted by calculating the page score and response time using GTmetrix. Overall, the website's performance is considered good, with a high performance score and low LCP and TBT values. However, there is still room for improvement, as a perfect score would be 100% for all metrics. More detailed overall scores for the website can be seen in Table 3.

Table 3. Overall Measurement Results with GTmetrix

Parameter	Description	Results
Overall Score	Overall Website Score	B
Performance	Website Performance Score	76%
Structure	Website Structure Score	90%
Largest Contentful Paint (LCP)	Measuring the loading time of the largest content elements, such as images or heading text	2,6 sec
Total Blocking Time (TBT)	Measuring the loading time of a web page until all its functions are accessible to users	16 ms
Content Layout Shift (CLS)	Measuring layout shifts during page loading until the display is fully stable	0

From Table 3, the results of the measurement using Gmetrix show an overall website score of B, with a performance score of 76% and a structure score of 90%. While the website's structure score is considered good, the performance score is relatively low. This indicates that there are areas where the website can be optimized to improve its loading speed and overall user experience. The website's performance can be

improved by optimizing images, reducing HTTP requests, minifying CSS and JavaScript files, and utilizing browser caching.

Below are the results of the website loading time measurement, which can be seen in Figure 3.

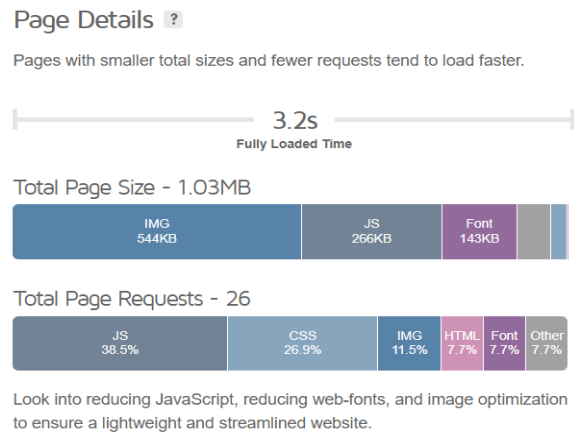


Figure 3. Results of Performance Efficiency Measurement of Website Loading Time

The overall website loading time result is 3.2 seconds. Additionally, the GTmetrix measurement in the performance tab displays a more detailed breakdown of the website loading time, as shown in Table 4.

Table 4. GTmetrix Measurement Results: Performance Metrics

Parameter	Description	Results
First Contentful Paint	How long it takes for the largest contentful paint to appear	1,6 seconds
Speed Index	How quickly the website content appears to be fully loaded	2,2 seconds
Time to Interactive	How long it takes for the website to become fully interactive	2,5 seconds

From the results in Table 4, it can be concluded that although the overall measurement received a grade of B with a performance score of 76%, the loading time result is 3.2 seconds. This result is then compared with the user satisfaction table regarding response time as proposed by Syehka Sofia Arya Larasati (2018). A website is considered good if the loading time is less than 10 seconds. Based on this result, it can be concluded that the CBT application system of SMP Islam Dian Didaktika meets the Performance Efficiency characteristic with a rating of good or satisfactory.

5.5. Security Measurement Results

Refers to the process of evaluating and quantifying the security posture of a system, or application. It involves assessing the effectiveness of security controls and identifying vulnerabilities that could be exploited by attackers. The results of the Security characteristic measurement can be seen in Figure 4.

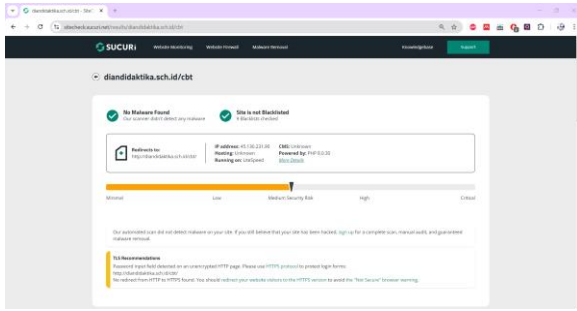


Figure 4. Security Measurement Results Using Sucuri SiteCheck

Based on the security measurement results using the Sucuri Sitehack web tool, the CBT application system of SMP Islam Dian Didaktika has a medium or moderate security risk. No malware was detected, and it is not listed on any blacklist. Therefore, it can be concluded that the CBT application system meets the security characteristic and is safe to use.

5.6. Maintainability Measurement Results

This measurement covers 3 aspects: instrumentation, consistency, and simplicity.

Table 6. Maintainability Measurement Aspects

Aspect	Assessment	Results
Instrumentation	There is a warning notification when an error occurs while filling out the data form, and a success notification when the data input is correct.	When the username and password entered do not match, the system provides a warning notification and the user is unable to access the application.
Consistency	Use of a single design model across the entire system design	The design model of the CBT application system has a consistent format, as seen in the system implementation section. The web interface shows similar appearance from one page to another, with a similar layout and consistency.
Simplicity	Ease of management, maintenance, and system development	The measurement results show that the system has a structured codebase. Each component is separated, making it easy to maintain and develop. If errors occur, they are easy to identify, as you only need to check the problematic component.

The measurement of the maintainability characteristic based on operational testing of the instrumentation aspect shows that the system has notifications. For the consistency aspect, the result indicates that the system has a uniform design model. For the simplicity aspect, the result shows that the system has a

structured source code. Therefore, the CBT application system of SMP Islam Dian Didaktika meets the maintainability characteristic.

5.7. Portability Measurement Results

The measurement of the Portability characteristic was conducted using the web tool Lambdatest. The CBT application system was tested across 3 different types of browsers on both desktop and mobile views: Google Chrome, Mozilla Firefox, and Safari. The results of the portability measurement can be seen in Table 7.

Table 7. Summary of Portability Characteristics Measurement Results

No	Operating System	Type	Browser	Results of Measurement
1	Windows 11	Desktop	Google Chrome	Functions well
			Mozilla Firefox	Functions well
2	MacOS	Desktop	Safari	Functions well
3	Android	Mobile	Google Chrome	Functions well
			Mozilla Firefox	Functions well

Based on the portability characteristic measurement using Lambdatest, it was found that the CBT application system of SMP Islam Dian Didaktika performs well across all browsers and meets the portability criteria.

5.8 Compatibility Measurement Results

The results of the compatibility measurement using PowerMapper software can be seen in Figure 5.

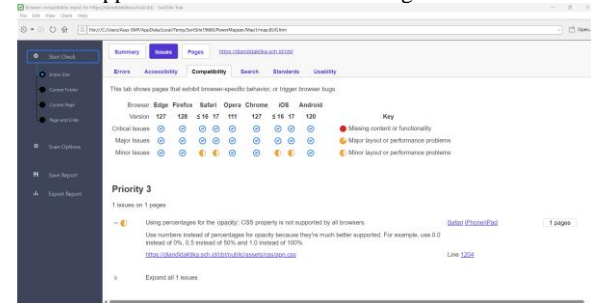


Figure 5. PowerMapper Measurement Results

The measurement of the Compatibility characteristic using PowerMapper on the CBT application system of SMP Islam Dian Didaktika across various browsers on both desktop and mobile devices showed only a few minor issues with Safari and iOS browsers. These issues occurred because the CSS code used in the CBT application does not fully support these browsers. However, the results for critical issues indicate that there are no problems across all browsers. Therefore, it can be concluded that the CBT application system meets the compatibility criteria.

6. CONCLUSIONS

The measurement of the CBT application system at SMP Islam Dian Didaktika follows the ISO 25010 standard product quality model, which encompasses 8 characteristics. The Functional Suitability was assessed using test cases with a black-box method and evaluated with a Guttman scale. The measurement results, based on the feature completeness matrix formula, meet the standards, as the value X equals 1. For Performance Efficiency, the GTMetrix software rated the system with a B grade and a response time of 3.2 seconds, categorized as

satisfactory. Regarding Compatibility, the PowerMapper tool indicated that the system is compatible with various desktop and mobile devices, though there is a minor issue with unsupported CSS code on iOS devices. However, critical issue results show no problems across all browsers, confirming the system's compatibility. The Usability was evaluated using a questionnaire distributed to respondents, with the sample size calculated using the Slovin formula, yielding a score of 90.93%, indicating very good usability. The Reliability assessment, conducted with WAPT software using the Nielsen model formula and Telcordia standards, showed no failures, thus categorized as excellent. For Security, the Sucuri SiteHack web tool identified a medium or moderate risk level. The Maintainability of the system, measured with the Land tool, met the criteria of instrumentation, consistency, and simplicity, making it easy to further develop. Finally, the Portability assessment using the LambdaTest tool showed that the system performs well across all browsers with good display results. Based on this analysis, the CBT application system at SMP Islam Dian Didaktika is deemed feasible and meets the ISO 25010 standards.

7. ACKNOWLEDGMENTS

The author would like to thank Gunadarma University and all lecturers, especially Dr. Hustinawati, S.Kom., MMSI and especially my family who have supported this research.

8. REFERENCES

- [1] I. Rahmania, B. Budiono, S. F. Soenaryo, A. Syakur, and A. Tinus, "Implementation of internal quality guarantee system to increase the quality of education in Junior High School 21 Malang," *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, vol. 3, no. 1, pp. 421–432, 2020.
- [2] J. Tasanen, "Methods of quality assurance for productionalization of cloud systems," Master's Thesis, 2022. Accessed: Sep. 07, 2024. [Online]. Available: <https://jyx.jyu.fi/handle/123456789/82126>
- [3] E. Peters and G. K. Aggrey, "An ISO 25010 based quality model for ERP systems," *Advances in Science, Technology and Engineering Systems Journal*, vol. 5, no. 2, pp. 578–583, 2020.
- [4] F. N. Colakoglu, A. Yazici, and A. Mishra, "Software product quality metrics: A systematic mapping study," *IEEE Access*, vol. 9, pp. 44647–44670, 2021.
- [5] S. F. Azzahra, L. Ramadani, and B. Rahmad, "Integrating System Quality, Information Quality, and Service Quality for Evaluating IS Quality," in *Proceedings of the International Conference on Enterprise and Industrial Systems (ICOEINS 2023)*, Springer Nature, 2023, p. 217. Accessed: Sep. 07, 2024. [Online]. Available: [https://books.google.com/books?hl=en&lr=&id=1nDrEAAAQBAJ&oi=fnd&pg=PA217&dq=Meanwhile,+the+quality+in+use+dimension+focuses+on+user+aspects+and+includes+indicators+like+usability+in+use,+flexibility+in+use,+and+safety+\(ISO/IEC-](https://books.google.com/books?hl=en&lr=&id=1nDrEAAAQBAJ&oi=fnd&pg=PA217&dq=Meanwhile,+the+quality+in+use+dimension+focuses+on+user+aspects+and+includes+indicators+like+usability+in+use,+flexibility+in+use,+and+safety+(ISO/IEC-25010:2011).+ISO+25010+is+used+because+it+emphasizes+system+quality+results+based+on+the+existing+indicators+from+ISO+25010.+&ots=pYbcWiRjg7&sig=7-FX0J8GbaR0T8-D22-Io1jfp94)
- [6] L. Castillo-Salinas, S. Sanchez-Gordon, J. Villarroel-Ramos, and M. Sánchez-Gordón, "Evaluation of the implementation of a subset of ISO/IEC 29110 Software Implementation process in four teams of undergraduate students of Ecuador. An empirical software engineering experiment," *Computer Standards & Interfaces*, vol. 70, p. 103430, 2020.
- [7] J. Verdugo and M. Rodríguez, "Assessing data cybersecurity using ISO/IEC 25012," *Software Qual J*, vol. 28, no. 3, pp. 965–985, Sep. 2020, doi: 10.1007/s11219-019-09494-x.
- [8] C. Ardil, "Software product quality evaluation model with multiple criteria decision making analysis," *International Journal of Computer and Information Engineering*, vol. 14, no. 12, pp. 486–502, 2022.
- [9] A. Mishra and Z. Otaiwi, "DevOps and software quality: A systematic mapping," *Computer Science Review*, vol. 38, p. 100308, 2020.
- [10] S. Sarwosri, S. Rochimah, U. L. Yuhana, and S. B. Hidayat, "Software Quality Measurement for Functional Suitability, Performance Efficiency, and Reliability Characteristics Using Analytical Hierarchy Process," *JOIV: International Journal on Informatics Visualization*, vol. 7, no. 4, pp. 2421–2426, 2023.
- [11] S. Ariyani, M. Sudarma, and P. A. Wicaksana, "Analysis of functional suitability and usability in sales order procedure to determine management information system quality," *INTENSIF: Jurnal Ilmiah Penelitian dan Penerapan Teknologi Sistem Informasi*, vol. 5, no. 2, pp. 234–248, 2021.
- [12] J. Jokinen, "Implementing web accessibility to an existing web application," PhD Thesis, Master's Thesis in Technology. Software Engineering. Department of Future ..., 2020. Accessed: Sep. 07, 2024. [Online]. Available: https://www.utupub.fi/bitstream/handle/10024/150948/Jokinen_Juha_Pekka_opinnayte.pdf?sequence=1
- [13] P. Pandey and M. M. Pandey, *Research methodology tools and techniques*. Bridge Center, 2021. Accessed: Sep. 07, 2024. [Online]. Available: <http://dspace.vnbrims.org:13000/jspui/bitstream/123456789/4666/1/RESEARCH%20METHODOLOGY%20TOOLS%20AND%20TECHNIQUES.pdf>
- [14] R. Acuna and A. Bansal, "Analysis-design-justification (adj): A framework to develop problem-solving skills," in *2021 IEEE Global Engineering Education Conference (EDUCON)*, IEEE, 2021, pp. 366–372. Accessed: Sep. 07, 2024. [Online]. Available: <https://ieeexplore.ieee.org/abstract/document/9454055/>