e-ISSN : 2829-4149
p-ISSN : 2829-4157

COELITE

JOURNAL OF COMPUTER ENGINEERING, ELECTRONICS AND INFORMATION TECHNOLOGY

OJS :

Publisher :

The Education University

Vol. 05| Issue. 02 | Oct 2026

Volume 5, Issue 2, October 2026

e-ISSN : 2829-4149
p-ISSN : 2829-4157

Journal of
Computer Engineering, Electronics and Information Technology
Universitas Pendidikan Indonesia

Jl. Pendidikan No.15, Cibiru Wetan, Kec. Cileunyi, Kab. Bandung, Jawa Barat 40625
Phone: (022) 7801840, Fax: (022) 7830426
E-Mail: coelite@upi.edu, Website: https://ejournal.upi.edu/index.php/COELITE

Editor in Chief
Dr. Eng. Munawir, S.Kom., M.T., (Scopus ID 57208758022)
Expertise: Data Mining, Text Mining.
Universitas Pendidikan Indonesia, Indonesia.

Executive Editor
Anugrah Adiwilaga, S.ST., M.T., (Scopus ID 57194714935)
Expertise: Robotic, Control and Intelligent Systems, AI, IoT.
Universitas Pendidikan Indonesia, Indonesia.

Editorial Board
Dr. Eng. Dinda Pramanta, M.Eng.
Expertise: Artificial Intelligence, FPGA, Robot and Neural Network.
Associate Professor at Kyushu Institute of Information sciences Japan.

Wirmanto Suteddy, S.T., M.T.,
Expertise: Embedded System, IoT, AI, VLSI, Computer Vision.
Universitas Pendidikan Indonesia, Indonesia.

Dr. Eng. Mia Rizkinia, S.T.,M.T.
Expertise: Optoelectrotechnique and Remote Sensing, Vision, Image and Graphics Processing.

Editorial Assistant
Deden Pradeka, S.T., M.Kom., (Scopus ID 57200731472)
Expertise: Software Engineering Development, Mobile Development, Cryptography, Steganography.
Universitas Pendidikan Indonesia, Indonesia.

Reviewers

Dr. Eng. Md. Zaman Molla
Expertise: Solar Cell.
Associate Professor of Physics at Ahsanullah University of Science and Technology Bangladesh.

Dr. Eng. Alfian Akbar Gozali, S.T., M.T
Expertise: Data Analytics, Machine Learning, Optimization Algorithm, Mobile Development.
Telkom University, Indonesia.

Dr. Eng. Bobby Kurniawan, S.T., M.T
Expertise: Production system and control, mathematical modeling, scheduling metaheuristics, AI.
Universitas Sultan Ageng Tirtayasa, Indonesia.

Syamsul Rizal S.T, M.T., PhD.
Expertise: Image Processing, IoT,Faulty Node, Fault Detection.
Telkom University, Indonesia.

Devi Aprianti Rimadhani Agustini, S.Si, M.Si
Expertise: Modeling and Simulation.
Universitas Pendidikan Indonesia, Indonesia.

Muhammad Taufik Dwi Putra, S.Tr.Kom., M.T.I
Expertise: Computer vision, deep learning, Machine Learning.
Universitas Pendidikan Indonesia, Indonesia.

Ana Rahma Yuniarti, S.T., M.Eng., (SCOPUS ID 57192948351)
Expertise: Biomedical Engineering, Machine Learning, Artificial Inteligence.
Universitas Pendidikan Indonesia, Indonesia.

Volume 5, Issue 2, October 2026

e-ISSN : 2829-4149
p-ISSN : 2829-4157

published by **Universitas Pendidikan Indonesia.**

Journal of

Computer Engineering, Electronics and Information Technology

COELITE

Volume 5, Issue 2, April 2026
Table of Contents

Design of a Web-Based E-Commerce System for Herbal Tea Products Using the Waterfall Method 71-82
Ozmar Azhari, M. Fauzi Isputrawan, Rhisa Adika Putri, Erin Erin, Felicia Evan, Jessicania Windari

Sentiment Analysis of Digital Literacy in Society Towards Financial Technology Lending Using The Naive Bayes 83-90
Vion Age Tricahyo, Dimas Kurnia Robby, Riyan Sanjaya, Wisnu Putri Airmas Jati, Nailul Munadhiroh, Annisa Ramadhani

Analysis of Household Electricity Consumption Patterns Using K-Means Clustering 91-98
Fika Saputri, Asminar Asminar, Tambi Tambi, Mustarum Musaruddin, Muhammad Nadzirin Anshari Nur, Adhi Setiawan Samsul

Quality Evaluation of an Academic Information System Using Decision Table Testing and State Transition Testing 99-110
Fajar Mahardika, Kukuh Muhammad, Angga Maulana Purba, Nur Muniroh

A Qualitative Usability Evaluation of Document-Like Web Interfaces for Village Administrative Staff 111-118
Angga Lisdiyanto, Agussalim Agussalim, Laqma Dica Fitrani, Miftahus Sholihin, Syahri Mumin, Tri Septianto, Winarti Winarti, Vinza Hedi Satria

Design and Development of an IoT-Based Automatic Water Gallon Filling System Using a YF-S201 Flow Sensor, ESP32, and Telegram Bot 119-130
Singgih Astaguna Tiroatmaja, Akhyar Muchtar, Andi Ahmad Taufiq, Muhammad Fauzan Yusuf

Indexed by.

Google Scholar GARUDA GARBA RUJUKAN DIGITAL sinta S4 Science and Technology Index

Volume 5, Issue 2, October 2026

e-ISSN : 2829-4149
p-ISSN : 2829-4157

Published by:
Universitas Pendidikan Indonesia
E-Mail: coelite@upi.edu
Website: https://ejournal.upi.edu/index.php/COELITE

JURNAL UPI

Journal of Computer Engineering, Electronics and Information Technology (COELITE)

Journal homepage: https://ejournal.upi.edu/index.php/COELITE

Design of a Web-Based E-Commerce System for Herbal Tea Products Using the Waterfall Method

Ozmar Azhari[1], M. Fauzi Isputrawan[2], Rhisa Adika Putri[3], Erin Erin[4], Felicia Evan[5], Jessicania Windari[6]*

[1-2]Program Studi Sistem Informasi, Universitas Bunda Mulia, Indonesia
[3-6]Program Studi Sistem Informasi, Universitas Bina Nusantara, Indonesia
Correspondence E-mail: l1582@lecturer.ubm.ac.id

ABSTRACT

The rapid growth of digital technology has encouraged SMEs to adopt e-commerce platforms to improve market reach and service efficiency. However, many SMEs in niche product sectors, including herbal tea businesses, still face challenges in developing structured and user-oriented digital commerce systems. This study aims to design and evaluate a web-based e-commerce system for Acachia herbal tea products using the Waterfall model. Business needs were identified using the Business Model Canvas, while system requirements were translated into a sitemap, use case diagram, activity diagrams, and interface implementation. The evaluation was conducted through scenario-based usability validation involving ten potential end users. The results show that the proposed interface is generally usable for supporting basic e-commerce activities, with an average score of 3.57 out of 5. However, product information completeness, checkout confirmation, payment integration, and order tracking still require improvement. This study contributes a structured design and preliminary usability validation framework for niche SME e-commerce development.

© 2026 Universitas Pendidikan Indonesia

ARTICLE INFO

Article History:
Submitted/Received 23 Apr 2026
First Revised 28 Apr 2026
Accepted 09 Oct 2026
First Available online 22 Oct 2026
Publication Date 22 Oct 2026

Keyword:
E-commerce, Waterfall Model, Business Model Canvas, Usability Validation, Herbal Tea Products

1. INTRODUCTION

The rapid development of internet technology has transformed conventional business activities into digital platforms. E-commerce has become an important medium for businesses to expand market reach, improve transaction efficiency, and enhance customer service. For SMEs, adopting e-commerce is increasingly necessary to maintain competitiveness in a dynamic market environment [1]. In Indonesia, the growth of internet usage has accelerated the adoption of e-commerce across various sectors. However, many SMEs still face challenges in developing effective digital commerce systems, including limited system planning, unclear navigation structures, and interfaces that are not sufficiently user-centered [2]. This condition indicates that digital transformation is not only necessary but also urgent to maintain market competitiveness, especially for SMEs transitioning from traditional to digital operations.

The success of an e-commerce platform is influenced not only by its functional features but also by the quality of its user interface (UI) and user experience (UX). A well-designed system can improve usability, facilitate product exploration, support efficient transaction processes, and increase user satisfaction [3]. In contrast, poor interface design may lead to user confusion, abandoned transactions, and lower customer retention. Therefore, interface quality becomes an important consideration in designing e-commerce systems, particularly for SME products that rely on clear product presentation and customer trust [4].

In addition to interface quality, developing a web-based e-commerce system requires a structured approach to ensure that business needs are translated into clear system requirements and user interaction models. In this study, business needs are identified using the Business Model Canvas (BMC), while system requirements are represented through a visual sitemap, use case diagram, activity diagrams, and interface implementation [5][6]. Techniques such as sitemap design, UML diagrams, and interface prototyping are widely used to support system modeling, improve usability, and enhance development efficiency [7][8].

Although many previous studies have discussed e-commerce system development, most focus on technical implementation, general interface design, or system modeling without providing early usability validation [9][10]. In the context of niche SME products such as herbal tea, limited studies have integrated business model analysis, structured system design, interface implementation, and scenario-based usability validation in a single development framework. Therefore, this study aims to design and evaluate a web-based e-commerce system for Acachia herbal tea products using the Waterfall model. The main contribution of this study is a structured design framework that connects business needs, system modeling, interface implementation, and preliminary usability assessment to support future e-commerce development for niche SME sectors.

2. METHODS

This study employed the Waterfall model as the system development approach for designing the Acachia web-based e-commerce system. The Waterfall model was selected because the proposed system had relatively stable requirements and clearly defined business processes [11][12]. The main e-commerce functions could be identified from the beginning through business and requirement analysis. Therefore, the Waterfall model was considered suitable for this study because it provides a systematic sequence from requirement identification and analysis to design, interface implementation, and evaluation [11][13][14].

In this research, the development process was organized into five stages: requirements-gathering, analysis, design, interface implementation, and evaluation. These stages were used to produce a structured conceptual design and a visual representation of the proposed e-

commerce platform. The adapted Waterfall model used in this study consists of five stages, as presented in **Figure 1**.

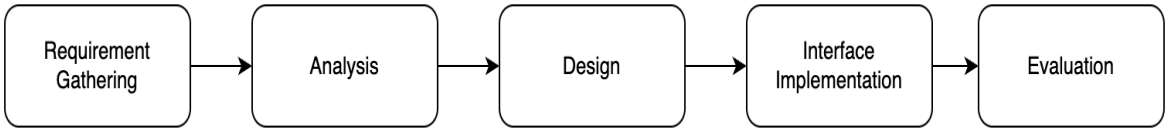


Figure 1. Method flow design web Acachia.

In the requirements-gathering stage, business needs and system objectives were identified using the Business Model Canvas (BMC). This stage aimed to define the main elements of the business, including value propositions, customer segments, channels, key activities, and revenue streams, which were then used as the basis for determining the required system features [15].

In the analysis stage, the identified business needs were translated into system requirements and navigation structures [16][17]. A visual sitemap was developed for the Acachia e-commerce website to represent the overall system structure and define the navigation flow between pages. The sitemap shows the main pages accessible to users, starting from the home page and continuing to supporting pages such as About, Search, product pages, cart, and history.

In the design stage, system interactions and workflow processes were modeled using a use case diagram and activity diagrams. The use case diagram was used to identify the main interactions between users and the system, while the activity diagrams were used to describe the workflow of core processes such as product browsing and ordering. This stage was intended to provide a structured representation of system functionality and user interaction flow [18].

In the interface implementation stage, the proposed interface design was represented through visual page layouts of the main website pages. These implementations included essential interface elements such as navigation menus, product information, images, prices, and transaction-related components. This stage was intended to show how the proposed system design could be translated into a more concrete and user-oriented web interface [19][20].

In the evaluation stage, scenario-based usability validation was conducted to assess the proposed website interface. The validation focused on several core e-commerce tasks, including accessing the homepage, browsing product categories, reviewing product information, adding products to the cart, reviewing cart contents, preparing for checkout, and reviewing order history. These scenarios were assessed based on interface clarity, ease of navigation, product information, visual appearance, transaction process, and overall satisfaction using a five-point Likert scale [21][22].

3. RESULTS AND DISCUSSION

The results of this study consist of several design artifacts and validation results that represent the proposed e-commerce system for Acachia herbal tea products. The discussion focuses on how these artifacts support structured system design, clear user interaction flow, interface usability, and preliminary scenario-based validation.

3.1. Requirement Gathering

DOI: https://doi.org/10.17509/coelite.v5i2.99237
p- ISSN 2829-4157 e- ISSN 2829-4149

The BMC was developed to identify the core business structure of Acachia and to determine the requirements that should be accommodated by the proposed e-commerce system. Based on the BMC, Acachia's business model emphasizes product quality, product variety, competitive pricing, and product knowledge as its main value propositions. This indicates that the e-commerce platform should not only function as a transactional medium but also as an informational platform that communicates product benefits and differentiates Acachia from competitors.

The BMC also identifies tea enthusiasts, health-conscious consumers, and gift shoppers as the main customer segments. These customer groups indicate the need for a system that supports clear product categorization, detailed product information, and an efficient purchasing process. In this way, the platform can accommodate different user needs, from browsing products to completing transactions, as illustrated in **Figure 2**.



Figure 2. Business model canvas of Acachia.

In addition, the BMC highlights the importance of digital channels, customer communication, and operational resources in supporting the business. This suggests that the proposed website should be designed to integrate product presentation, transaction processes, and customer engagement in a structured manner. Therefore, the BMC serves as the basis for determining the main system features and design priorities in the following stages.

3.2. Analysis

A visual sitemap was developed for the Acachia e-commerce website to represent the overall system structure and define the navigation flow between pages. The sitemap shows the main pages accessible to users, starting with the home page and continuing to supporting pages such as About, Search, product pages, cart, and history. It also illustrates the relationship between authentication pages, product browsing, cart management, and checkout processes.

The sitemap was designed to provide a clear hierarchical structure that helps users navigate the website more easily and access the required information without confusion. In particular, the arrangement of product categories, cart features, and checkout flow reflects

the main user activities in the e-commerce platform. This structure is important for supporting usability, as it helps users move efficiently from product exploration to transaction completion.

In addition, the sitemap serves as an initial reference for the next design stage, especially in developing the wireframe and interface flow of the proposed system. By defining page relationships and navigation paths early, the sitemap helps ensure that the interface design remains consistent with the system structure and user needs, as presented in **Figure 3**.

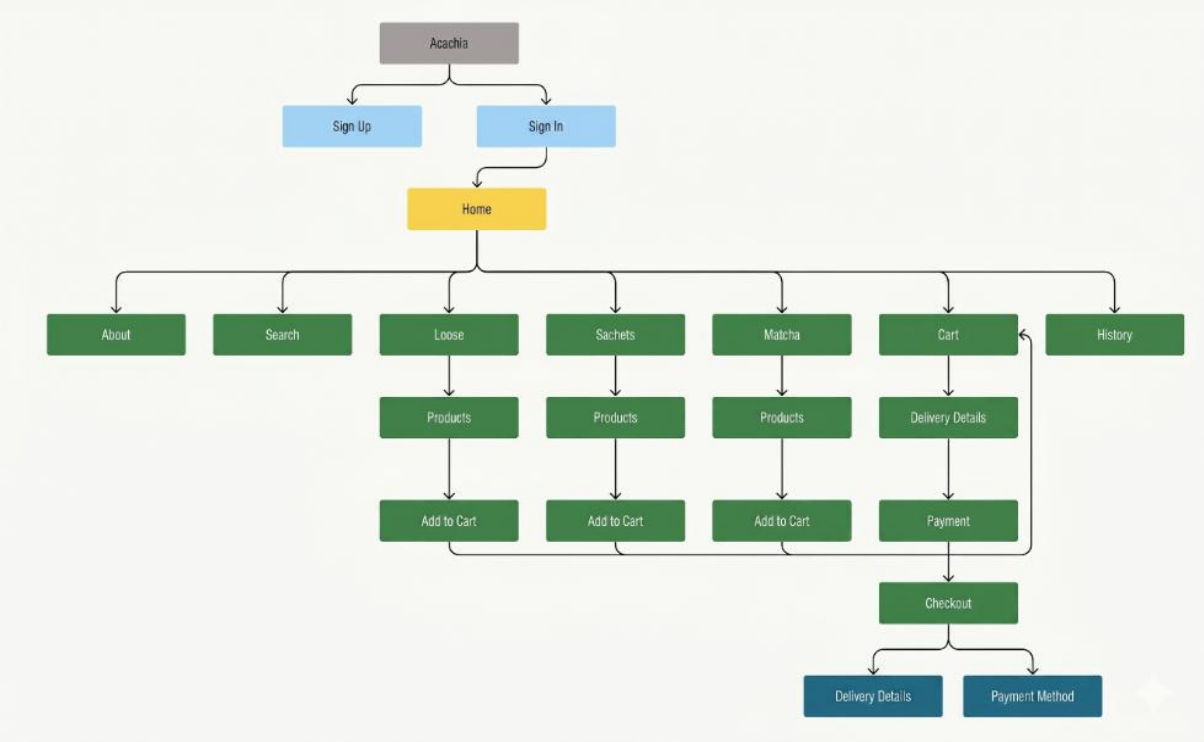


Figure 3. Visual sitemap design Acachia.

3.3 Design

3.3.1 Use Case Diagram

A Use Case Diagram was developed to identify the main interactions between the user and the Acachia e-commerce system. The diagram shows that the user can perform several main activities, including sign up, sign in, accessing the home page, viewing product categories, adding products to the cart, checking out, viewing order details, giving ratings and reviews, viewing order history, and logging out. In addition, the checkout process includes supporting functions such as applying coupons, entering delivery details, and selecting a payment method.

As shown in **figure 4**, the Use Case Diagram provides an overview of the system's functional scope and illustrates how each feature is connected to user needs. By identifying these interactions, the diagram helps ensure that the proposed system supports the main activities commonly performed in an e-commerce platform. Therefore, the Use Case Diagram serves as an important reference for the subsequent interface and process design stages.

DOI: https://doi.org/10.17509/coelite.v5i2.99237
p- ISSN 2829-4157 e- ISSN 2829-4149

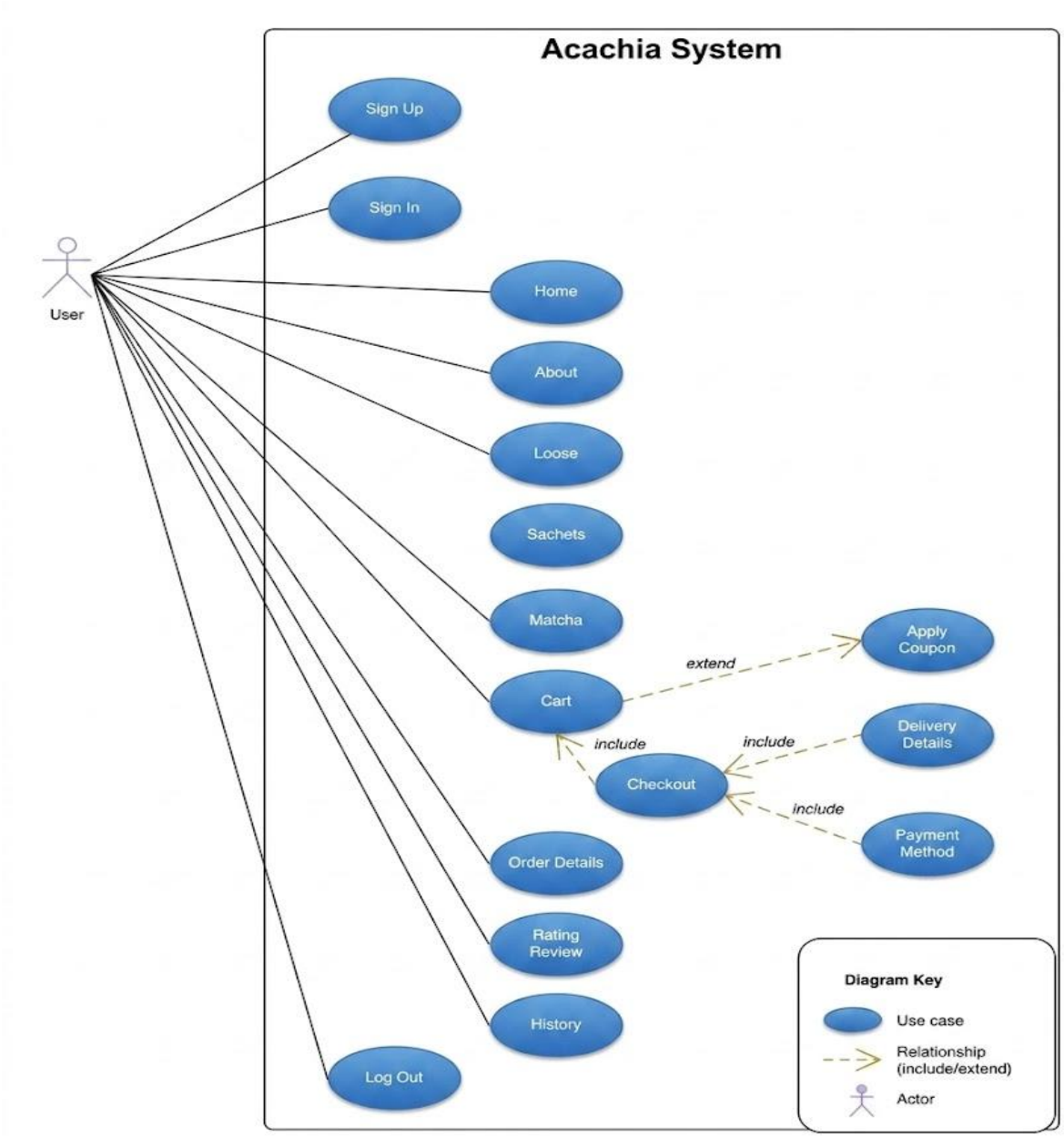


Figure 4. Use Case Diagram of Acachia.

3.3.2 Activity Diagram

Two Activity Diagrams were selected to represent the main workflows of the Acachia e-commerce system, namely the homepage and product browsing process, and the ordering process. These diagrams were considered sufficient to illustrate the core user activities in the platform, from product exploration to transaction completion. The homepage and product browsing activity diagram shows how users navigate the website and select products, while the order activity diagram describes the sequence from adding items to the cart to completing checkout and payment. Together, these diagrams provide a clear representation of the main process flow of the proposed system and support the development of a structured and user-centered e-commerce design, as presented in **Figure 5 and 6**.

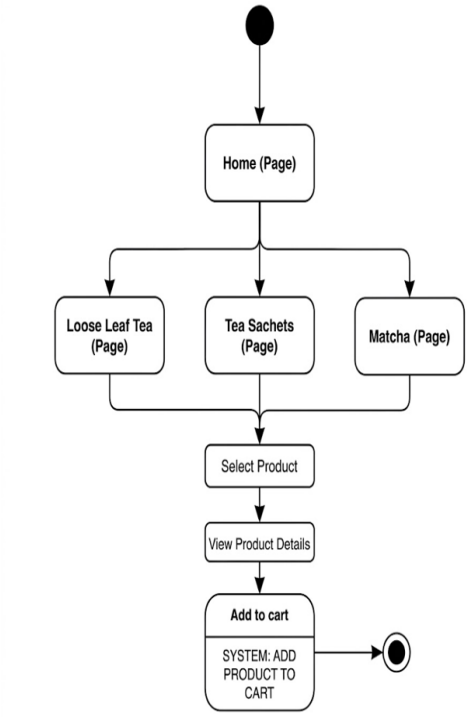


Figure 5. Activity Diagram homepage and products.

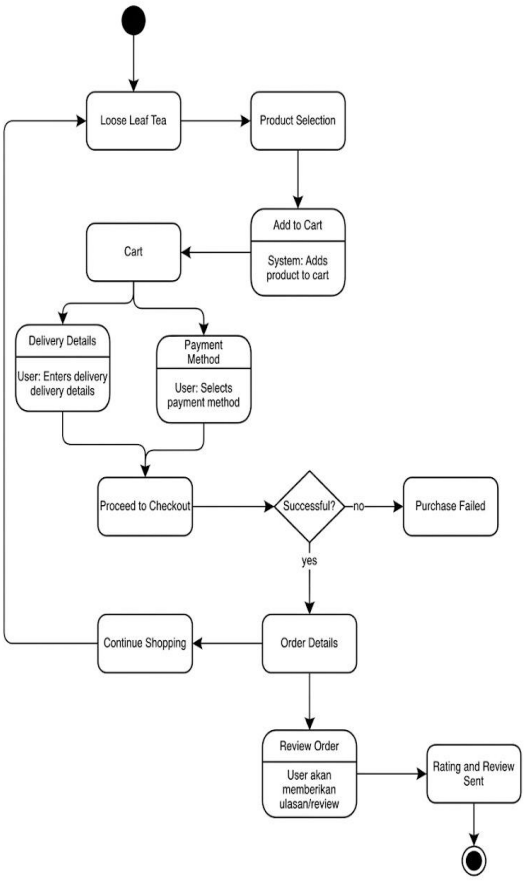


Figure 6. Activity Diagram order.

3.4 Interface Implementation

The implementation stage involves applying the interface design to visual page layouts for the Acachia e-commerce website. This stage focuses on demonstrating how the proposed design is implemented across the system's main pages, including the Matcha product page and cart page. Each page contains essential interface elements such as product images, descriptions, prices, navigation menus, and action buttons.

The implemented interface was designed with an emphasis on clarity, readability, and consistency to support user interaction. Through these page implementations, the proposed system can be represented in a more concrete and structured form, providing an overview of how users may interact with the platform in practice.

Figure 7 illustrates the implementation of the Matcha page in the proposed system. The page integrates product information, navigation features, and product listings in a structured interface to support usability and improve the user browsing experience.

DOI: https://doi.org/10.17509/coelite.v5i2.99237
p- ISSN 2829-4157 e- ISSN 2829-4149

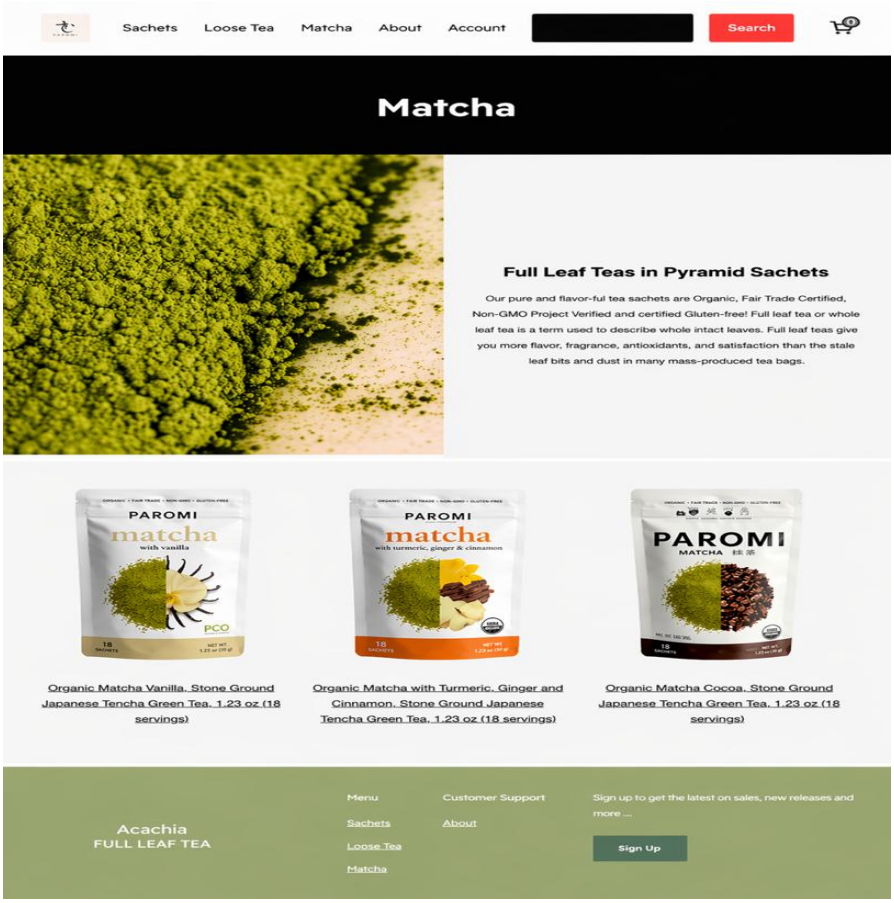


Figure 7. Interface implementation of matcha home page.

Figure 8 shows the implementation of the cart page in the proposed Acachia e-commerce system. This page displays the products selected by the user along with relevant purchase information, allowing users to review their orders before proceeding to checkout. The interface is designed to support clarity and ease of use by presenting product details, quantity, and transaction-related actions in a structured manner.

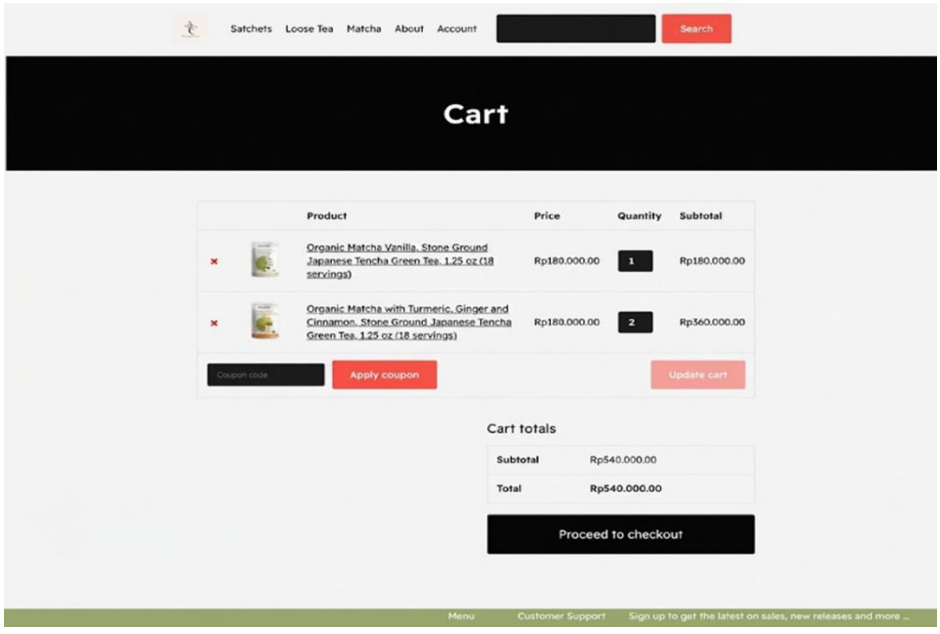


Figure 8. Interface implementation of cart page.

3.5 Evaluation

The evaluation stage was conducted using scenario-based usability validation to assess whether the proposed interface could support the main tasks commonly performed by e-commerce users. The evaluated scenarios included accessing the homepage, browsing product categories, reviewing product information, adding products to the cart, reviewing cart contents, preparing for checkout, and reviewing order history.

The assessment focused on six aspects, namely interface clarity, ease of navigation, product information, visual appearance, transaction process, and overall satisfaction. Each aspect was assessed using a five-point Likert scale, where 1 indicated very poor, and 5 indicated very good, as presented in **Table 1**.

Table 1. User satisfaction evaluation aspects.

No.	Evaluation Aspect	Description
1	Interface clarity	Ease of understanding the layout and displayed information
2	Ease of navigation	Ease of moving between pages and accessing features
3	Product information	Clarity and completeness of product details
4	Visual appearance	Attractiveness of the interface design
5	Transaction process	Ease of using cart and checkout features
6	Overall satisfaction	General satisfaction with the website implementation

The validation involved ten respondents who were selected as potential end users of the Acachia e-commerce website. The respondents were asked to review the proposed interface based on predefined e-commerce scenarios. The score in **Table 2** represents the average score obtained from the respondents for each scenario.

Table 2. Scenario-Based Usability validation results.

No.	User Scenario	Observation Result	Score
1	Accessing the homepage	The homepage provides clear branding and main navigation.	4
2	Browsing product categories	Product categories are visible and support product exploration.	4
3	Reviewing product information	Product name, image, and price are clear, but ingredients and product benefits need improvement.	3
4	Adding products to the cart	Cart-related actions are easy to identify.	4
5	Reviewing cart contents	The cart page displays selected products and transaction information clearly.	4
6	Preparing for checkout	Checkout flow is represented, but payment confirmation needs further development.	3
7	Reviewing order history	Order history is included, but tracking status is not yet fully represented.	3
		Total	**25**
		Average	**3.57**

Based on Table 2, the proposed interface achieved a total score of 25 and an average score of 3.57 out of 5. The highest scores were found in homepage access, product browsing, cart interaction, and cart review, each receiving an average score of 4. These results indicate that the system provides a clear navigation structure and supports the main user flow from

DOI: https://doi.org/10.17509/coelite.v5i2.99237
p- ISSN 2829-4157 e- ISSN 2829-4149

product exploration to cart review. However, product information, checkout preparation, and order history received lower average scores, each receiving a score of 3. This indicates that the proposed system still requires improvement in product detail completeness, payment confirmation, and order tracking features.

3.6 Discussion

The results of this study show that the proposed Acachia e-commerce system was developed through a structured process that connects business needs, system modeling, interface implementation, and usability validation. The Business Model Canvas identifies the main business requirements, including product quality, product variety, competitive pricing, and product knowledge. These requirements were then translated into design artifacts, including the sitemap, use case diagram, activity diagrams, and interface pages. This indicates that the proposed system was designed not only as a transaction platform but also as an information platform for herbal tea products.

The sitemap and use case diagram show that the system provides a clear navigation structure and covers essential e-commerce activities. The sitemap supports user navigation from the homepage to product pages, cart, checkout, and order history. Meanwhile, the use case diagram describes the main interactions between users and the system, such as sign up, sign in, product browsing, cart management, checkout, rating and review, order history, and logout. These results indicate that the proposed system has a coherent structure for supporting the main user journey in an e-commerce platform.

The activity diagrams further explain the workflow of the main processes, particularly product browsing and ordering. The ordering process shows a logical flow from product selection to checkout preparation. However, this process still needs further improvement, especially in payment confirmation, delivery status, and transaction notification. Therefore, the current design can be considered an initial validated design that still requires full functional implementation before real deployment.

The scenario-based usability validation produced a total score of 25 and an average score of 3.57 out of 5. The highest scores were found in homepage access, product browsing, cart interaction, and cart review, each receiving a score of 4. These results indicate that the proposed interface is generally usable for supporting basic e-commerce activities. However, product information, checkout preparation, and order history received lower scores, each receiving a score of 3. This shows that several aspects still need improvement, particularly ingredients and product benefit information, payment confirmation, and order tracking.

Compared with previous studies that mainly focus on general e-commerce design or technical implementation, this study integrates business analysis, system modeling, interface implementation, and preliminary usability validation for a niche SME product. Therefore, the contribution of this study lies in the structured development framework and initial validation results that can support future development of e-commerce systems for specialized SME products. However, this study is still limited because the validation involved only ten respondents and was conducted as a preliminary scenario-based usability validation. Future studies should implement the system fully and conduct broader empirical usability testing with more respondents.

4. CONCLUSION

This study designed and evaluated a web-based e-commerce system for Acachia herbal tea products using the Waterfall model. The Waterfall model was considered suitable because the proposed system had relatively stable requirements and clearly defined business processes. The integration of the Business Model Canvas, sitemap, use case diagram, activity diagrams, interface implementation, and scenario-based usability validation produced a structured representation of an e-commerce system that supports both business needs and user interaction.

The scenario-based usability validation involving ten respondents showed that the proposed interface achieved a total score of 25 and an average score of 3.57 out of 5. These results indicate that the proposed interface is generally usable for supporting basic e-commerce activities, particularly homepage access, product browsing, cart interaction, and cart review. However, several aspects still require improvement, especially product information completeness, checkout confirmation, payment integration, and order tracking.

This study contributes a structured design and preliminary usability validation framework for developing e-commerce systems for niche SME products such as herbal tea. Future studies are recommended to develop the system into a fully functional application, integrate database and payment features, and conduct broader empirical usability testing with more respondents using established usability measurement instruments.

5. AUTHOR'S NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

6. REFERENCES

[1] G. D. P. Tsabbita Isnina Hasana, Christine Irene Silalahia, Reinert Yosua Rumagita, "UI/UX Design Impact on E-Commerce Attracting Users," *Procedia Comput. Sci.*, vol. 245, pp. 1075–1082, 2024, doi: 10.1016/j.procs.2024.10.336.

[2] C. Bachri and Wahyudi, "Perancangan Sistem Informasi Penyewaan Bus Pariwisata pada PO. Rejeki Gemilang Berbasis Web," *Akrab Juara : Jurnal Ilmu-Ilmu Sosial*, vol. 6, no. 5, pp. 174–184, 2021, doi: 10.58487/akrabjuara.v6i5.1697.

[3] F. Muzakki and A. Ariesta, "E-commerce Untuk Meningkatkan Penjualan Menggunakan Content Management System Pada Toko Bakso Frozen Mas Gondrong," *ZONAsi: Jurnal Sistem Informasi*, vol. 8, no. 1, pp. 34–47, 2026, doi: 10.31849/twrjkz93.

[4] S. F. Fakhirah, A. Tyanafisya, A. N. Annaufal, and I. A. Mahendar, "Design and Development of an E-Commerce Website Using the Waterfall Method with the Laravel Framework," vol. 8, no. 2, pp. 441–452, 2025.

[5] W. A. Husna, A. Purno, and W. Wibowo, "Analysis of the Impact of UX (User Experience) Design on E-Commerce Website Conversion," vol. 5, no. 4, pp. 3773–3781, 2024.

[6] L. Liliana, Y. Krishartanto, and D. Vera, "Aplikasi E-Commerce Kaset Online Berbasis Website," *JBASE - Journal of Business and Audit Information Systems*, vol. 4, no. 1, Apr. 2021, doi: 10.30813/jbase.v4i1.2732.

[7] A. Rakhmadi, M. Iqbal, and Y. Sulistyo, "A Systematic Implementation of the Waterfall Model in E- Commerce System Development for Small Businesses," *COmputing and INformation Systems*, vol. 1, no. 1, pp. 28–35, 2025.

[8] D. Yurisca Bernanda and O. Azhari, "Software Freight Forwarding Angkutan Darat untuk Antar Propinsi Menggunakan SDLC Water Fall," *JURNAL INFORMATIKA*, vol. 8, no. 2, 2021, doi: 10.31294/ji.v8i2.10568.

DOI: https://doi.org/10.17509/coelite.v5i2.99237
p- ISSN 2829-4157 e- ISSN 2829-4149

[9] R. Darmawan and B. Hakim, "Perancangan Sistem Website E-Commerce Pada PT. Natura Indoland dengan Codeigniter," *JBASE - Journal of Business and Audit Information Systems*, vol. 5, no. 2, Oct. 2022, doi: 10.30813/jbase.v5i2.3776.

[10] K. Hansdinata, O. Azhari, J. M. Anthony, and A. F. N. Runkat, "Aplikasi Penggajian Berbasis Web Pada PT XYZ," *JBASE - Journal of Business and Audit Information Systems*, vol. 8, no. 1, pp. 23–34, 2025, doi: 10.30813/jbase.v8i1.6235.

[11] F. S. Lee, F. Nurprihatin, H. Honni, A. P. Santoso, and F. F. Tampinongkol, "Aplikasi Pelaporan Kerja Cleaning Serice dengan Metode Waterfall," *Infotech: Journal of Technology Information*, vol. 10, no. 1, pp. 61–70, Jun. 2024, doi: 10.37365/jti.v10i1.248.

[12] G. P. Pinatih and D. Hidayatullah, "Rancang Bangun Inventory System Menggunakan Model Waterfall Berbasis Website," 2022. doi: 10.35957/jatisi.v9i1.1561.

[13] F. Wisnu Wijaya and D. Lomban, "Sistem Informasi Inventory Barang Menggunakan Metode Waterfall," 2022. doi: 10.31294/ijse.v7i1.10601.

[14] S. Fadilah, M. Danny, N. Surojudin, U. Pelita, and B. Bekasi, "Sistem Informasi Inventory Barang Berbasis Web Pada PT. Herso Ticep Indonesia Dengan Metode Waterfall," 2024. doi: 10.35200/ex.v14i2.124.

[15] A. Budiyantara, A. J. Nababan, B. Owen, J. Fernandes Andry, F. S. Lee, and O. Azhari, "Analisis IT Policy pada Ujian Berbasis ONLINE di SMK S SPES PATRIAE Analysis of IT Policy on Online-Based Examinations at SMK S SPES PATRIAE," *Jurnal of Business and Audit Information System (JBASE)*, vol. 7, no. 1, pp. 58–66, 2024, doi: 10.30813/jbase.v7i1.5624.

[16] H. Tannady, S. L. Felix, K. Christianto, F. S. Lee, and F. Isputrawan, "Aplikasi Persediaan, Penjualan, dan Pencatatan Piutang Pada PT. Sultana Agro Lestari," *JBASE - Journal of Business and Audit Information Systems*, vol. 5, no. 2, Aug. 2022, doi: 10.30813/jbase.v5i2.3775.

[17] O. Azhari, P. W. Setyaningsih, S. Eka, A. Buananta, F. Maitri, and F. S. Lee, "Pengembangan Aplikasi E-Booking Konser K-Pop Berbasis QRIS dengan Pendekatan User-Centered Design untuk Optimalisasi Pengalaman dan Efisiensi Transaksi," *Bulletin of Computer Science Research*, vol. 6, no. 3, pp. 853–860, 2026, doi: 10.47065/bulletincsr.v6i3.981.

[18] A. O. Pranoto and E. Sediyono, "Perancangan Sistem Informasi Inventaris Barang Berbasis Web," *Jurnal Teknik Informatika dan Sistem Informasi*, vol. 7, no. 2, Aug. 2021, doi: 10.28932/jutisi.v7i2.3597.

[19] Christanto and M. Fauzi Isputrawan, "Pengembangan Aplikasi E-Kost Berbasis Website Menggunakan Metode Microservice," *JBASE - Journal of Business and Audit Information Systems*, vol. 5, no. 1, 2022, doi: 10.30813/jbase.v5i1.3464.

[20] Y. M. Geasela, T. Lijadi, D. Tanria, T. Drisella, and B. R. Dagara, "Rancang Bangun Aplikasi Penyewaan Mobil Online 'Eazyrent' Berbasis Website," *Infotech: Journal of Technology Information*, vol. 9, no. 2, pp. 145–154, Nov. 2023, doi: 10.37365/jti.v9i2.193.

[21] K. Christianto, A. Budiyantara, F. S. Lee, J. F. Andry, D. Y. Bernanda, and D. Ananda, "Aplikasi Informasi UKM Pada Universitas di Jakarta Utara," *Infotech: Journal of Technology Information*, vol. 11, no. 1, pp. 1–8, Jun. 2025, doi: 10.37365/jti.v11i1.341.

[22] F. Agil Sakinah, F. Prima Aditiawan, and A. Lina Nurlaili, "Pengujian Pada Aplikasi Manajemen Aset Menggunakan Black Box Testing," 2024. doi: 10.36040/jati.v8i3.9524.

JURNAL UPI

Journal of Computer Engineering, Electronics and Information Technology (COELITE)

Journal homepage: https://ejournal.upi.edu/index.php/COELITE

Sentiment Analysis of Digital Literacy in Society Towards Financial Technology Lending Using The Naive Bayes

Vion Age Tricahyo[1], Dimas Kurnia Robby[2,] , Riyan Sanjaya[3], Wisnu Putri Airmas Jati[4], Nailul Munadhiroh[5], Annisa Ramadhani[6]*

[1-6]Departemen of Library and Information Science, Universitas Negeri Jakarta, Indonesia
Correspondence E-mail: vionage@unj.ac.id

ABSTRACT

The existence of financial technology lending (pinjol), as a fintech innovation, has become a hot topic in society. Its emergence, driven by the rapid growth of the internet and ease of access to information, has a significant impact on the financial sector. Behind its convenience, this service also faces various issues due to the low digital literacy of the public. Therefore, the Financial Services Authority (OJK) uses the social media platform X (Twitter) to monitor public opinion regarding this matter. Based on this background, this research is conducted to analyze the sentiment of the Indonesian public by categorizing it into positive and negative. The text classification in this study utilizes the effective and accurate Naïve Bayes algorithm, with a dataset of 2179 tweets obtained through crawling. The implementation steps of the method include literature study, data collection, preprocessing, labeling, Naïve Bayes implementation, results, and evaluation.

© 2026 Universitas Pendidikan Indonesia

ARTICLE INFO

Article History:
Submitted/Received 25 Sep 2025
First Revised 12 Oct 2026
Accepted 21 Oct 2026
First Available online 22 Oct 2026
Publication Date 22 Oct 2026

Keyword:
Sentiment Analysis,
Digital Literacy,
Naive Bayes,
OJK,
Pinjaman Online (pinjol).

1. INTRODUCTION

Online loans, or also referred to as pinjol, are a form of innovation in the field of Financial Technology (fintech) Lending that offers convenience for the public to apply for money loans. With just an internet connection, people can apply for loans anytime and anywhere through online loan service provider websites or applications. The ease of the process and loan requirements provides potential borrowers with various options to determine the services that fit their needs [1]. Nevertheless, the decision to engage in online loans needs to be accompanied by careful consideration and accurate calculations, as there are several risks that often accompany the practice of online borrowing. One of the main issues is the lack of digital literacy and understanding among the Indonesian public regarding the negative impacts of using online loans irresponsibly. Compared to conventional loans, online loans tend to offer higher interest rates and shorter repayment terms. This raises concerns, especially regarding the high-interest rate risks that can trap users in prolonged debt and make it difficult for them to repay the loans [2][3]. The existence of online loans has sparked various controversies and issues that attract public attention [4][5]. According to data from the PASTI Task Force (Satuan Tugas Pemberantasan Aktivitas Keuangan Ilegal) and the Financial Service Authority (OJK), throughout 2024, 3,240 illegal financial entities were found, of which 2,930 were illegal loan applications. Additionally, there were approximately 15,162 complaints related to illegal loans out of a total of 16,231 complaints. [6] In this case, the Financial Services Authority (OJK) supervises the development of online loans, one of which is through the social media platform Twitter, which is often used as the main platform to monitor public opinion regarding these services. Twitter is also frequently utilized as a data source in sentiment analysis [7]. Identifying the factors that trigger positive and negative sentiments towards online loan services is an important step in providing understanding and education to the public about the benefits and risks involved. In practice, sentiment analysis can be applied to various types of data such as reviews, comments, or public opinions [8]-[10].

From various research sources that use sentiment analysis, it can be found that the use of methods is very important to determine accuracy [11][12]. The Naïve Bayes method is one of the commonly used methods in sentiment analysis and has been widely applied in various similar studies. This method is known to have good accuracy and is capable of providing analysis results quickly and effectively. Among the following studies, it can be concluded that Naïve Bayes is highly recommended for the implementation of sentiment analysis, especially for research topics conducted by researchers using large data [13]-[19]

2. METHODS

The initial stage of this research is the data collection process carried out through crawling on social media platform X. The data retrieval process uses the keyword "pinjol" within the time frame from June 1, 2025, to August 31, 2025. The data crawling process is conducted using the Python programming language via Google Colab. Then the preprocessing or data processing stage is a step in the classification process aimed at cleaning and preparing the data so that it can be optimally processed in the subsequent classification stage.

2.1. Preprocessing stage

The stages are case folding for lowercase letters and characters with CaseFold(T) = lower(T) (1), cleaning to remove numbers, symbols, URLs, emojis, and special characterswith Clean(T)=T-{remove everything except the words} (2), tokenizing for change the sentence to a singular word with Tokenize(T)=[W_i, W_2,…,W_n] (3), normalization for changing

DOI: https://doi.org/10.17509/coelite.v5i2.90572
p- ISSN 2829-4157 e- ISSN 2829-4149

unstandardized sentences to standardized ones with Normalize (w_i)= {K [W_i] / [W_i],if $W_i \in K$, if $W_i \notin K$ (4), stopword removal for removing words that are not very important with Stopword(W)=W−S (5), and stemming for changing the word to its base form (using Indonesian dictionary standart) with Stem(W)=[stem(Wi),stem($W2$),...,stem(Wn)] (6).

2.2. Labeling stage

After applying preprocessing, the labeling process is continued, as illustrated in **Figure 1**. Labeling functions to facilitate the sentiment classification process, whether the review is positive or negative. Reviews with positive sentiment are labeled with the number one, while negative sentiment is labeled with zero. The formula used is Label(di)= Cj (7), di: for document or teks the-i, Cj: Class label the-j, likes : C_0= Negative C_1= Positive.

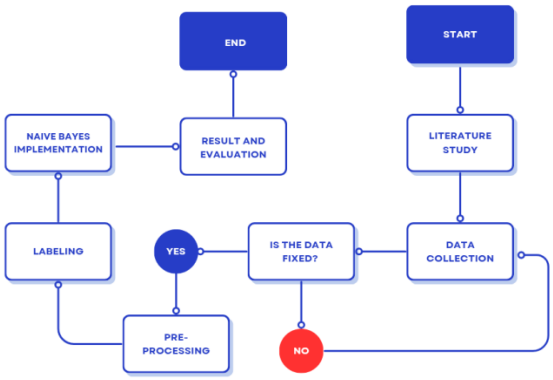


Figure 1. Research Flow

2.3. Naive Bayes Implementation stage

The last step is the implementation of naive bayes. Naïve Bayes itself is one of the classification algorithms widely used in the fields of Data Mining and Text Mining. This data consists of text that will be classified into two categories, namely text that contains sentiment. The naïve bayes algorithm works based on Bayes' theorem, which operates according to the principle of conditional probability. Conditional probability represents the likelihood or chance of an event occurring, given that another event has already occurred. Below is the formula for conditional probability.

$$(P(A|B) = \frac{P(B|A).(A)}{P(B)} \qquad (8)$$

The explanation of the formula is P(A|B) = The probability of event A given that B has occurred, P(B|A) = The probability of event B given that A has occurred, P(A) = The probability of event A and P(B) = The probability of event B.

2.4. Evaluation Model

In determining the best model, something is needed to measure the performance of a model so that it can be compared with one another. One way to do this is by using a confusion matrix. A confusion matrix is a table that indicates how many test data points are correctly and incorrectly classified [20]. The parameters used in the test data are TP (true positive), FN (false negative), TN (true negative), FP (false positive).

DOI: https://doi.org/10.17509/coelite.v5i2.90572
p- ISSN 2829-4157 e- ISSN 2829-4149

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \quad (9)$$

$$\text{Precision} = \frac{TP}{TP+FP} \quad (10)$$

$$\text{Recall} = \frac{TP}{TP+FN} \quad (11)$$

$$\text{F1-Score} = \frac{2X\ Precision x Recall}{Precision+Recall} \quad (12)$$

Through the calculations above, the data will show the percentage values of each component starting from accuracy, precision, recall, and f1-score. The values represent the overall data that has gone through the training and testing process.

3. RESULTS AND DISCUSSION

3.1. Data Collection and Preprocessing

Data collected from social media X over 3 months amounted to 2179 data points. Through tweet-harvest, the collected data will be stored in .csv format to facilitate the execution of programs with Python in Google Colab. The data that has gone through the pre-processing stage will proceed to the labeling process, which is calculated from the sentiment polarity value using the sentiment method from the TextBlob object. The implementation using the following code is:

```
sentimen_percentages = (sentimen_counts / total_data) * 100.
```

From the implementation of the code above, the output percentage will appear as follows.

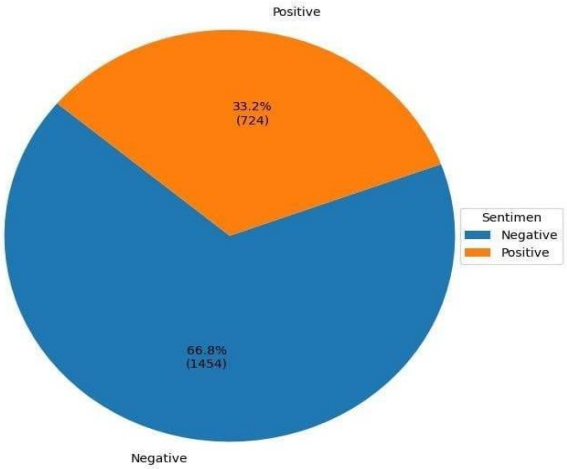


Figure 2. Output percentage

From the results above, as presented in **Figure 2**, it can be seen that the sentiment calculated using the value_count() code produces a majority of negative data. This means that the public's sentiment towards online loans has a low positive perception of 33.2 percent and a negative perception of 66.8 percent from the public. This also proves that the majority of the population is trapped in low digital literacy. Many comments indicate they are less careful about bombastic online loan offers that are often cheaper than conventional loans. However,

DOI: https://doi.org/10.17509/coelite.v5i2.90572
p- ISSN 2829-4157 e- ISSN 2829-4149

the reality is that bank interest rates are higher, resulting in the community becoming increasingly trapped in a more difficult economic situation.

3.2. TF-IDF Implementation, Naive Bayes and Evaluation

After determining the percentage of society through its perception, the data calculation continues with Term Frequency-Inverse Document Frequency (TF-IDF). This process repeats the tokenization process in which the weight of each root word is calculated. The result of the TF-IDF implementation is decipted in **Figure 3**.

	term	TF	TF-IDF
0	0	{'spam': 0.1, 'call': 0.1, 'menggangu': ...	{'spam': 0.404857614376652, 'call': 0.5047...
1	1	{'investasi': 0.1, 'bodong': 0.1, 'negara...	{'investasi': 0.538357721049886, 'bodong':...
2	2	{'wakil': 0.05263157894736842, 'rakyat': 0...	{'wakil': 0.3680534275278736, 'rakyat': 0...
3	3	{'lindung': 0.11764705882352941, 'konsumen'...	{'lindung': 0.564210652423146, 'konsumen':...
4	4	{'simple': 0.08333333333333333, 'kurang': ...	{'simple': 0.5249889951977512, 'kurang': 0...
...	...	...	...
2173	2173	{'sop': 0.06666666666666667, 'kantor': 0.1...	{'sop': 0.38268347696250615, 'kantor': 0.6...
2174	2174	{'gue': 0.1, 'gapeduli': 0.1, 'gaya': 0....	{'gue': 0.26957297167141697, 'gapeduli': 0...
2175	2175	{'nyokap': 0.09090909090909091, 'tau': 0.0...	{'nyokap': 0.4525556456718814, 'tau': 0.24...
2176	2176	{'jual': 0.125, 'buku': 0.0625, 'bekas':...	{'jual': 0.5356206152288437, 'buku': 0.368...
2177	2177	{'galbay': 0.125, 'panjul': 0.125, 'paspo...	{'galbay': 0.3654985460868937, 'panjul': 0...

Figure 3. TF-IDF result

After that, the data above will be separated into training data and test data. Based on the processed data, it will be divided with a proportion of 70% for training data and 30% for test data. Using `X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=654.` Continue the implementation of naive bayes using `nb_classifier = MultinomialNB() nb_classifier.fit(X_train_tfidf, y_train).` And the evaluation ended with the use of a confusion matrix, the results are as follows:

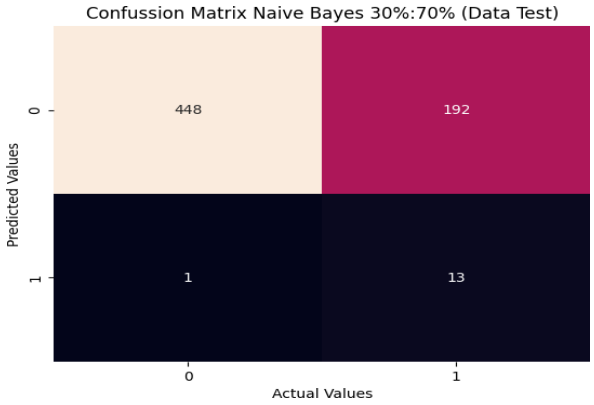


Figure 4. Confusion Matrix result

Based on **Figure 4**, there are 13 positive data accurately predicted as positive, 192 positive data incorrectly predicted as negative, 448 negative data accurately predicted as negative, and 1 negative data incorrectly predicted as positive. The results are then evaluated using a classification report as shown in **Table 1**.

DOI: https://doi.org/10.17509/coelite.v5i2.90572
p- ISSN 2829-4157 e- ISSN 2829-4149

Table 1. Naive Bayes result

	Precision	Recall	F1-Score	Report
Negative	0,70	1,00	0,82	449
Positive	0,93	0,06	0,12	205
Accuracy			0,70	654
Macro Avg	0,81	0,53	0,47	654
Weighted Avg	0,77	0,70	0,60	654

The data above shows the classification report results from the Naïve Bayes algorithm using 30% of the test data from a total of 2,185 tweets, which amounts to 654 data points. Based on this evaluation, the precision is obtained at 93%, the recall at 6%, the f1-score at 12%, and the accuracy reaching 70% in this test.

To facilitate the observation of the data, barplot and wordcloud visualizations are used. The visualizations will depict both positive and negative sentiments that illustrate the frequency or occurrence of related words. Below are the results of the visualizations:

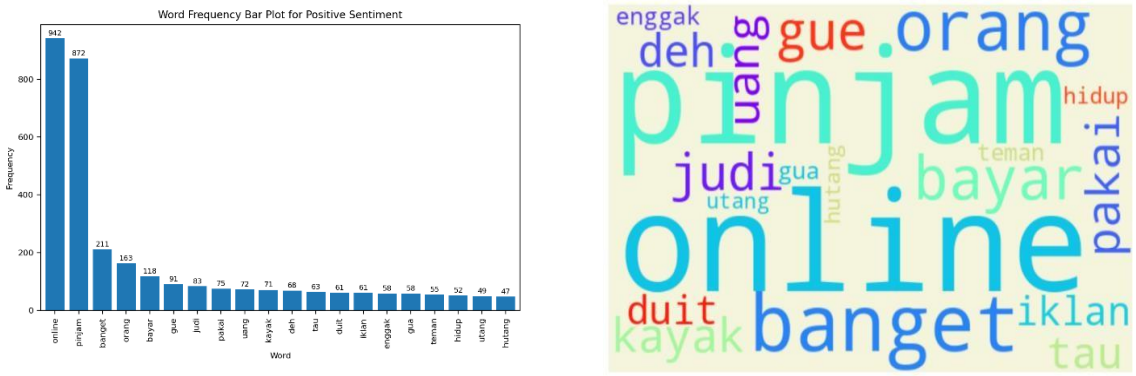


Figure 5. Barplot and wordcloud of positive sentiment

Based on **Figure 5**, several words that appear most frequently are obtained, such as the word "online" with a frequency of 942 times, the word "pinjam" 872 times, "banget" 211 times, and so on. This data shows supportive words or additional expressions in sentences with a positive sentiment. Of the 33.2 percent of sentences identified as positive, the public still uses the list of words above to express sentences related to online loans.

Meanwhile, as depicted in **Figure 6**, there are also several words that appear most frequently, such as the word "online" with a frequency of 1866 times, the word "pinjam" 1727 times, "bayar" 274 times, and so on. The words that appear are those that have negative sentiment and are the most frequently discussed topics by users. In the list of words above, it can also be analyzed that the word 'lilit' is in the negative sentiment category and certainly is not in the positive sentiment list. In addition, the words 'bayar' and 'judi', although they are also in the positive sentiment list, have a clearly larger and more significant percentage in negative sentiment.

DOI: https://doi.org/10.17509/coelite.v5i2.90572
p- ISSN 2829-4157 e- ISSN 2829-4149

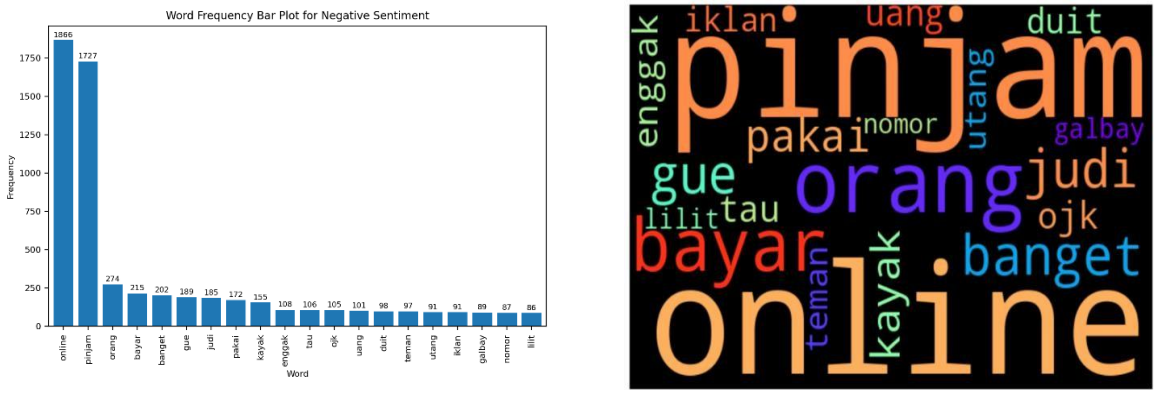


Figure 6. Barplot and wordcloud of negative sentiment

Words of larger size in the wordcloud indicate that these words appear more frequently and are part of the discussion topic for both positive and negative assessments by users.

4. CONCLUSION

This research uses the Naïve Bayes algorithm to classify sentiment towards online loans on social media X. The analysis results show that the majority of public sentiment is negative with a percentage of 66.8% and positive at 33.4%. Evaluation using a confusion matrix indicates a Naïve Bayes accuracy of 70% on a 30:70 data split. For the implementation of bar plots and word clouds, both positive and negative sentiments show that the words borrow, online, people, and gambling are among the top list of words frequently used by users to express in sentence form.

5. ACKNOWLEDGMENT

The writer expresses gratitude to the team involved in this research, and the support system from the university that continues to encourage the writer to grow and make an impact.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

REFERENCES

[1] Ramdani, B., Saputra, A. D., Rafli, M., & Zahir, A. (2024). Analisis Sentimen Terhadap Ulasan Aplikasi Pinjaman Online (PINJOL) di Google Play Store Menggunakan Naive Baiyes Classifer. *Jurnal Riset Informatika dan Teknologi Informasi. 1*(2), 61–64.

[2] Kusuma, F. W., Dermawan, P., Samsie, I., & Salman, N. (2024). Tinjauan Sentimen Terhadap Ulasan Aplikasi Peminjaman Online Dengan Metode Support Vector Machine (SVM). *MALCOM: Indonesian Journal of Machine Learning and Computer Science 4*(1), 13–21.

[3] Wijayanti, S. (2022). Dampak Aplikasi Pinjaman Online Terhadap Kebutuhan Dan Gaya Hidup Konsumtif Buruh Pabrik. *MIZANIA: Jurnal Ekonomi dan Akuntansi*, 2(2), 230-235.

[4] Arvante, J. Z. Y. (2022). Dampak Permasalahan Pinjaman Online dan Perlindungan Hukum Bagi Konsumen Pinjaman Online. *Ikatan Penulis Mahasiswa Hukum Indonesia Law Journal*, 2(1), 73-87.

DOI: https://doi.org/10.17509/coelite.v5i2.90572
p- ISSN 2829-4157 e- ISSN 2829-4149

[5] Sugangga, R., and Sentoso, E. H. (2020). Perlindungan Hukum Terhadap Pengguna Pinjaman Online (Pinjol) Ilegal. *Pakuan Justice Journal of Law*, 1(1), 47-61.
[6] ANTARA, J. (2025). *OJK: Pinjol ilegal jadi kasus paling banyak ditemukan SatgasPASTI*. Jakarta (ANTARA). https://www.antaranews.com/berita/4663565/ojk-pinjol-ilegal-jadi-kasus-paling-banyak-ditemukan-satgas-pasti
[7] Ismail, A. R., and Hakim, R. B. F. (2023). Implementasi Lexicon Based Untuk Analisis Sentimen Dalam Mengetahui Trend Wisata Pantai Di DI Yogyakarta Berdasarkan Data Twitter. *Emerging Statistics and Data Science Journal*, 1(1), 37-45.
[8] Medhat, W., Hassan, A., and Korashy, H. (2014). Sentiment analysis algorithms and applications: A survey. *Ain Shams Engineering Journal*, 5(4), 1093-1113.
[9] Utami, D. S., and Erfina, A. (2021). *Analisis Sentimen Pinjaman Online Di Twitter Menggunakan Algoritma Support Vector Machine (SVM)*. 299–305.
[10] Munna, A., and Zuliarso, E. (2024). Interpretasi model Stacking Ensemble untuk analisis sentimen ulasan aplikasi pinjaman online menggunakan LIME. *AITI: Jurnal Teknologi Informasi*, *21*(2), 183–196.
[11] Awangga, R. M., and Khonsa, N. H. (2022). Analisis Performa Algoritma Random Forest dan Naive Bayes Multinomial pada Dataset Ulasan Obat dan Ulasan Film. *InComTech: Jurnal Telekomunikasi dan Komputer*. *12*(1), 60–70.
[12] Mualfah, D., Prihatin, A., and Firdaus, R. (2023). Analisis Sentimen Masyarakat Terhadap Kasus Pembobolan Data Nasabah Bank BSI Pada Twitter Menggunakan Metode Random Forest Dan Naïve Bayes. *Jurnal FASILKOM (Teknologi Informasi Dan Ilmu Komputer) 13*(3), 614–620.
[13] Miranda, K., and Suryono, R. R. (2025). Analisis Sentimen Pinjaman Online: Studi Komparatif Algoritma Naïve Bayes, Decision Tree, dan KNN. *Edumatic: Jurnal Pendidikan Informatika*, 9(2), 372-381.
[14] Siki, Y. C. H., Tokan, T. B. A., Manehat, D. J., Ngaga, E., and Mau, S. D. B. (2025). Perbandingan Metode Naïve Bayes dan K-Nearest Neighbor Terhadap Sentimen Analisis Pinjaman Online. *Jurnal Media Informatika*, 6(3), 1614-1622.
[15] Ghozali, M. I., Sugiharto, W. H., and Iskandar, A. F. (2023). Analisis Sentimen Pinjaman Online Di Media Sosial Twitter Menggunakan Metode Naive Bayes. *KLIK: Kajian Ilmiah Informatika Dan Komputer 3*(6), 1340–1348. https://doi.org/10.30865/klik.v3i6.936
[16] Miftahusalam, A., Pratiwi, H., and Slamet, I. (2023). Perbandingan Metode Random Forest dan Naive Bayes pada Analisis Sentimen Review Aplikasi BCA Mobile. *SIPTEK : Seminar Nasional Inovasi dan Pengembangan Teknologi* Pendidikan, 1–8.
[17] Huda, M. M., Tricahyo, V. A., Yusron, R. D. R., and Septarina, A. A. (2024). Analisis Tingkat Literasi Digital Siswa Berbasis Web Game Edukasi Sebagai Bagian Kesiapan Pembelajaran Digital. *Jurnal Sistem Informasi dan Teknologi Informasi Komputer*. 2(6), 85-97. https://doi.org/10.53624/jsitik.v2i2.352
[18] Rieuwpassa, J. A., Sugito, and Widiharih, T. (2023). Implementasi Metode Naive Bayes Classifier Untuk Klasifikasi Sentimen Ulasan Pengguna Aplikasi Netflix Pada Google Play. *Jurnal Gaussian*, 12(3), 362-371. https://doi.org/10.14710/j.gauss.12.3.362-371
[19] Yanto, A. F. A., and Testiana, G. (2024). Implementasi Metode Klasifikasi Naïve Bayes Untuk Memprediksi Juara La Liga. *Jurnal Teknologi Sistem Informasi*, 5(2). https://doi.org/10.35957/jtsi.v5i2.8028
[20] Tharwat, A. (2021). Classification assessment methods. *Applied Computing and Informatics*, 17(1), 168-192.

DOI: https://doi.org/10.17509/coelite.v5i2.90572
p- ISSN 2829-4157 e- ISSN 2829-4149

JURNAL UPI

Journal of Computer Engineering, Electronics and Information Technology (COELITE)

Journal homepage: https://ejournal.upi.edu/index.php/COELITE

Analysis of Household Electricity Consumption Patterns Using K-Means Clustering

Fika Saputri[1], Asminar [2], Tambi[3], Mustarum Musaruddin[4], Muhammad Nadzirin Anshari Nur[5], Adhi Setiawan Samsul[6]*

[1,2,3,4,5,6]Department of Electrical Engineering, Universitas Halu Oleo, Indonesia
Correspondence E-mail: fikasaputri29@gmail.com

ABSTRACT

The continuous increase in household electricity consumption and irregular usage patterns pose challenges for efficient energy management. Irregular electricity load patterns can lead to energy waste, increased costs, and disruptions to the distribution system. Therefore, a method capable of accurately identifying electricity consumption patterns is needed. This study aims to analyze household electricity consumption patterns using the K-Means Clustering algorithm. The data used comes from PLN UP3 Kendari in the form of historical data for the 2023–2025 period and real-time data processed into daily parameters. The K-Means method was used to cluster the data based on the similarity of electricity consumption characteristics. The determination of the optimal number of clusters was performed using the Elbow Method and the Silhouette Score. The results of the study indicate that the optimal number of clusters is four, with a Silhouette Score of 0.5122 and a Davies-Bouldin Index of 0.6881, indicating that the cluster quality is quite good. Each cluster represents a distinct consumption pattern: low, stable medium, high, and fluctuating. Thus, the K-Means Clustering algorithm is effective for identifying household electricity consumption patterns.

© 2026 Universitas Pendidikan Indonesia

ARTICLE INFO

Article History:
Submitted/Received 31 Mar 2026
First Revised 07 Oct 2026
Accepted 20 Oct 2026
First Available online 22 Oct 2026
Publication Date 22 Oct 2026

Keyword:
K-Means Clustering,
Electricity Consumption,
Electricity Load Patterns,
Load Profiling,
Data Mining

1. INTRODUCTION

Residential electricity consumption continues to rise in tandem with population growth and technological advancements. This increase poses challenges for efficient energy management, including energy waste, rising operational costs, and environmental impacts resulting from emissions from fossil-fuel-based power plants [1][2].

In the Kendari region, electricity consumption patterns are influenced by diverse community activities, resulting in fluctuating and unpredictable electricity load patterns [1][3]. These irregular electricity load patterns can cause problems in the power distribution system, such as voltage drops, increased power losses, and network stability disturbances. Therefore, a method is needed that can identify and group electricity consumption patterns.

Previous studies have employed clustering methods to identify patterns in electricity consumption [4], one of which is the K-Means Clustering algorithm, known for its simplicity and efficiency in grouping data based on similar characteristics [2][5][6]. Furthermore, cluster quality evaluation is generally performed using the Silhouette Score and the Davies-Bouldin Index to ensure optimal clustering results [7][8]. However, the application of this method to residential electricity consumption data, taking into account daily load characteristics and distribution system operational parameters, still requires further study to obtain representative clustering results.

Based on these issues, this study aims to analyze household electricity consumption patterns using the K-Means clustering algorithm. The results of this study are expected to provide an overview of the characteristics of electricity consumption patterns and serve as a basis for decision-making to improve the efficiency and reliability of the electricity distribution system. Clustering approaches are also continuously evolving and are used in various fields of data analysis to improve the accuracy of data grouping [9].

2. METHODS

This study uses household electricity consumption data obtained from PLN UP3 Kendari, consisting of historical data for the 2023–2025 period and real-time data, which were processed into daily parameters. The variables used include date, feeder name, voltage, current, active power, active energy, power factor, system frequency, peak load, load factor, peak load duration, and number of customers, which are used as parameters to describe electricity consumption characteristics. The research stages were conducted systematically, as shown in **Figure 1.**

DOI: https://doi.org/10.17509/coelite.v5i2.98496
p- ISSN 2829-4157 e- ISSN 2829-4149

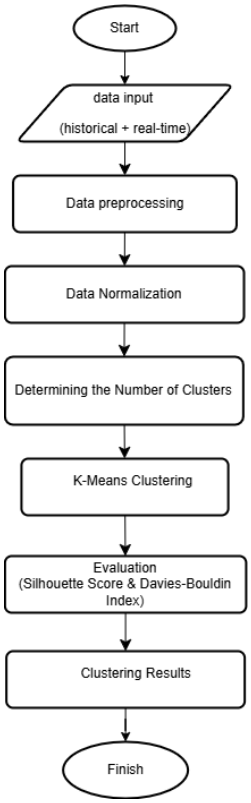


Figure 1. Research flowchart.

Based on **Figure 1**, the research stages are described as follows:

1. Data Input
   The data collection process, consisting of historical and real-time data, which is used as the basis for analyzing electricity consumption patterns.
2. Cleaning Data
   Removing invalid data and duplicates, as well as handling missing data, to ensure data quality is maintained.
3. Data Normalization
   Standardizing the scale across variables to prevent any single variable from dominating the clustering process.
4. Determining the Number of Clusters
   The optimal number of clusters is determined using the Elbow Method and Silhouette Score to identify the most representative number of clusters.
5. K-Means Clustering
   The clustering process is performed using the K-Means algorithm, which groups data [10][11] based on their distance from the centroids. The distance between data points is calculated using Euclidean distance, which is defined as follows [12]:

   $$d(x, \mu) = \sqrt{\sum_{i=1}^{n} (x_i - \mu_i)^2}$$

   Where x_i is the data value on the $-i$, μ_i is the cluster centroid on the kth dimension $-i$, and n is the number of variables.
6. Evaluation

DOI: https://doi.org/10.17509/coelite.v5i2.98496
p- ISSN 2829-4157 e- ISSN 2829-4149

The clustering results were evaluated using the Silhouette Score [7][13] and the Davies-Bouldin Index (DBI) [8][14] to assess cluster quality. The Silhouette Score is defined as follows [7]:

$$S(i) = \frac{b(i) - a(i)}{\max(a(i), b(i))}$$

Where $a(i)$ is the average distance of the data points from the same cluster, while $b(i)$ is the average distance to the nearest cluster. A value close to 1 indicates good cluster quality. In addition to the Silhouette Score, the Davies-Bouldin Index (DBI) is used, which is defined as follows [8]:

$$DBI = \frac{1}{k}\sum_{i=1}^{k} \max_{j \neq i}\left(\frac{S_i + S_j}{M_{ij}}\right)$$

Where k is the number of clusters, S_i and S_j are the average distances between data points within the-i and ke- j clusters, *respectively, and* M_{ij} is the distance between the centroids of the-i and the-j clusters.

7. Clustering Results
   The final step involves interpreting the results of the data clustering based on the observed characteristics of electricity consumption.

3. RESULTS AND DISCUSSION

The household electricity consumption data used in this study were obtained from PLN UP3 Kendari for the period 2023–2025. After data cleaning, a total of 5,305 data points were used in the analysis.

The number of clusters was determined using the Elbow Method and the Silhouette Score. Based on the analysis results, the optimal number of clusters was determined to be four (k=4). A Silhouette Score of 0.5122 indicates that the cluster quality is in the fairly good category [15], while a Davies-Bouldin Index (DBI) value of 0.6881 indicates that the separation between clusters is quite clear.

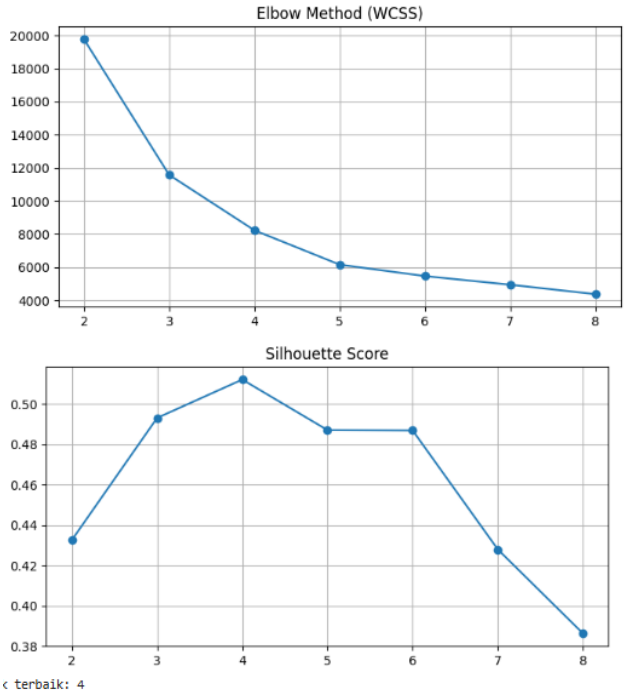


Figure 2. Determining the optimal number of clusters.

DOI: https://doi.org/10.17509/coelite.v5i2.98496
p- ISSN 2829-4157 e- ISSN 2829-4149

Based on **Figure 2**, the results of clustering using the K-Means algorithm show that household electricity consumption data can be grouped into four clusters with distinct characteristics. These differences indicate variations in electricity consumption patterns among residential customers. Clustering methods have been widely used in electricity consumption analysis to identify energy usage patterns [16][17][18][19]. To clarify the characteristics of each cluster, a summary of the cluster profiles is presented in Table 1.

Table 1. Cluster profile.

cluster	tegangan_rata2	arus_rata2	daya_aktif	energi_aktif	faktor_daya	frekuensi_sistem	beban_puncak	load_factor	durasi_puncak_jam	jumlah_pelanggan
0	21000.0	41.229113	1.261050	30.265203	0.85	50.0	1.774525	71.751309	17.220314	9822.030784
1	21000.0	181.449879	5.549899	133.197566	0.85	50.0	7.614046	73.279439	17.587065	22889.244032
2	21000.0	116.586466	3.565960	85.583047	0.85	50.0	4.462256	80.142676	19.234242	15368.667759
3	21000.0	87.809874	2.685788	64.458910	0.85	50.0	5.623405	47.711655	11.450797	19707.785311

Based on **Table 1**, the clustering results using the K-Means algorithm show that the data is divided into four clusters with distinct characteristics. Cluster 0 exhibits the lowest values for current, active power, and active energy, and is therefore categorized as a cluster with low energy consumption. Conversely, Cluster 1 has the highest parameter values and the largest number of customers, indicating the highest level of electricity consumption.

Cluster 2 represents medium-level energy consumption with parameter values falling between the low and high clusters, and has a relatively high load factor. Meanwhile, Cluster 3 exhibits a more fluctuating consumption pattern, characterized by a lower load factor and

DOI: https://doi.org/10.17509/coelite.v5i2.98496
p- ISSN 2829-4157 e- ISSN 2829-4149

a shorter peak load duration. To reinforce the results of the analysis, representative feeder profiles for each cluster were visualized, as shown in **Figure 3.**

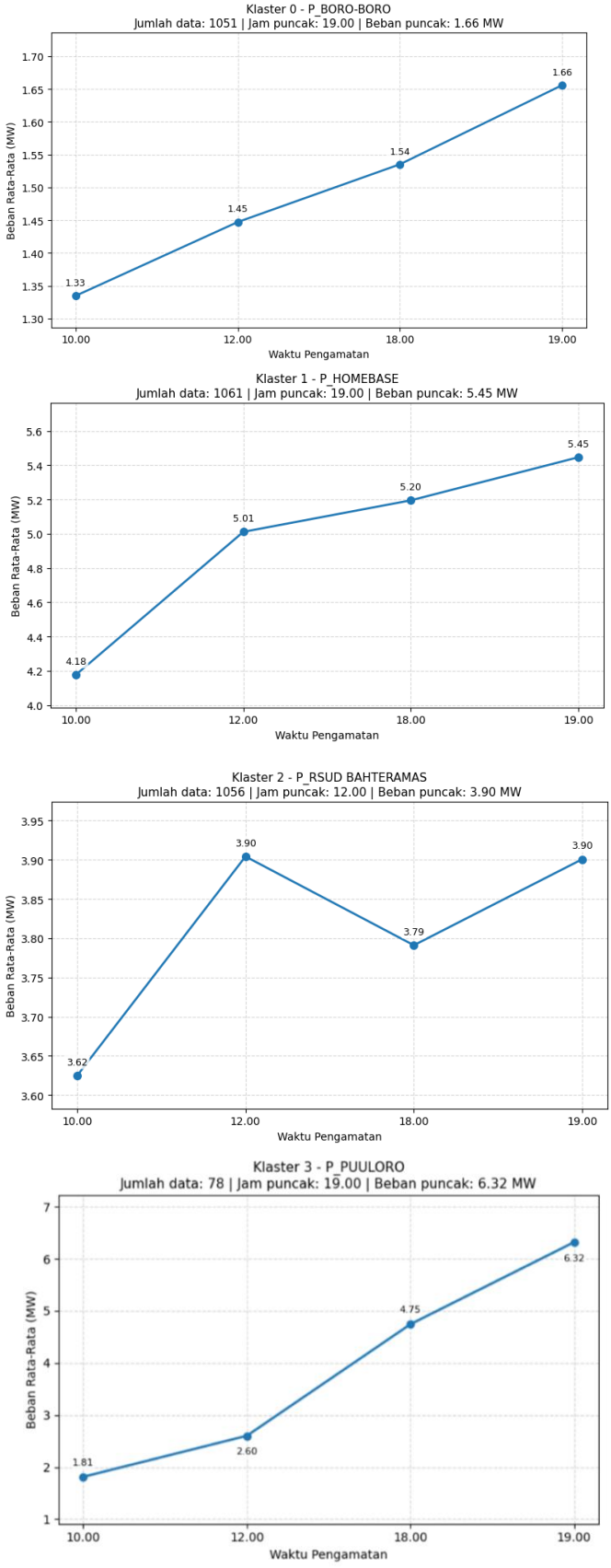


Figure 3. Profile of pepresentative distributors for each cluster.

DOI: https://doi.org/10.17509/coelite.v5i2.98496
p- ISSN 2829-4157 e- ISSN 2829-4149

Figure 3, shows the average load profile of representative feeders in each cluster based on observation time. In general, all clusters exhibit a trend of increasing load toward peak times, though with different characteristics.

Clusters 0 and 1 show a relatively stable increase until the evening peak, while Cluster 2 exhibits a more dynamic pattern with a peak during the day. Meanwhile, Cluster 3 shows the most significant increase with the highest peak load.

These differences indicate variations in electricity consumption patterns within each cluster, both in terms of load levels and peak times. This aligns with previous research showing that clustering methods can effectively identify electricity consumption patterns [20].

4. CONCLUSION

This study successfully grouped household electricity consumption patterns using the K-Means Clustering algorithm into four clusters with distinct characteristics. The evaluation results showed a Silhouette Score of 0.5122 and a Davies-Bouldin Index of 0.6881, indicating that the quality of the clustering falls into the “fairly good” category.

Each cluster represents a distinct consumption pattern—low, medium, high, and fluctuating—with differences in load levels and the timing of peak loads.

Overall, the K-Means method is effective in identifying electricity consumption patterns and can serve as a foundation for load management and electricity distribution planning.

5. ACKNOWLEDGMENT

The author would like to thank PT PLN (Persero) UP3 Kendari for its support and for providing data for this study. The author also extends gratitude to the academic advisor for providing guidance throughout the research process. Furthermore, the author would like to thank Halu Oleo University for its academic support.

6. AUTHORS’ NOTE

The authors declare that there are no conflicts of interest regarding the publication of this article. The authors affirm that this journal is free of plagiarism

7. REFERENCES

[1] F. Haykal, R. R. Hariadi, and K. Ghozali, “Rancang Bangun Sistem Pemantauan dan Forecasting Konsumsi Energi Listrik Menggunakan Internet of Things dan Algoritma Seasonal Time Series,” Jurnal Teknik ITS, vol. 11, no. 2, pp. A103–A109, 2022.

[2] A. N. A. Maulidhia, I. I. Widyastuti, F. I. Sukarno, R. B. S. Tsany, and T. Brian, “Implementation of the K-Means Algorithm on Household Electric Load,” Jurnal Sistem Telekomunikasi Elektronika Sistem Kontrol Power Sistem dan Komputer, vol. 5, no. 1, pp. 17–24, 2025.

[3] G. Okereke et al., “K-means clustering of electricity consumers using smart meter data,” Journal of Electrical Systems and Information Technology, 2023.

[4] A. K. Jain, M. N. Murty, and P. J. Flynn, “Data clustering: A review,” ACM Computing Surveys, vol. 31, no. 3, pp. 264–323, 1999.

[5] G. Chicco, “Overview and performance assessment of the clustering methods for electrical load pattern grouping,” Energy, vol. 42, no. 1, pp. 68–80, 2012.

[6] I. H. Witten, E. Frank, and M. A. Hall, Data Mining: Practical Machine Learning Tools and Techniques. Morgan Kaufmann, 2011.

DOI: https://doi.org/10.17509/coelite.v5i2.98496
p- ISSN 2829-4157 e- ISSN 2829-4149

[7] P. J. Rousseeuw, “Silhouettes: A Graphical Aid to the Interpretation and Validation of Cluster Analysis,” Journal of Computational and Applied Mathematics, vol. 20, pp. 53–65, 1987.
[8] D. L. Davies and D. W. Bouldin, “A Cluster Separation Measure,” IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. PAMI-1, no. 2, pp. 224–227, 1979.
[9] S. Haben, C. Singleton, and P. Grindrod, “Analysis and clustering of residential customers energy behavioral demand using smart meter data,” IEEE Transactions on Smart Grid, vol. 7, no. 1, pp. 136–144, 2020.
[10] J. MacQueen, “Some Methods for Classification and Analysis of Multivariate Observations,” in Proc. Fifth Berkeley Symp. Mathematical Statistics and Probability, 1967, pp. 281–297.
[11] S. Lloyd, “Least squares quantization in PCM,” IEEE Transactions on Information Theory, vol. 28, no. 2, pp. 129–137, 1982.
[12] F. Falanda, R. Gustriansyah, and H. Hartini, "Penentuan Objek Wisata, Objek Kuliner Serta Akomodasi Disekitar Pengguna Dikota Palembang Dengan Menggunakan Algoritma Euclidean Distance," *Jurnal Ilmiah Informatika Global*, vol. 7, no. 2, Dec. 2016.
[13] Y. Hasan, "Pengukuran Silhouette Score dan Davies-Bouldin Index pada Hasil Cluster K-Means dan DBSCAN," J. Inform. Tek. Elektro Terap., vol. 12, no. 3S1, 2024.
[14] L. Hanum, “Pengelompokan Gaya Belajar Mahasiswa Menggunakan Metode K-Means dan Validasi Menggunakan Davies Bouldin Index,” Jurnal Manajemen, Pendidikan dan Ilmu Komputer, vol. 2, no. 2, pp. 37–47, 2025.
[15] Y. Zhang, "Modified silhouette score with generalized mean and trimmed mean," Ph.D. dissertation, 2023.
[16] R. Wu, "Behavioral analysis of electricity consumption characteristics for customer groups using the k-means algorithm," *Syst. Soft Comput.*, vol. 6, p. 200143, 2024.
[17] H. Yu *et al.*, "Corn leaf diseases diagnosis based on K-means clustering and deep learning," *IEEE Access*, vol. 9, pp. 143824-143835, 2021, doi: 10.1109/ACCESS.2021.3120379
[18] S. Noertjahjani, D. P. Setyawan, and A. Kiswanto, "Analysis of Household Electricity Consumption Segmentation using K-means Clustering," *Int. J. Inform. Comput.*, vol. 7, no. 2, pp. 449-461, 2025.
[19] G. Chicco, R. Napoli, and F. Piglione, “Comparisons among clustering techniques for electricity customer classification,” IEEE Transactions on Power Systems, vol. 21, no. 2, pp. 933–940, 2006.
[20] J. Kwac, J. Flora, and R. Rajagopal, “Household energy consumption segmentation using hourly data,” IEEE Transactions on Smart Grid, vol. 5, no. 1, pp. 420–430, 2014.

DOI: https://doi.org/10.17509/coelite.v5i2.98496
p- ISSN 2829-4157 e- ISSN 2829-4149

Journal of Computer Engineering, Electronics and Information Technology (COELITE)
Journal homepage: https://ejournal.upi.edu/index.php/COELITE

Quality Evaluation of an Academic Information System Using Decision Table Testing and State Transition Testing

Fajar Mahardika[1], Kukuh Muhammad[2], Angga Maulana Purba[3], Nur Muniroh[4]*

[1-2]Department of Computer and Business, Informatics Engineering Program, Cilacap State Polytechnic, Indonesia
[3-4]Department of Computer and Business, Multimedia Engineering Technology, Cilacap State Polytechnic, Indonesia
Correspondence E-mail: fajarmahardika@pnc.ac.id

ABSTRACT

An Academic Information System plays a crucial role in managing course registration, grading, and student data administration, so its quality must be ensured. This study evaluates the quality of an Academic Information System using Decision Table Testing and State Transition Testing as functional testing approaches, focusing on the login and session management modules. Decision Table Testing verifies system behavior based on combinations of input conditions and business rules, while State Transition Testing analyzes system responses across different states and transitions. A total of 8 test cases designed using Decision Table Testing revealed 1 defect (12.5%) related to improper validation of inactive account status. Meanwhile, 5 test cases using State Transition Testing identified 1 defect (20%) in handling logout actions from a logged-out state. Overall, the system achieved a functional success rate of 84.6%, indicating a high level of reliability. These results show that Decision Table Testing is effective for detecting rule-based errors, while State Transition Testing is suitable for identifying weaknesses in state management. Combining both methods provides a comprehensive evaluation approach that improves the reliability and functional quality of the system.

ARTICLE INFO

Article History:
Submitted/Received 07 Apr 2026
First Revised 12 Oct 2026
Accepted 21 Oct 2026
First Available online 22 Oct 2026
Publication Date 22 Oct 2026

Keyword:
Academic Information System, Software Quality Evaluation, Decision Table Testing, State Transition Testing, Functional Testing

© 2026 Universitas Pendidikan Indonesia

1. INTRODUCTION

The rapid advancement of information technology has significantly transformed the education sector, particularly through the implementation of Academic Information Systems. These systems support essential academic processes such as course registration, grading, and student data management. However, as system complexity increases, ensuring software quality becomes a major challenge. Inadequate testing processes may lead to functional errors, inconsistent data processing, and unreliable system performance, which can ultimately disrupt academic activities and decision-making processes [1]. Despite the widespread use of Academic Information Systems, many institutions still face issues related to improper implementation of business rules and incorrect handling of system states. For example, errors may occur in validating course registration requirements or in managing transitions between academic statuses, such as active[2][3], inactive, or graduated. These issues are often caused by insufficient or inappropriate testing methods. Conventional testing approaches may not effectively capture complex rule combinations or state-dependent behaviors, resulting in undetected defects within the system[4][5].

Previous studies have highlighted the importance of functional testing in improving software quality. Decision Table Testing has been widely used to evaluate systems with complex business rules by systematically analyzing combinations of input conditions and expected outcomes. Meanwhile, State Transition Testing has proven effective in identifying defects related to system state changes and transitions. However, most existing research applies these methods separately[6][7], focusing on either rule-based validation or state-based behavior analysis. Limited studies have explored the combined application of both methods to achieve a more comprehensive evaluation of system quality, particularly in the context of Academic Information Systems, as summarized in **Table 1**. Although Decision Table Testing and State Transition Testing have been individually applied in software testing, there is a lack of integrated studies that combine both methods to evaluate[8][9]. Academic Information Systems comprehensively. Most prior research either emphasizes rule-based testing or state-based testing alone, leaving potential defects undetected when systems involve both complex business rules and multiple state-dependent processes[10][7]. Furthermore, quantitative data on defect detection rates using the combined approach in academic settings is still limited, making it difficult to assess its effectiveness and practical benefits.

Given the critical role of Academic Information Systems in supporting institutional operations, ensuring their quality and reliability is essential. The lack of comprehensive testing approaches may result in undetected errors that affect system functionality and user trust. Therefore, this research is necessary to provide a structured and integrated testing approach by combining Decision Table Testing and State Transition Testing[11][12]. The findings of this study are expected to contribute to improving software testing practices and enhancing the overall quality of Academic Information Systems, particularly in handling complex rules and state-dependent processes[10].

DOI: https://doi.org/10.17509/coelite.v5i2.98668
p- ISSN 2829-4157 e- ISSN 2829-4149

Table 1. State of the Art of Research on Academic System Testing Using Decision Table Testing and State Transition Testing

No	Researcher / Year	Research Focus	Testing Method	Key Findings	Limitation / Research Gap
1	[13]	Student management system testing	Decision Table Testing	Detected errors in business rule combinations	Only focused on rule-based testing; did not test student status transitions.
2	[14]	Online registration system	State Transition Testing	Identified errors in status transitions (active/inactive)	Did not test input condition combinations, so rule-based errors were not detected
3	[15]	Academic system quality evaluation	Decision Table & State Transition (separately)	Validated functionality of specific modules	Methods applied separately; no integrated approach for comprehensive evaluation
4	[16]	Web-based campus information system	Black Box & White Box Testing	Found bugs in login and course registration modules	Less focus on complex business rules and state-dependent processes
5	This Study (2026)	Academic Information System	Combined Decision Table & State Transition Testing	Comprehensive quality evaluation, detecting both rule-based and state-based errors	Fills previous research gaps by integrating both methods and providing quantitative defect data

2. METHODS

2.1. Research Type

This study employs a quantitative descriptive approach aimed at evaluating the quality of an Academic Information System in an objective and measurable manner. The descriptive approach is used to explain the system's condition based on testing results, while the quantitative approach is used to convert testing outcomes into numerical values, particularly in the form of success percentages[17][18].

The testing method applied in this study is black-box testing, which focuses on evaluating system functionality without examining the internal code structure. Two main techniques are utilized: Decision Table Testing, which evaluates logical combinations of input conditions, and State Transition Testing, which analyzes system behavior based on changes in system states triggered by specific events.

2.2. Research Object

DOI: https://doi.org/10.17509/coelite.v5i2.98668
p- ISSN 2829-4157 e- ISSN 2829-4149

The object of this study is an Academic Information System (AIS) used to support academic activities within an educational institution. The system consists of several main modules [19][20]to be tested, including:

a. Authentication module (login and logout)
b. Course registration module (Study Plan / KRS)
c. Academic results module (KHS)
d. Course scheduling module
e. Prerequisite validation module

The evaluation focuses on these core functionalities to ensure that the system operates in accordance with user requirements and academic regulations.

2.3. Data Collection Techniques

Data collection in this study is conducted using the following methods:

a. Observation

Observation involves directly examining how users interact with the system. This aims to understand system workflows, user interactions, and identify potential issues within the system features[21][22].

b. Documentation

Documentation involves collecting supporting materials such as:

1. Use case diagrams
2. Activity diagrams
3. Standard Operating Procedures (SOPs)
4. System requirement documents

2.4. System Testing

The system testing process is carried out through the following steps:

1. Identifying the system modules to be tested
2. Defining testing scenarios based on system requirements
3. Designing test cases
4. Conducting testing using Decision Table Testing and State Transition Testing
5. Recording test results
6. Analyzing the testing outcomes

2.5. Decision Table Testing

Decision Table Testing is a technique used to evaluate system behavior based on various combinations of input conditions and corresponding system actions[23].

Steps:

1. Identify conditions
   Example:
   - C1: Valid username
   - C2: Valid password
   - C3: Active account status
2. Identify actions
   - A1: Login successful
   - A2: Error message displayed
3. Construct a decision table
4. Determine the number of rules (test cases) using the formula:

$$R = 2^n$$

DOI: https://doi.org/10.17509/coelite.v5i2.98668
p- ISSN 2829-4157 e- ISSN 2829-4149

Where:

- R= number of rules (test cases)
- n= number of conditions

5. Generate test cases based on the rules
6. Execute testing
7. Record the results

2.6. State Transition Testing

State Transition Testing is used to evaluate system behavior based on changes in system states caused by specific events.

Steps:

1. Identify system states
   Example:
   - S1: Logged Out
   - S2: Logged In
   - S3: Session Expired
2. Identify events
   - E1: Login input
   - E2: Logout
   - E3: Timeout
3. Create a state transition diagram
4. Develop a state transition table
5. Determine the number of possible transitions using the formula:

$$T = S \times E$$

Where:

- T= number of possible transitions
- S= number of states
- E= number of events

6. Design test cases for:
   - Valid transitions
   - Invalid transitions
7. Execute testing and record results

2.7. Data Analysis Techniques

Data analysis is conducted by comparing actual test results with expected outcomes for each test case.

1. Success Rate

$$\text{Success Rate}(\%) = \frac{TC_{success}}{TC_{total}} \times 100\%$$

Where:

- $TC_{success}$= number of successful test cases
- TC_{total}= total number of test cases

DOI: https://doi.org/10.17509/coelite.v5i2.98668
p- ISSN 2829-4157 e- ISSN 2829-4149

2.8. Failure Rate

$$\text{Failure Rate}(\%) = \frac{TC_{failure}}{TC_{total}} \times 100\%$$

2.9. System Quality Classification

The success rate is then classified into four quality categories, as presented in **Table 2.**

Table 2. System Quality Classification

Percentage	Category
81% – 100%	Very Good
61% – 80%	Good
41% – 60%	Fair
≤ 40%	Poor

3. RESULTS AND DISCUSSION

3.1. Results

1. Testing Results

This section presents the results of system testing conducted using Decision Table Testing and State Transition Testing on the Academic Information System (AIS). The testing focuses on evaluating key modules such as login, course registration (KRS), and logout processes to ensure that the system operates according to its functional requirements and can properly handle various input conditions and user actions.

a. Decision Table Testing Results

Decision Table Testing was applied to evaluate logical combinations of input conditions in the login module. The identified conditions include username validity, password validity, and account status. Based on these conditions, a decision table was constructed to represent all possible combinations and expected system responses, as shown in **Table 3.**

Table 3. Decision Table for Login Module

Rule	Username Valid	Password Valid	Account Active	Expected Result	Actual Result	Status
R1	Yes	Yes	Yes	Login Successful	Login Successful	Pass
R2	Yes	No	Yes	Error Message	Error Message	Pass
R3	No	Yes	Yes	Error Message	Error Message	Pass
R4	No	No	Yes	Error Message	Error Message	Pass

DOI: https://doi.org/10.17509/coelite.v5i2.98668
p- ISSN 2829-4157 e- ISSN 2829-4149

R5	Yes	Yes	No	Access Denied	Login Successful	Fail
R6	Yes	No	No	Error Message	Error Message	Pass
R7	No	Yes	No	Error Message	Error Message	Pass
R8	No	No	No	Error Message	Error Message	Pass

Based on three conditions, the number of possible test cases was calculated using the formula $R = 2^n = 2^3 = 8$. All test cases were executed, resulting in 7 successful cases and 1 failed case. The failure occurred in Rule 5, indicating that the system incorrectly allowed login for an inactive account, which reflects a weakness in access control validation.

b. State Transition Testing Results

State Transition Testing was conducted to analyze system behavior based on transitions between states triggered by specific events such as login, logout, and session timeout. The identified states include Logged Out, Logged In, and Session Expired, while the events include login, logout, and timeout, with the results summarized in **Table 4.**

Table 4. State Transition Testing Results

Current State	**Event**	**Next State**	**Expected Result**	**Actual Result**	**Status**
Logged Out	Login	Logged In	Access Granted	Access Granted	Pass
Logged In	Logout	Logged Out	Session Ended	Session Ended	Pass
Logged In	Timeout	Session Expired	Auto Logout	Auto Logout	Pass
Expired	Login	Logged In	Re-login Required	Re-login Required	Pass
Logged Out	Logout	Logged Out	No Action	Error Occurred	Fail

The total number of possible transitions was calculated using the formula $T = S \times E = 3 \times 3 = 9$. However, only 5 relevant transitions were tested. The results show that 4 transitions were successful, while 1 failed. The failure indicates that the system does not properly handle invalid transitions, particularly when a logout action is performed in a logged-out state.

2. Data Analysis

a. Success Rate Calculation

A summary of the test results for both methods is presented in **Table 5.**

DOI: https://doi.org/10.17509/coelite.v5i2.98668
p- ISSN 2829-4157 e- ISSN 2829-4149

Table 5. Summary of Test Results

Testing Method	Total Test Cases	Successful	Failed
Decision Table Testing	8	7	1
State Transition Testing	5	4	1
Total	13	11	2

The success rate is calculated using the formula:

$$\text{Success Rate} = \frac{11}{13} \times 100\% = 84.6\%$$

This result indicates that most of the system functionalities operate correctly.

b. Failure Rate Calculation

$$\text{Failure Rate} = \frac{2}{13} \times 100\% = 15.4\%$$

This shows that a small portion of the system still experiences functional issues.

c. *Defect Density*

$$\text{Defect Density} = \frac{2}{13} = 0.15$$

This value indicates a relatively low number of defects per test case.

3. Quality Interpretation

Based on the success rate of 84.6%, the system falls into the "Very Good" category (81%–100%). This indicates that the Academic Information System has a high level of functional reliability. However, the existence of failed test cases suggests that improvements are still needed, particularly in input validation and state transition handling, to further enhance system robustness and reliability.

3.2. Discussion

The results of this study demonstrate that the application of Decision Table Testing is highly effective in identifying logical errors arising from various combinations of input conditions, particularly within the login module of the Academic Information System. The testing process revealed a critical issue related to inactive account validation, where the system incorrectly granted access despite the account status being inactive. This finding indicates that the system does not yet implement adequate access control mechanisms, especially in enforcing account status constraints during authentication processes. Such a weakness may lead to potential security risks and unauthorized access if not properly addressed.

Furthermore, the implementation of State Transition Testing proved to be effective in analyzing system behavior based on changes in user states and system events. The results identified a weakness in handling invalid state transitions, specifically when a logout action

DOI: https://doi.org/10.17509/coelite.v5i2.98668
p- ISSN 2829-4157 e- ISSN 2829-4149

was performed while the system was already in a logged-out state. Ideally, the system should reject or ignore such invalid transitions; however, the observed behavior suggests that the system lacks proper validation of session states prior to executing user commands. This indicates a deficiency in session management logic, which is crucial for maintaining system consistency and preventing unexpected behavior.

Overall, the system demonstrates a relatively high level of functional reliability, as indicated by a success rate exceeding 80%, which falls into the "Very Good" category. This suggests that most system functionalities operate in accordance with their expected behavior. Nevertheless, the presence of failed test cases highlights several areas that require further improvement. These include strengthening input validation mechanisms to ensure all user inputs are properly verified, enhancing session management handling to accurately control user states and transitions, and improving error handling procedures to effectively manage invalid or unexpected user actions.

In light of these findings, several recommendations are proposed to improve the overall quality of the system. First, stricter validation rules should be implemented to ensure that inactive accounts are denied access under all conditions. Second, the system's session handling logic should be refined to accurately track and validate user states before executing any operation. Third, additional validation should be incorporated to properly handle invalid state transitions, thereby preventing inconsistent system behavior. Finally, periodic system testing should be conducted to continuously monitor system performance, detect potential issues early, and maintain the overall quality and reliability of the Academic Information System over time.

4. CONCLUSION

The Academic Information System (AIS) plays a critical role in managing essential academic activities, including login authentication, course registration, grading, and student data management. Ensuring the system's quality and reliability is vital for maintaining accurate and efficient academic operations. This study evaluated the quality of the AIS using Decision Table Testing and State Transition Testing, focusing on key modules such as login and session management. A total of 13 test cases were executed, comprising 8 cases using Decision Table Testing and 5 cases using State Transition Testing. The testing identified 2 defects—1 related to improper validation of inactive accounts and 1 associated with invalid state transitions during logout—resulting in an overall functional success rate of 84.6%. The findings demonstrate that Decision Table Testing is effective in detecting errors related to logical and rule-based processing, while State Transition Testing is suitable for uncovering issues in state-dependent processes. The combined use of these methods provides a comprehensive evaluation of system behavior, effectively identifying both rule-based and state-based defects that may otherwise remain undetected. In conclusion, integrating Decision Table Testing and State Transition Testing significantly enhances the functional quality, reliability, and overall performance of the AIS. It ensures compliance with expected system behavior and supports academic institutions in delivering consistent, accurate, and error-free services. Future AIS implementations are recommended to adopt combined functional testing strategies and incorporate systematic defect tracking to further improve system quality and user satisfaction.

5. ACKNOWLEDGMENT

The author would like to express sincere gratitude to all parties who have contributed to this research. The author also appreciates the institutions and laboratories that provided the

DOI: https://doi.org/10.17509/coelite.v5i2.98668
p- ISSN 2829-4157 e- ISSN 2829-4149

facilities and resources supporting the research activities. Thanks are also extended to colleagues, research assistants, and all participants who contributed through their assistance, feedback, and collaboration during data collection, testing, and analysis. This acknowledgment reflects the collective efforts of all parties that made the completion of this research possible and is hoped to provide benefits for the advancement of scientific knowledge.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. All data presented are accurate, obtained in accordance with ethical research practices, and all sources have been properly cited. No unethical procedures were used, and all participants, if involved, provided informed consent. This statement ensures transparency, academic integrity, and the credibility of the research findings.

7. REFERENCES

[1] Z. Ugray, B. D.-J. of I. S. Education, and undefined 2022, "Quality assurance of learning assessments in large information systems and decision analysis courses," *aisel.aisnet.org*, Accessed: Apr. 06, 2026. [Online]. Available: https://aisel.aisnet.org/jise/vol33/iss4/7/

[2] V. Gupta, P. Kaur, H. S.-I. Access, and undefined 2024, "Bi-Level Decision Tree Approach for Web Quality Assessment," *ieeexplore.ieee.org*, Accessed: Apr. 06, 2026. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10670374/

[3] A. Nugroho, J. Purwanto, M. A. Muin, and F. Mahardika, "UI / UX Design of a Web-Based Student Organizations System Using the Design Thinking Method Approach," vol. 7, no. 1, pp. 24–38, 2025.

[4] S. Valenti, A. Cucchiarelli, M. P.-J. of I. Technology, and undefined 2002, "Computer based assessment systems evaluation via the ISO9126 quality model," *jite.org*, vol. 1, no. 3, 2002, Accessed: Apr. 06, 2026. [Online]. Available: https://jite.org/documents/Vol1/v1n3p157-175.pdf

[5] A. Al Nawaiseh, Y. Helmy, E. K.-I. J. S. T. Res, and undefined 2020, "Software testing with the approach of blackbox testing on the academic information system," *ijistech.org*, Accessed: Apr. 06, 2026. [Online]. Available: http://ijistech.org/ijistech/index.php/ijistech/article/view/54

[6] Z. Khaerunnisa, K. Muhammad, and F. Mahardika, "Indonesian Journal of Digital Business Optimization of Cloud-Based Digital Archiving System Using Golang and the ICONIX Process," vol. 5, no. April, pp. 87–96, 2025.

[7] S. Pradhan, M. Ray, M. Jena, M. Tripathy, and I. Panda, "Adopting state transition testing techniques in scenario-based test case generation," *Springer*, 2025, doi: 10.1007/S13198-025-03047-1.

[8] K. Bollaerts, E. Ledent, T. de Smedt, D. W.- Vaccine, and undefined 2020, "ADVANCE system testing: Benefit-risk analysis of a marketed vaccine using multi-criteria decision analysis and individual-level state transition modelling," *Elsevier*, Accessed: Apr. 06, 2026. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0264410X19312435

[9] F. Mahardika, A. R. Naufal, and M. AL AMIN, "Desain UI dan UX dalam Sistem Informasi Akademik Menggunakan Metode Extreme Programming," *Progresif J. Ilm. Komput.*, vol. 19, no. 1, pp. 105–116, Feb. 2023, doi: 10.35889/PROGRESIF.V19I1.1023.

[10] S. Pradhan, M. Ray, S. S.-J. of K. S. University-Computer, and undefined 2022,

"Transition coverage based test case generation from state chart diagram," *Elsevier*, Accessed: Apr. 06, 2026. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1319157818311078

[11] H. Jayusman and F. Mahardika, "Mobile-Based Event Decoration Ordering System Using UAT Method with PIECES Framework," *J. Innov. Inf. Technol. Appl.*, vol. 7, pp. 1623–172, 2024.

[12] F. Mahardika, R. B. B. Sumatri, T. Informatika, J. Komputer, and P. N. Cilacap, "IMPLEMENTASI PENDEKATAN METODE DESIGN THINKING SISTEM PERSURATAN ONLINE BERBASIS," vol. 13, no. 2, 2025.

[13] P. A.-F. exacta and undefined 2018, "Perancangan Sistem Informasi Akademik Online Menggunakan Black Box Testing Pada Sekolah Tinggi Ilmu Ekonomi Surya Nusantara," *jurnal.unai.edu*, vol. 2, no. 1, pp. 41–52, 2023, Accessed: Apr. 06, 2026. [Online]. Available: https://jurnal.unai.edu/teika/article/view/664

[14] S. Nafisah, S. R.-I. J. of D. Studies, and undefined 2021, "Pengembangan Sistem Informasi Kemajuan Akademik Menggunakan Model Incremental Berbasis Evaluasi Usability Dan White Box Testing," *ejournal.instiki.ac.id*, vol. 2, no. 1, pp. 41–52, 2023, Accessed: Apr. 06, 2026. [Online]. Available: http://ejournal.instiki.ac.id/index.php/sintechjournal/article/view/661

[15] A. Setiawan, S. Samsugi, D. A.-J. I. Dan, and undefined 2023, "Rancang Bangun Sistem Informasi Akademik SMK TAMAN SISWA 1 Tanjung Karang BERBASIS WEB," *pdfs.semanticscholar.org*, vol. 2, no. 1, pp. 41–52, 2023, Accessed: Apr. 06, 2026. [Online]. Available: https://pdfs.semanticscholar.org/b64b/5240acace32660bc2de2773206339fac6487.pdf

[16] M. Alkhairi, … S. A.-J. (Jurnal, and undefined 2024, "Implementasi Unit Testing Dan End-To-End Testing Pada Sistem Informasi Akademik Teknik Informatika," *jurnal.stkippgritulungagung.ac.id*, Accessed: Apr. 06, 2026. [Online]. Available: https://jurnal.stkippgritulungagung.ac.id/index.php/jipi/article/download/5626/2323

[17] R. Sangga Rasefta and S. Esabella, "Sistem Informasi Akademik Smk Negeri 3 Sumbawa Besar Berbasis Web," *J. Inform. Teknol. dan Sains*, vol. 2, no. 1, pp. 50–58, 2020, doi: 10.51401/jinteks.v2i1.558.

[18] R. Rasefta, S. E.-J. I. T. dan, and undefined 2020, "Sistem informasi akademik smk negeri 3 sumbawa besar berbasis web," *scholar.archive.org*, Accessed: Apr. 06, 2026. [Online]. Available: https://scholar.archive.org/work/acgyhi6gpza4bain4lltzss3am/access/wayback/http://www.jurnal.uts.ac.id/index.php/JINTEKS/article/download/558/400

[19] Z. Hakim, P. M.-J. S. Informasi, T. Informatika, and undefined 2022, "Sistem Informasi Akademik Berbasis Webiste," *jurnal.umj.ac.id*, Accessed: Apr. 06, 2026. [Online]. Available: https://jurnal.umj.ac.id/index.php/just-it/article/view/13610

[20] H. Lukmana, M. Al-Husaini, … I. H.-T. J., and undefined 2023, "Perancangan Sistem Informasi Deteksi Dini Stunting Berbasis Website Menggunakan Metode User Center Design," *ojs.uniska-bjm.ac.id*, vol. 14, no. 3, 2023, Accessed: Feb. 11, 2026. [Online]. Available: https://ojs.uniska-bjm.ac.id/index.php/JIT/article/view/12025

[21] O. Musa, "Sistem Informasi Kepegawaian Berbasis Website pada Dinas Pariwisata Dan Kebudayaan," *J. Teknol. Inf. Indones.*, vol. 5, no. 2, pp. 9–15, 2020, doi: 10.30869/jtii.v5i2.641.

[22] A. Ariska, W. W.-J. sintaks logika, and undefined 2022, "Penerapan Kriptografi Menggunakan Algoritma Des (Data Encryption Standard)," *jurnal.umpar.ac.id*, vol. 2,

no. 2, 2022, Accessed: Mar. 03, 2025. [Online]. Available: http://jurnal.umpar.ac.id/index.php/sylog/article/view/1734

[23] G. A. Pradipta, R. R. Huizen, I. M. D. Susila, D. Hermawan, P. D. W. Ayu, and D. P. Hostiadi, "Rancang Bangun Sistem Informasi Administrasi Kantor Pada Badan Usaha Milik Desa Studi Kasus Desa Pemecutan Kaja Mandiri," *J. Tekno Kompak*, vol. 17, no. 2, pp. 100–113, 2023, [Online]. Available: https://ejurnal.teknokrat.ac.id/index.php/teknokompak/article/view/2332

DOI: https://doi.org/10.17509/coelite.v5i2.98668
p- ISSN 2829-4157 e- ISSN 2829-4149

Journal of Computer Engineering, Electronics and Information Technology (COELITE)

Journal homepage: https://ejournal.upi.edu/index.php/COELITE

A Qualitative Usability Evaluation of Document-Like Web Interfaces for Village Administrative Staff

Angga Lisdiyanto[1], Agussalim[2], Laqma Dica Fitrani[3], Miftahus Sholihin[4], Syahri Mumin[5], Tri Septianto[6], Winarti[7], Vinza Hedi Satria[8]*

[1,2]Departemen of Magister Information Technology, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Indonesia

[3]Departemen of Digital Bussiness, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Indonesia

[4]Departemen of Informatics, Universitas Islam Lamongan, Indonesia

[5]Departemen of Information System, Universitas Nahdlatul Ulama Sidoarjo, Indonesia

[6]Departemen of Information Technology, Politeknik Negeri Madiun, Indonesia

[7]Departemen of Informatics, Universitas Darul Ulum, Indonesia

[8]Departemen of Informatics, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Indonesia

Correspondence E-mail: angga_lisdiyanto.mti@upnjatim.ac.id

ABSTRACT

Village offices in Indonesia are adopting digital administration, but staff struggle with standard web forms. These forms feel unfamiliar because they separate data entry from the final letter. This study examines whether a document-like web interface eases administrative work for staff. The interface resembled an A4 letter, with input fields inside its sentences. We used Cognitive Walkthrough, Retrospective Think-Aloud, and JavaScript logging to see how users worked. Eight village staff participated. They completed tasks on a conventional web form (System A) and the document-like interface (System B). We recorded completion time, idle time, clicks, and backspace use. Results show System B was faster and required fewer clicks and corrections. Users felt confident because the screen looked like the letters they type. These findings suggest that familiar, document-like interfaces reduce confusion and support low-literacy users in rural e-government services.

© 2026 Universitas Pendidikan Indonesia

ARTICLE INFO

Article History:
Submitted/Received 09 Oct 2026
First Revised 12 Oct 2026
Accepted 21 Oct 2026
First Available online 22 Oct 2026
Publication Date 22 Oct 2026

Keyword:
Usability
Document-like interface
Skeuomorphic design
Rural administration
E-government
Qualitative evaluation

1. INTRODUCTION

In many villages across Indonesia, administrative work still revolves around paper and Microsoft Word [1]. Staff type letters, fill in citizen data, and print documents for signatures. This way of working has been around for decades. It is not efficient, but it is familiar. When the government introduces web-based administrative systems, the transition is often harder than expected. The problem is not only about internet access or computers [2]. It is also about how the interface feels to people who are not used to digital tools [3].

Most village administrative staff have low to medium digital literacy [1]. They know how to type a letter, but they are not comfortable with abstract web forms. Conventional e-government systems usually present data entry as a series of isolated text boxes. The user has to fill in one box, move to the next, and imagine how the final letter will look. This creates a mental gap. Users have to translate what they see on the screen into the document they are trying to produce. For people with limited digital experience, this translation is not easy. Studies have shown that flat, minimalist interfaces can slow down older and novice users, and increase the number of errors they make [4][5].

Skeuomorphic design offers a possible solution. Skeuomorphism means making digital objects look like their physical counterparts [6][7]. In this case, a web interface can be designed to look like a paper document. The input fields are placed directly inside the sentences of the letter. Users type into the letter itself, not into separate boxes. This approach leverages the user's existing mental model. Instead of learning a new system, they are doing what they already know: filling in a printed form or typing a letter [8][9].

Several studies have explored skeuomorphism for older adults and low-literacy users. Lee et al. found that paper-like structures in digital kiosks improved ease of use for older adults [9]. Liu et al. showed that familiar icons reduce cognitive burden [8]. Medhi-Thies et al. demonstrated that text-free interfaces can help illiterate users [10]. However, most of this research focuses on kiosks, mobile apps, or general user interfaces. There is still very little work on document-like web interfaces specifically for rural village administration. Most e-government studies also rely on surveys and statistical models like TAM or UTAUT. They rarely look at what happens at the interface level—the small pauses, the clicks, the corrections [9][10].

This study tries to fill that gap. We designed a web interface that looks like an A4 official letter. Village staff can enter citizen data directly into the letter's sentences. We then compared it with a conventional web form. We wanted to know three things:

a. RQ1: How does the document-like interface affect task completion time, idle time, navigation clicks, and backspace use?
b. RQ2: How do users describe their experience with the interface?
c. RQ3: What mechanisms explain why visual familiarity and contextual data entry reduce cognitive friction?

By answering these questions, we hope to provide practical design guidance for e-government systems in rural areas.

2. METHODS

2.1. Research Design

We used a triangulation approach. This means we combined two qualitative methods—Cognitive Walkthrough (CW) and Retrospective Think-Aloud (RTA)—with automated behavioral logging. The logging was done through a JavaScript script embedded in both systems. This script recorded four things: task completion time, idle time between fields,

DOI: https://doi.org/10.17509/coelite.v5i2.106651
p- ISSN 2829-4157 e- ISSN 2829-4149

navigation clicks, and backspace presses. The combination of methods allowed us to see not only what users did, but also why they did it. The overall design is illustrated in **Figure 1**.

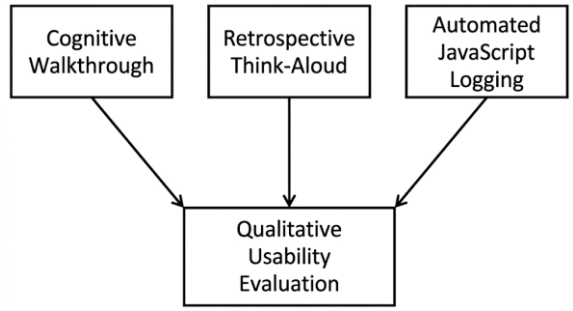


Figure 1. Research Design Triangulation Diagram

2.2. Participants

Eight administrative staff from rural village offices in East Java, Indonesia, took part in the study. They were selected using purposive sampling. All participants had experience drafting official letters and handling citizen data. Their digital literacy ranged from low to medium. None of them had prior experience with the document-like interface. The small sample size is appropriate for an exploratory qualitative study. The goal is not statistical generalization but analytical generalization [11]. Participation was voluntary, and we obtained informed consent.

2.3. Procedure

The evaluation took place in the participants' own offices. This was done to keep the setting as natural as possible. The procedure had three phases.

Phase 1: Introduction and Familiarization. We explained the purpose of the study and the tasks. Participants were given five minutes to try both interfaces. They were not trained on how to complete the tasks.

Phase 2: Task Execution with Logging. Each participant completed two tasks: entering data for a population report and filling in a letter of domicile. They did this on two systems:

a. System A (Conventional): A standard web-based e-government form. It had isolated text boxes arranged from top to bottom. **Figure 2** shows the layout of this conventional form.

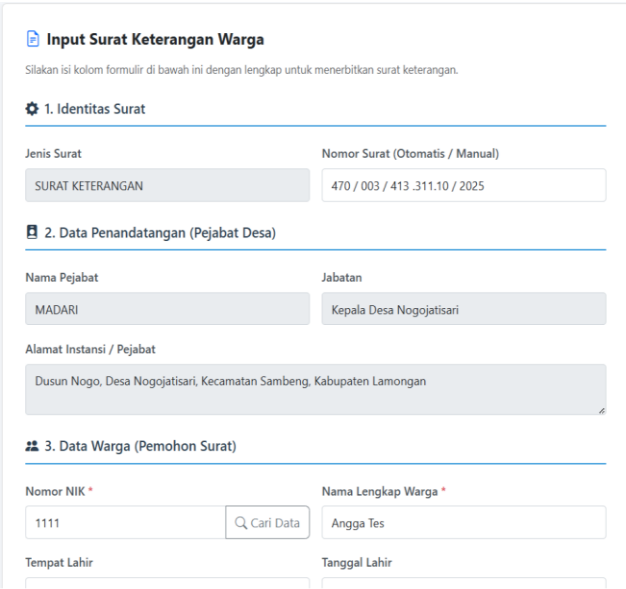


Figure 2. Conventional Web Form Interface (System A)

DOI: https://doi.org/10.17509/coelite.v5i2.106651
p- ISSN 2829-4157 e- ISSN 2829-4149

b. System B (Document-Like): A web interface designed to look like a physical A4 letter. Data entry fields were embedded directly inside the sentences. The document-like interface is shown in **Figure 3**.



Figure 3. Document-Like Skeuomorphic Interface (System B)

To avoid order effects, we counterbalanced the presentation. Some participants used System A first, others used System B first. The JavaScript logging script recorded all interactions silently.

Phase 3: Retrospective Think-Aloud and Cognitive Walkthrough. After finishing the tasks, participants watched a screen recording of their own session. They were asked to speak aloud about what they were thinking and feeling at each step. We also conducted a Cognitive Walkthrough using a set of structured questions [12]. All audio was recorded and transcribed.

2.4. Data Analysis

Quantitative log data were summarized using descriptive statistics. Qualitative data from RTA and CW sessions were analyzed using thematic analysis [13]. We looked for patterns related to cognitive load, confidence, and mental model alignment.

3. RESULTS AND DISCUSSION

3.1. Objective Behavioral Metrics

The JavaScript logs showed clear differences between the two systems. **Table 1** summarizes the results.

Table 1. Comparison of objective usability metric

Metric	System A (Conventional)	System B (Document-Like)	Reduction
Mean Task Completion (sec)	264.69	149.00	43.7%
Mean Idle Time (sec)	82.88	27.94	66.3%
Mean Navigation Clicks	24.31	11.81	51.4%
Mean Backspace Count	17.13	4.94	71.2%

DOI: https://doi.org/10.17509/coelite.v5i2.106651
p- ISSN 2829-4157 e- ISSN 2829-4149

On System A, users paused frequently between fields. These pauses were especially long when they had to figure out where their input would appear in the final letter. On System B, the flow was much smoother. Idle time dropped by about two-thirds. Users also clicked less and made fewer corrections. The backspace count was 71% lower on System B. This suggests that the contextual layout helped them enter data correctly on the first try.

The differences in completion time and idle time are also visualized in **Figure 4**. Meanwhile, **Figure 5** presents the comparison of navigation clicks and backspace counts.

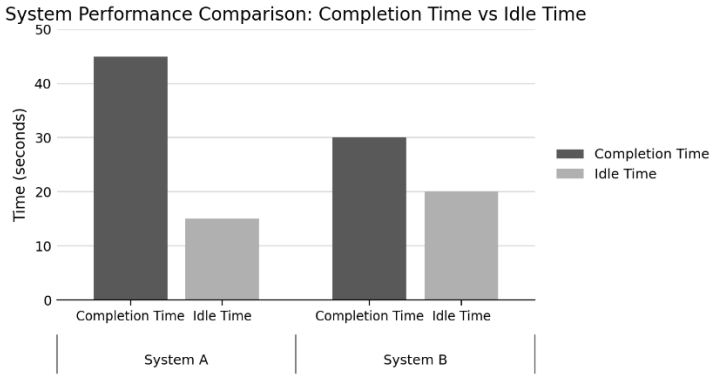


Figure 4. Comparison of Mean Task Completion Time and Idle Time

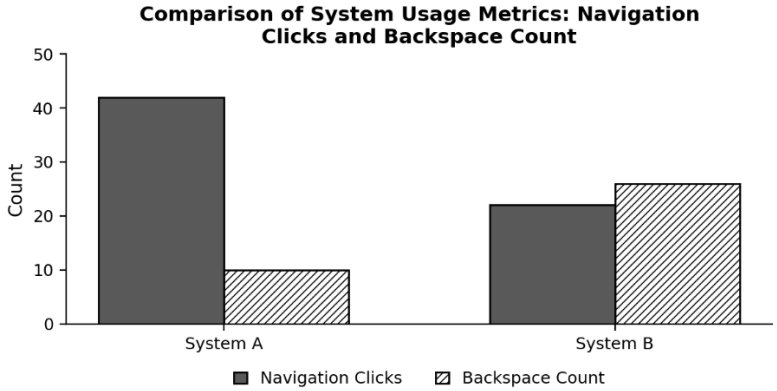


Figure 5. Comparison of Mean Navigation Clicks and Backspace Count

3.2. Retrospective Think-Aloud Findings

Two main themes emerged from the RTA transcripts.

Theme 1: Feeling safer and more confident. Participants said they preferred the document-like design because it looked like the letters they usually type. One participant said: “When I use the standard form, I am always worried I will type in the wrong box because I cannot see the whole letter. With this new system, it feels like typing on a regular piece of paper. The data just fits into the sentences.” This fear of making mistakes is a big barrier for low-literacy users. System B reduced that fear. The familiar layout gave them a sense of psychological safety.

Theme 2: Less mental mapping. Users also talked about how confusing System A was. They felt “lost” and “confused” about the order of the form. With System B, they described the process as “effortless” and “straightforward.” They could “see the whole picture.” This matches the idea of mental model alignment. Their existing knowledge of word processors

DOI: https://doi.org/10.17509/coelite.v5i2.106651
p- ISSN 2829-4157 e- ISSN 2829-4149

transferred directly to the web interface. They did not have to build a new mental model from scratch. These themes and their sub-themes are summarized in **Figure 6**.

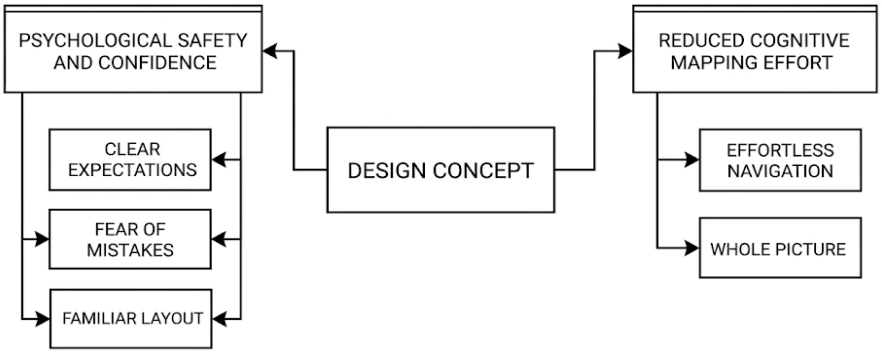


Figure 6. Thematic Map of User Experience

The Cognitive Walkthrough confirmed these findings. On System B, participants correctly identified the next action at each step. On System A, they often failed to notice that they needed to scroll down or that a field was optional. This led to hesitation and a loss of confidence.

3.3. Discussion

Our findings support previous research on cognitive accessibility. Concrete, familiar visual cues work better than abstract designs for novice users [10][8]. The triangulation of objective logs and subjective feedback gives us a clearer picture of why this happens. The proposed cognitive bridge model is depicted in **Figure 7**.

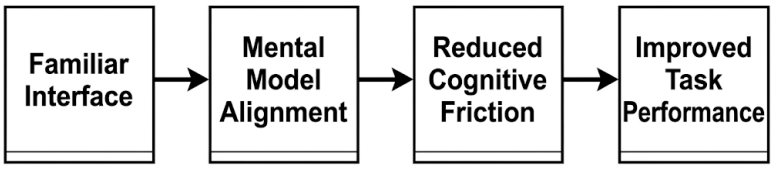


Figure 7. Cognitive Bridge Model

First, familiarity reduces cognitive friction. The 66.3% drop in idle time on System B is the strongest evidence. This is not just about saving time. It shows that users spent less mental effort on mapping. On System A, they had to translate abstract fields into the concept of a letter. On System B, the interface was the letter. No translation needed.

Second, the benefit is not just visual familiarity. It is also procedural familiarity. Users were not just looking at a familiar object. They were performing a familiar action: filling in blanks within a text. This is an important distinction. It suggests that e-government interfaces should mimic the workflow of the traditional paper-based task, not just its appearance.

Third, the reduction in backspace use is a behavioral sign of increased confidence. Fewer corrections mean users are making correct first guesses about where to input data. This confirms that the interface aligns with their expectations.

These findings have practical implications. We should not assume that flat design is always best. For tech-savvy users, it may be fine. But for low-literacy populations, it can be a barrier [9][10]. Designers should consider re-mediating existing workflows instead of reinventing them. The goal is to build a cognitive bridge that helps users move from analog to digital.

4. CONCLUSION

This study provides evidence that document-like interfaces can help address the digital divide in rural administration. By replacing fragmented web forms with visually cohesive

DOI: https://doi.org/10.17509/coelite.v5i2.106651
p- ISSN 2829-4157 e- ISSN 2829-4149

digital letters, we reduced cognitive friction. Users were faster, clicked less, and made fewer corrections. They also felt more confident.

The main limitation is the small sample size. We cannot claim statistical generalization. The findings offer analytical generalization instead. They give us a deep understanding of how and why this interface works in a specific rural context. Future research should test this approach across more villages and with more participants. Longitudinal studies could also look at whether long-term use improves digital literacy.

5. ACKNOWLEDGMENT

We thank the village administrative staff who participated in this study. Their honesty and patience made this research possible. We also thank Universitas Pembangunan Nasional Veteran Jawa Timur for supporting this work.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

7. REFERENCES

[1] R. Waluyo, F. E. Gunawan, and I. Setiawan, "The Measurement of Information and Communication Technology Literacy: A Case Study of the Village Officials in Purbalingga," *CommIT (Communication and Information Technology) Journal*, vol. 16, no. 1, pp. 19–25, 2022.

[2] D. M. Sihotang, B. Purwandari, I. Eitiveni, M. F. Putri, and A. N. Hidayanto, "Factors Influencing Village Information Systems Adoption in Indonesia: A Qualitative Study," *The Electronic Journal of Information Systems in Developing Countries*, vol. 89, no. 5, Art. no. e12271, 2023.

[3] I. Medhi, S. Patnaik, E. Brunskill, S. N. N. Gautama, W. Thies, and K. Toyama, "Designing Mobile Interfaces for Novice and Low-Literacy Users," *ACM Transactions on Computer-Human Interaction*, vol. 18, no. 1, Art. no. 2, 2011.

[4] Urbano, J. Guerreiro, and H. Nicolau, "From skeuomorphism to flat design: age-related differences in performance and aesthetic perceptions," *Behaviour & Information Technology*, vol. 41, no. 3, pp. 452–467, 2020.

[5] M. Islam, N. Khan, T. T. Inan, and I. H. Sarker, "Designing user interfaces for illiterate and semi-literate users: A systematic review and future research agenda," *SAGE Open*, vol. 13, no. 2, 2023.

[6] A. Ellis and M. T. Marshall, "Can Skeuomorphic Design Provide a Better Online Banking User Experience for Older Adults?" *Multimodal Technologies and Interaction*, vol. 3, no. 3, Art. no. 63, 2019.

[7] C. H. Lee, J. Lee, D. Kim, I. Kim, and H. Song, "Designing Self-Ordering Kiosk for Older Adults: Familiarity Design Focusing on Representation, Manipulation, and Organization," *Computers in Human Behavior*, vol. 156, Art. no. 108236, 2024.

[8] H. Liu, W. Wang, Y. Liu, F. Song, S. Wang, and H. Guo, "Study on the differences of icon cognition of graphical interface for age-friendly design," *Journal of Gerontological Social Work*, vol. 66, no. 5, pp. 662–679, 2022.

[9] C. Lee, J. Lee, D.-H. Kim, I. Kim, and H. Song, "Designing self-ordering kiosk for older adults: Familiarity design focusing on representation, manipulation, and organization," *Computers in Human Behavior*, vol. 156, 108236, 2024.

[10] I. Medhi-Thies, A. Sagar, and K. Toyama, "Text-free user interfaces for illiterate and semi-literate users," in *Proc. 2006 Int. Conf. Information and Communication Technologies and Development*, 2006, pp. 72–82.

[11] R. K. Yin, *Case Study Research: Design and Methods*, 5th ed. Sage Publications, 2014.

[12] C. Wharton, J. Rieman, C. Lewis, and P. Polson, "The cognitive walkthrough method: A practitioner's guide," in *Usability Inspection Methods*, J. Nielsen and R. L. Mack, Eds. John Wiley & Sons, 1994, pp. 105–140.

[13] V. Braun and V. Clarke, "Reflecting on reflexive thematic analysis," *Qualitative Research in Sport, Exercise and Health*, vol. 11, no. 4, pp. 589–597, 2019.

[14] R. Aditya, L. E. Nugroho, and Widyawan, "Digital divide in Indonesia: A study of e-government implementation in rural areas," *International Journal of Electronic Government Research*, vol. 19, no. 2, pp. 45–62, 2023.

[15] M. Arief and W. Saputra, "Challenges of e-government adoption in developing countries: A focus on user digital literacy," *Journal of Information Systems and Public Administration*, vol. 8, no. 4, pp. 112–128, 2022.

[16] D. Kusumaningrum, A. Pratama, and S. Wibowo, "The friction of digital transformation in village administration: A socio-technical perspective," *Journal of Rural Development and Technology*, vol. 12, no. 1, pp. 77–93, 2024.

[17] Y. Chen, H. Wang, and S. Liu, "Capturing real-time behavioral data in usability studies: A methodological review," *International Journal of Human-Computer Interaction*, vol. 40, no. 3, pp. 215–230, 2024.

[18] M. Ekin, K. Krejtz, C. Duarte, L. S. Pereira, A. Marcus-Quinn, and I. Krejtz, "Impact of web accessibility on cognitive engagement in individuals without disabilities: Evidence from a psychophysiological study," *PLOS One*, vol. 20, no. 1, e0328552, 2025.

[19] K. A. Ericsson and H. A. Simon, *Protocol Analysis: Verbal Reports as Data*, Revised ed. MIT Press, 1993.

[20] D. Radovanović et al., "Digital literacy key performance indicators for sustainable development," *Social Inclusion*, vol. 8, no. 2, pp. 109–123, 2020.

DOI: https://doi.org/10.17509/coelite.v5i2.106651
p- ISSN 2829-4157 e- ISSN 2829-4149

Journal of Computer Engineering, Electronics and Information Technology (COELITE)

Journal homepage: https://ejournal.upi.edu/index.php/COELITE

Design and Development of an IoT-Based Automatic Water Gallon Filling System Using a YF-S201 Flow Sensor, ESP32, and Telegram Bot

*Singgih Astaguna Tiroatmaja[1], Akhyar Muchtar[2, *], Andi Ahmad Taufiq[3], Muhammad Fauzan Yusuf[4]*

[1]Department of Electrical Engineering, Universitas Negeri Makassar, Indonesia
[1234]Universitas Negeri Makassar
Correspondence E-mail: akhyarmuchtar03@unm.ac.id.

ABSTRACT

Manual refilling of water gallons at refill drinking-water depots relies on an operator switching the pump on and off, which can cause inaccurate volumes, water wastage, and dependence on the operator. This study designed and built an Internet of Things (IoT)-based automatic gallon-filling system using a YF-S201 Hall-effect flow sensor, an ESP32 microcontroller, a 5 V relay module that switches the AC 220 V depot pump, and a Telegram Bot as a remote user interface. The firmware counts sensor pulses through a hardware interrupt and updates the volume every second in a non-blocking millis()-based loop. Two protection layers stop the pump when no flow is detected for 10 s or when the volume reaches 19.0 L, and only a registered Telegram chat ID can issue the /isi_galon, /stop, and /status commands. Volume accuracy was tested in 40 trials with a 19,000 mL target. The pump stopped automatically in every trial, but all trials overfilled: the filled volume ranged from 19,320 to 20,080 mL, with a mean overfill of 612.75 mL and a mean relative error of 3.225% (1.684–5.684%). The overfill is attributed to relay switching delay, flow inertia, and flow-sensor tolerance, so sensor calibration and overshoot compensation are needed.

ARTICLE INFO

Article History:
Submitted/Received 13 Oct 2026
First Revised 13 Oct 2026
Accepted 21 Oct 2026
First Available online 22 Oct 2026
Publication Date 22 Oct 2026

Keyword:
Automation,
Internet of Things,
Flow sensor,
YF-S201,
ESP32,
Telegram Bot,
Refill drinking water.

© 2026 Universitas Pendidikan Indonesia

1. INTRODUCTION

Many electronic devices now apply automatic control to improve operational efficiency and ease of use. Advances in information and communication technology and the Internet of Things (IoT) allow real-time monitoring and control of water infrastructure and give users data and tools to manage water use more effectively [1], and IoT-based real-time monitoring has also been applied to three-phase electrical power systems [2]. Control-system technology is also increasingly introduced in vocational education [3]. One application of automatic control is the filling of refill drinking water. In practice, however, many refill drinking-water depots still fill gallons manually, relying on a switch to turn the water pump on and off.

In a manual filling system, control and monitoring depend on the operator. This can cause problems such as overfilling, inaccurate volumes, and wasted water. To address these problems, several automatic filling systems for refill depots have been proposed, including an Arduino Uno-based automation prototype for refill drinking-water depots [4], a data logger for automatic gallon filling based on an ATMega32 microcontroller [5], and an IoT-based control and monitoring system for automatic refill filling using an ESP32 [6]. Automatic gallon-filling systems have also been introduced to refill-depot operators through community-service mentoring [7].

One way to control the filled volume is to measure the water entering the gallon with a flow sensor. A Hall-effect sensor produces an output voltage in response to a magnetic field [8], and in a turbine-type flow meter the rotation of the rotor is converted into pulses whose frequency depends on the flow rate [9]. The pulse count of a low-cost Hall-effect flow-rate sensor has been shown to correlate with the dispensed volume, so the volume can be estimated from the pulse count after calibration [10]. The YF-S201 sensor works on this principle and can therefore be used to calculate the volume of water in real time.

For the controller, the ESP32 is a low-cost microcontroller module with integrated Wi-Fi and Bluetooth [11], [12], and its general-purpose input/output pins make it suitable for IoT devices that connect sensors and actuators [12]. A remote user interface can be provided through a Telegram bot: the Telegram Bot API is an HTTP-based interface for building bots, and every incoming message identifies the chat it belongs to [13], so commands can be restricted to registered users.

Previous work has developed IoT-based control and monitoring of automatic refill filling using an ESP32 [6]. This study follows that direction by combining flow-sensor-based volume control with a Telegram bot interface. The firmware counts sensor pulses through a hardware interrupt and runs a non-blocking main loop, provides two protection layers (no-flow detection and a maximum-volume limit), and accepts the /isi_galon, /stop, and /status commands only from a registered chat ID.

Therefore, this study aims to design and build an IoT-based automatic gallon-filling system using a YF-S201 flow sensor, an ESP32 microcontroller, a relay, and a Telegram bot, and to evaluate its filling-volume accuracy to improve efficiency, accuracy, and reliability in filling refill drinking water.

2. METHODS

This section describes the design and testing stages of the automatic gallon-filling system. The stages comprise system design, hardware design, software design, and system testing.

2.1. System Design

The IoT-based automatic gallon-filling system integrates several main components that work together to automatically control the filling process, as shown in **Figure 1**. The YF-S201

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149

flow sensor is the input, the ESP32 is the main controller, the 5 V relay module is the output that switches the AC 220 V depot water pump, and the Telegram Bot API is the IoT interface through which the user sends commands and receives notifications. Each component has a specific function in the system, covering input, processing, and output.

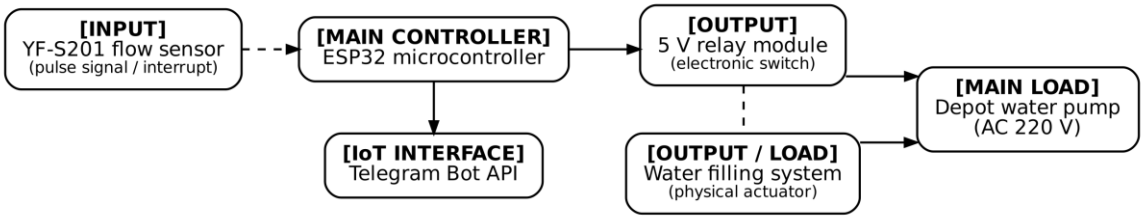


Figure 1. Block diagram of the IoT-based automatic water gallon filling system

2.2. YF-S201 Flow Sensor

The YF-S201 water flow sensor **Figure 2** is the main component for detecting the water flowing into the gallon. The sensor works on the Hall-effect principle [8]: it contains a small turbine that rotates when water flows, and this rotation produces electrical pulses that are sent to the microcontroller [9]. Each pulse is directly related to the amount of water flowing. By counting the pulses per unit time, the microcontroller determines the flow rate and volume of water [10]. The sensor has three pins: VCC, GND, and signal output. In this system, the sensor is the main input that determines when filling must stop based on the volume reached. The YF-S201 has been used together with an ESP32 in other water-monitoring systems and measures flow rates of 1–30 L/min [14].



Figure 2. YF-S201 flow sensor

2.3. Microcontroller

The ESP32 microcontroller **Figure 3** acts as the control center of the system. The ESP32 is a low-cost microcontroller module with integrated Wi-Fi and Bluetooth [11], [12]. It receives the pulse signal from the flow sensor and processes the data to calculate the volume of water in real time. The microcontroller also (i) converts the pulse data into a volume value, (ii) compares the volume with the 19.0 L limit, (iii) sends the control signal to the relay, and (iv) communicates with the Telegram Bot API over the WiFi network. The microcontroller is therefore the brain of the system that governs the entire automation process.

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149



Figure 3. ESP32 microcontroller

2.4. Relay

The 5 V relay module in **Figure 4** replaces the manual switch. It works as an electronic switch controlled by the signal from the microcontroller. When the microcontroller outputs a HIGH signal, the relay is activated and connects the AC 220 V supply to the water pump, so the pump turns on. When a LOW signal is given, the relay cuts the power, and the pump stops. In this system, the relay is the main control output that determines whether the pump is on or off.



Figure 4. Relay module

2.5. Water Pump

The water pump in **Figure 5** is the actuator that moves water from the source into the gallon. The pump is controlled by the relay rather than directly by the user. When the relay is active, the pump runs and starts filling the gallon; when the relay is off, the pump stops automatically. The depot water pump operates on AC 220 V. The pump is therefore the execution component of the system.



Figure 5. Water pump

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149

2.6. Power Supply

The power supply in **Figure 6** provides electrical energy to the system. The ESP32 microcontroller and the 5 V relay module are powered by a 5 V DC power adapter, while the depot water pump is powered from the AC 220 V mains through the relay contacts in **Figure 1**. The power supply must match the requirements of each component so that the system operates stably and safely.



Figure 6. Power supply

2.7. Software Algorithm and Flowchart

Overall, the software algorithm for this Internet of Things (IoT)-based automatic water gallon-filling system is divided into three main process blocks: Initialization and Interrupt, Main Logic (Volume Calculation and Protection), and Telegram Message Handling Logic. The system flowchart in **Figure 7** is designed so that the microcontroller can run several tasks in a non-blocking manner (without waiting for one another), allowing sensor readings and responses to user commands to run in real time.

The system begins its operating cycle by executing the Inisialisasi() procedure. At this stage, the microcontroller performs the initial setup, which includes enabling serial communication, configuring the relay pin as an output (with an initial OFF/LOW state), and configuring the water flow sensor pin as an input with pull-up. In addition, the system connects to the WiFi network and authenticates with the Telegram Bot API server.

To ensure that no sensor readings are missed while the microcontroller executes other lines of code, the system uses a hardware interrupt on the sensor pin. Whenever a falling-edge signal is detected from the water flow sensor, the microcontroller automatically calls the Ambil_Pulsa_Sensor() procedure. This procedure runs independently in the background and increments the hitungan_pulsa variable by 1.

Once initialization is complete, the microcontroller enters an infinite loop (main loop). In this block, the system tracks time using the millis() function (time in milliseconds) to avoid using the delay function, which would halt system operation.

If filling is active and the time interval has reached 1000 milliseconds (1 second), the system briefly disables interrupts to protect the data, then reads and resets the value of hitungan_pulsa. The pulse count is converted into a water flow rate using the sensor calibration factor [15]-[17], the volume delivered during that second is calculated, and this volume is accumulated into Total_Volume, as expressed in Equations (1)–(3).

$$Q = N / K \quad (1)$$

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149

$$\Delta V = Q / 60 \quad (2)$$

$$V_total = V_total + \Delta V \quad (3)$$

where N is the number of pulses counted in the 1-second interval (hitungan_pulsa), K is the sensor calibration factor (faktor_kalibrasi), Q is the water flow rate in L/min (debit_air), ΔV is the volume delivered during that second in litres (volume_detik_ini), and V_total is the accumulated volume (Total_Volume). (State the value of K used in the firmware here, e.g. K = … pulses per second per L/min.)

To ensure operational safety, the algorithm is equipped with two layers of protection. The first protection is clogged-flow / empty-water-source detection. The system monitors the time between sensor pulse updates. If no water flow is detected within 10 seconds (waktu_sekarang – waktu_terakhir_aliran ≥ 10000 ms), the system assumes that the water source has run out or that a malfunction has occurred. The system then automatically turns off the pump (relay OFF) and sends an emergency warning message to the user's Telegram.

The second protection is the maximum volume limit. The system continuously compares Total_Volume with the standard gallon capacity. When the volume of water delivered reaches or exceeds 19.0 litres, the system stops the pump, sets the filling status to inactive, and sends a Telegram notification that the filling process has finished.

The Telegram Message Logic block serves as a remote user interface (UI) [18], [19]. The system periodically checks whether a new command message has arrived from the Telegram Bot. If there is a message, the system first performs a security check by matching ID_Pengirim against the registered CHAT_ID_Valid. If the ID is not recognized, the system denies access.

If the ID is validated, the system processes the command according to the content of the message.

- **/isi_galon** resets Total_Volume to zero, turns on the pump, sets the status to active, and restarts the protection timer. If the system is already active, it ignores the command and sends a warning message that filling is already in progress.
- **/stop** acts as a remote emergency stop. It forcibly turns off the pump at any time, changes the filling status, and notifies the user.
- **/status** asks the microcontroller to send feedback on the pump status (active/inactive) and the current volume of water that has entered the gallon.

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149

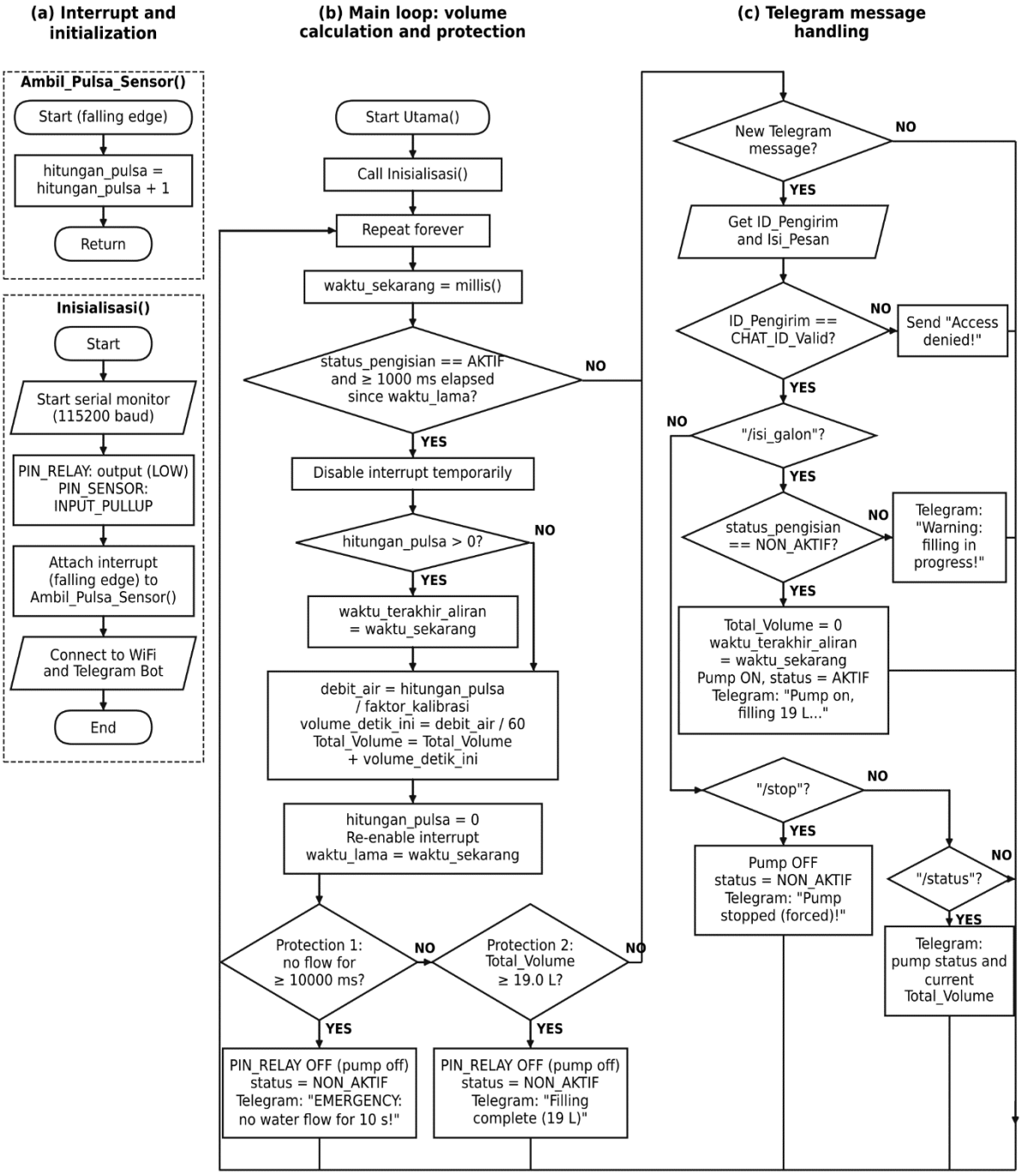


Figure 7. Flowchart of the software algorithm: (a) interrupt and initialization procedures, (b) main loop with volume calculation and protection, and (c) Telegram message handling. Connectors A and B link the panels

2.8. Wiring Design

The wiring design of the automatic water gallon filling system is shown in **Figure 8**.

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149

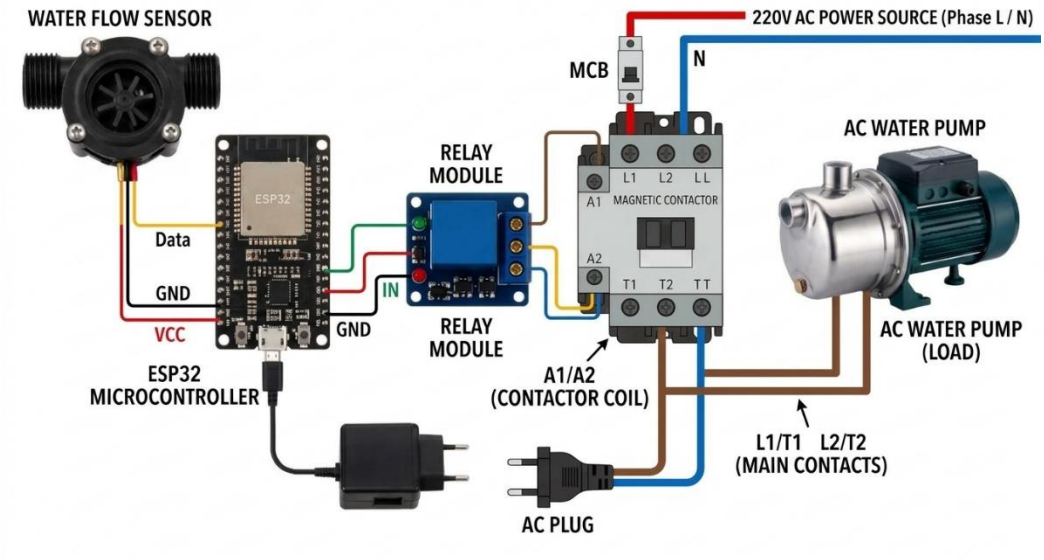


Figure 8. Wiring diagram of the automatic water gallon filling system.

2.9. LabVIEW Design

The automatic water gallon filling system was also designed using the LabVIEW application. **Figure 9** shows the front panel design of the control system, and **Figure 10** shows its block diagram.



Figure 9. Front panel design of the automatic water gallon filling control system

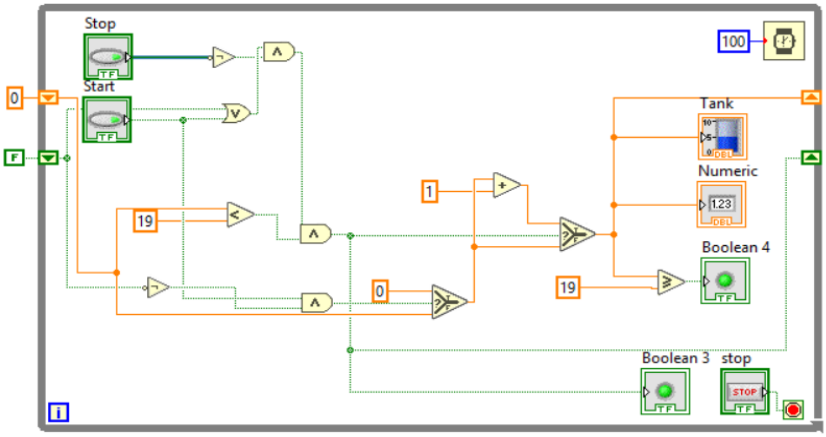


Figure 10. Block diagram of the automatic water gallon filling system

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149

2.10. Testing Procedure

The system was tested in 40 trials with a target volume of 19,000 mL (19 L). For each trial, the filled volume was recorded, the difference from the target was calculated, and the relative error was computed using Equation (4). The test reported in this study evaluates the filling-volume accuracy of the system.

$$\text{Error (\%)} = (V_{filled} - V_{target}) / V_{target} \times 100\% \quad (4)$$

where V_filled is the volume of water filled into the gallon (mL), and V_target is the target volume (19,000 mL).

3. RESULTS AND DISCUSSION

In the tested system, the flow sensor detects the water flow, and the microcontroller calculates the volume from the number of pulses produced. The relay acts as the actuator switch that turns the water pump on and off automatically. During filling, the flow sensor reads the water flow in real time and sends the data to the microcontroller. When the calculated volume reaches the setpoint, the system commands the relay to switch off so that the pump stops. In practice, however, the filled volume still exceeded the target. The test results are presented in **Table 1** and **Figure 11**.

Table 1. Results of the automatic water gallon filling test (target volume 19,000 mL)

No.	Target (mL)	Filled (mL)	Difference (mL)	Error (%)	No.	Target (mL)	Filled (mL)	Difference (mL)	Error (%)
1	19,000	19,420	420	2.211	21	19,000	19,400	400	2.105
2	19,000	19,980	980	5.158	22	19,000	19,370	370	1.947
3	19,000	19,350	350	1.842	23	19,000	19,450	450	2.368
4	19,000	20,020	1,020	5.368	24	19,000	19,500	500	2.632
5	19,000	19,950	950	5.000	25	19,000	19,410	410	2.158
6	19,000	19,480	480	2.526	26	19,000	20,040	1,040	5.474
7	19,000	19,390	390	2.053	27	19,000	19,960	960	5.053
8	19,000	19,510	510	2.684	28	19,000	20,000	1,000	5.263
9	19,000	19,460	460	2.421	29	19,000	19,340	340	1.789
10	19,000	19,380	380	2.000	30	19,000	19,460	460	2.421
11	19,000	20,050	1,050	5.526	31	19,000	19,390	390	2.053
12	19,000	19,430	430	2.263	32	19,000	19,420	420	2.211
13	19,000	19,990	990	5.211	33	19,000	19,480	480	2.526
14	19,000	19,320	320	1.684	34	19,000	19,520	520	2.737
15	19,000	20,010	1,010	5.316	35	19,000	19,430	430	2.263
16	19,000	19,470	470	2.474	36	19,000	19,370	370	1.947
17	19,000	19,360	360	1.895	37	19,000	19,490	490	2.579
18	19,000	20,030	1,030	5.421	38	19,000	19,510	510	2.684
19	19,000	19,970	970	5.105	39	19,000	20,080	1,080	5.684
20	19,000	19,920	920	4.842	40	19,000	19,400	400	2.105
					Mean of 40 trials (n = 40)			**612.75**	**3.225**

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149

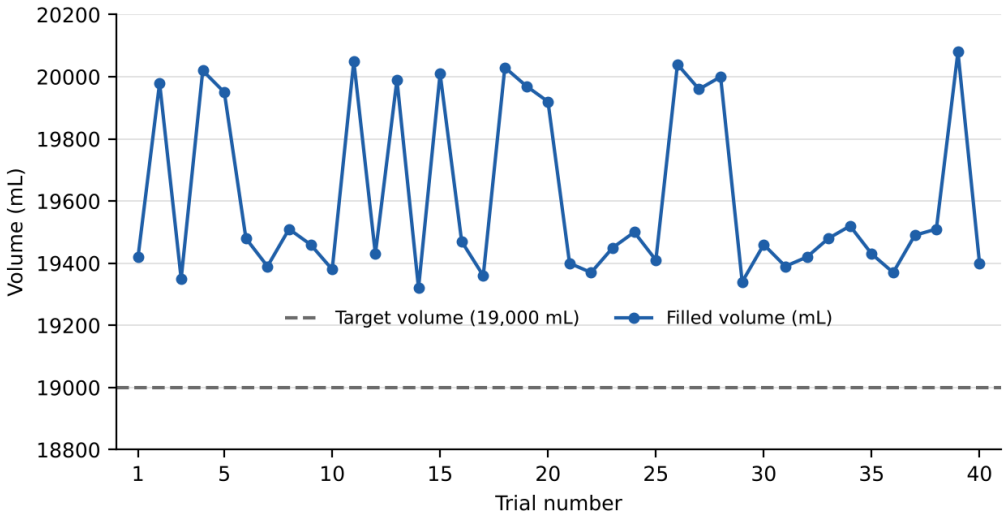


Figure 11. Filled volume in each of the 40 trials compared with the 19,000 mL target

Table 1 shows that every filling produced a volume larger than the target, so the system consistently overfilled in all 40 trials. The filled volume ranged from 19,320 to 20,080 mL, with a mean of 19,612.75 mL (standard deviation 277.19 mL). The overfill ranged from 320 to 1,080 mL, with a mean of 612.75 mL. Based on Equation (4), the minimum error was 1.684%, the maximum error was 5.684%, and the mean error was 3.225%.

The results also form two distinct groups. In 27 trials, the filled volume was between 19,320 and 19,520 mL (overfill 320–520 mL), while in 13 trials it was between 19,920 and 20,080 mL (overfill 920–1,080 mL). This indicates that the overfill is not a single constant offset, and that the cause of the larger overfill in some trials needs further investigation.

The overfill in every trial is attributed to several factors: a delay when the relay switches off, the inertia of the water flow in the hose, and the tolerance of the flow sensor in reading pulses. The conversion from pulse count to volume in low-cost Hall-effect flow sensors depends on calibration [10], [15]-[17], so an uncalibrated conversion factor can contribute to a systematic volume error. In addition, the system does not stop instantly, so some water continues to flow after the pump is switched off. These factors were not measured separately in this study and should be quantified in future work.

Overall, the automatic gallon-filling system based on a flow sensor and a relay was able to stop filling automatically in all 40 trials. However, with a mean error of 3.225% and an overfill in every trial, its filling precision still needs to be improved. Further development is required, such as a faster flow-stopping mechanism, more precise sensor calibration, or compensation of the setpoint for the measured overfill. In addition, the response time of the Telegram commands and the behaviour of the no-flow protection were not evaluated quantitatively in this study and should be tested in future work.

4. CONCLUSION

Based on the design, implementation, and testing of the automatic gallon-filling system, the IoT-based system built using a YF-S201 flow sensor, an ESP32 microcontroller, a relay as the pump controller, and a Telegram bot as the remote interface was able to fill water automatically. The firmware counts the sensor pulses through a hardware interrupt, calculates the volume in a non-blocking main loop, provides two protection layers (no-flow

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149

detection after 10 s and a 19.0 L volume limit), and accepts the /isi_galon, /stop, and /status commands only from a registered Telegram chat ID.

Testing in 40 trials showed that the system stopped the pump automatically in every trial, with a minimum error of 1.684%, a maximum error of 5.684%, and a mean error of 3.225%. All trials overfilled the 19 L target, with a mean overfill of 612.75 mL, and the results formed two groups with overfills of 320–520 mL and 920–1,080 mL.

The overfill is attributed to a delay when the relay switches off, the inertia of the water flow in the hose [20], and the reading tolerance of the flow sensor; in addition, the water flow does not stop instantly, so extra volume is added after the system switches off the pump.

Overall, the designed system meets the research objective of automating the water-filling process with remote control and notification through Telegram. It can serve as a practical solution to improve efficiency and reduce dependence on manual operation, although further development is still needed: calibrating the flow sensor, compensating for the overshoot to improve filling precision, and quantitatively evaluating the Telegram command response and the no-flow protection.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

6. REFERENCES

[1] Palermo, S. A., Maiolo, M., Brusco, A. C., Turco, M., Pirouz, B., Greco, E., Spezzano, G., and Piro, P. (2022). Smart technologies for water resource management: An overview. *Sensors*, *22*(16), 6225. https://doi.org/10.3390/s22166225

[2] Putra, N. A. I. E., Fitriati, A., Muchtar, A., and Fajar, N. (2025). Development of a real time three phase power parameter monitoring system using programmable logic controller (PLC) and Internet of Think (IoT). *Jurnal Media Elektrik*, *23*(1), 81-88.

[3] Muchtar, A., Burhan, M. I., Sari, D. A. L., Makmur, E., and Ashari, H. (2024). Pelatihan pemanfaatan media pembelajaran sistem kontrol berbasis elektro pneumatik di SMKN 9 Makassar. *TEKIBA: Jurnal Teknologi dan Pengabdian Masyarakat*, *4*(2), 242-248.

[4] Arfandi, A., and Supit, Y. (2019). Prototipe sistem otomasi pada pengisian depot air minum isi ulang berbasis Arduino Uno. *Simtek: Jurnal Sistem Informasi dan Teknik Komputer*, *4*(1), 91-99. https://doi.org/10.51876/simtek.v4i1.53

[5] Supandi, S., Hilda, H., and Hadary, F. (2017). Perancangan sistem data logger pengisian air galon otomatis berbasis mikrokontroler ATMega32. *Jurnal Edukasi dan Penelitian Informatika (JEPIN)*, *3*(1), 1-6. https://doi.org/10.26418/jp.v3i1.19239

[6] Pamungkas, D. D., and Setyadjit, K. (2023). Rancang bangun sistem kontrol dan monitoring pengisian air minum isi ulang otomatis menggunakan ESP32 berbasis IoT. *Prosiding Senakama*, *2*(1), 652-662.

[7] Muchtar, A., Makmur, E., Ashari, H., Burhan, M. I., and Riska, M. (2026). Pendampingan pemanfaatan sistem pengisian galon otomatis bagi depot air minum isi ulang. *Jurnal Pengabdian Masyarakat*, *4*(1), 150-155.

[8] Paun, M.-A., Sallese, J.-M., and Kayal, M. (2013). Hall effect sensors design, integration and behavior analysis. *Journal of Sensor and Actuator Networks*, *2*(1), 85-97. https://doi.org/10.3390/jsan2010085

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149

[9] Baker, R. C. (2016). *Flow measurement handbook: Industrial designs, operating principles, performance, and applications* (2nd ed.). Cambridge University Press. https://doi.org/10.1017/CBO9781107054141

[10] Eronu, E. M., and Odiagbe, M. (2020). Evaluation and modelling of a low budget Hall effect based flow-rate sensor using adaptive calibration paradigm. *European Journal of Engineering and Technology Research*, *5*(9). https://doi.org/10.24018/ejeng.2020.5.9.2154

[11] Maier, A., Sharp, A., and Vagapov, Y. (2017). Comparative analysis and practical implementation of the ESP32 microcontroller module for the Internet of Things. In *2017 Internet Technologies and Applications (ITA)*. IEEE. https://doi.org/10.1109/ITECHA.2017.8101926

[12] Hercog, D., Lerher, T., Truntič, M., and Težak, O. (2023). Design and implementation of ESP32-based IoT devices. *Sensors*, *23*(15), 6739. https://doi.org/10.3390/s23156739

[13] Telegram. (n.d.). *Telegram Bot API*. Retrieved October 13, 2026, from https://core.telegram.org/bots/api

[14] Öztürk, M. A., Ünsal, E., and Yelkuvan, A. F. (2025). Development of an Internet of Things-based ultra-pure water quality monitoring system. *Sensors*, *25*(4), 1186. https://doi.org/10.3390/s25041186

[15] Lalnunthari, J., and Thanga, H. (2017). Dependence of Hall effect flow sensor frequency on the attached inlet and outlet pipe size. In 2017 IEEE International Conference on Consumer Electronics-Asia (ICCE-Asia), 56–60. IEEE. https://doi.org/10.1109/ICCE-ASIA.2017.8307842

[16] Riupassa, R. D., Raflis, H., and Hendro. (2018). Optimasi nilai konstanta kalibrasi pada water flow sensor YF-S201. *Sistemik: Jurnal Ilmiah Nasional Bidang Ilmu Teknik*, 6, 1–5. https://ejournal.utb-univ.ac.id/Ejournal/JurnalDetail/523

[17] Rashad, A. A., Ulikaryani, Girawan, B. A., Ariawan, R., Sodikin, J., and Hastuti, H. D. (2023). Uji fungsi dan kalibrasi sensor water flow YF-S201 berbasis Arduino Uno pada mesin penjernih air sungai. *Jurnal Teknik Mesin, Elektro dan Ilmu Komputer*, 3(2), 1–9. https://doi.org/10.55606/teknik.v3i2.1850

[18] Tisna, D. R., Maharani, T., and Nugroho, K. T. (2024). Pemanfaatan chatbot Telegram untuk monitoring dan kontrol kualitas air menggunakan ESP32. *JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika)*, 9(3), 1292–1306. https://doi.org/10.29100/jipi.v9i3.5329

[19] Setyawan, N. R., Sumarahinsih, A., and Setiawan, A. B. (2026). Penerapan IoT pada sistem monitoring dan otomatisasi pengoperasian pompa air kabel duct gardu induk Tanggul. *METROTECH (Journal of Mechanical and Electrical Technology)*, 5(2), 253–261. https://ejournal.uniramalang.ac.id/metrotech/article/view/8711

[20] Ghidaoui, M. S., Zhao, M., McInnis, D. A., and Axworthy, D. H. (2005). A review of water hammer theory and practice. Applied Mechanics Reviews, 58(1), 49–76. https://doi.org/10.1115/1.1828050

DOI: https://doi.org/10.17509/coelite.v5i2.106731
p- ISSN 2829-4157 e- ISSN 2829-4149