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A Systematic Implementation of the Waterfall Model in E-Commerce System Development for Small Businesses

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Abstract

The Waterfall model remains a widely used software development methodology, offering a structured, phase-driven approach to system development. This study applies the Waterfall model in developing a web-based e-commerce system for small businesses, aiming to improve business operations, usability, and system efficiency. The system was implemented for Anisha Klapertart and Cake to address manual sales and inventory management inefficiencies. Black Box Testing confirmed 100% functionality across core modules, including authentication, product management, and order processing. Usability testing using the System Usability Scale (SUS) with 30 respondents resulted in a score of 70.16, categorizing the system as "Good" and "Acceptable". Despite its benefits, challenges include limited adaptability to requirement changes and scalability concerns. Future enhancements will focus on integrating a payment gateway, improving security, and adding customer loyalty programs. These findings demonstrate the practicality of the Waterfall model in structured e-commerce development, offering valuable insights for small businesses transitioning to digital platforms.

Keywords: Waterfall Model; E-Commerce System Development; Small Business Digitalization; Software Engineering Methodology; System Usability Evaluation.

1. Introduction

The quick advancement of information technology has meaningfully impacted many sectors, including business, education [1], healthcare, and employment [2]. One of the most influential technological developments in the business sector is the rise of e-commerce. E-commerce enables companies to conduct sales, marketing, and transactions through digital platforms, making it easier for customers to access products and services anytime and anywhere [3]. As a result, many small businesses have started adopting e-commerce systems to enhance their operations, improve customer service, and stay competitive in the digital marketplace [4].

Anisha Klapertart and Cake is a small business specializing in baked goods, particularly cakes and pastries. Despite being established for over nine years, the company still relies on manual methods for managing product availability, customer inquiries, and sales transactions. This traditional approach presents several challenges, including difficulty tracking product availability, inefficient order management, and limited customer engagement. To address these issues, a web-based e-commerce system is planned as a key to streamline business operations and enhance service quality [5].

A web-based e-commerce system permits businesses to automate numerous processes, such as catalogue management, order processing, and buyer transactions [6]. The company can expand customer satisfaction and operational effectiveness by providing an online platform where customers can browse products, room orders, and receive real-time updates. Additionally, a well-structured e-commerce system can provide valuable data insights, helping business owners make informed decisions about sales trends, customer preferences, and inventory management.

Developing an effective e-commerce system requires a systematic and structured approach to software engineering. The Waterfall Model is widely used among numerous software development methodologies due to its precise, phase-based structure [7]. The Waterfall Model follows a sequential procedure consisting of five key stages: requirements analysis, system design, implementation, testing, and maintenance. This method certifies that each stage is completed before proceeding to the next, allowing for thorough documentation and reduced development risks [8].

This study applies the Waterfall Model to develop a web-based e-commerce system for Anisha Klapertart and Cake. The project begins with an in-depth business requirements analysis followed by system design and database development. The implementation phase includes coding the system using PHP as the primary programming language and MySQL for database management [9]. The testing phase contains black-box testing to assess system functionality and usability testing employing the System Usability Scale (SUS) to measure user satisfaction [10]. Lastly, the maintenance phase confirms continuous system updates and enhancements based on user response.

The usability of an e-commerce system plays a critical role in its success. If a system is challenging to use, customers may abandon transactions, leading to decreased sales and lower customer retention [11]. Therefore, this study conducts usability testing to evaluate how straightforwardly users can navigate the system and complete transactions. The System Usability Scale (SUS) is used as a measurement tool, providing a standardized evaluation of the system's effectiveness, efficiency, and user satisfaction.

Previous studies on e-commerce systems have highlighted the importance of usability, security, and functionality in improving customer experience [12]. Research also suggests that small businesses benefit significantly from adopting digital solutions, as they provide a competitive edge and increase accessibility to a broader customer base. However, many small businesses struggle with digital transformation due to limited technical knowledge and resources. By adopting a structured development methodology like the Waterfall Model, companies can mitigate these challenges and ensure a successful transition to an online platform [13].

One key motivation behind this study is the growing demand for digitalization in small and medium-sized enterprises (SMEs). Many SMEs face operational inefficiencies due to the absence of automated systems, resulting in higher costs and slower response times. Implementing an e-commerce system streamlines business operations and enhances marketing opportunities through online visibility and customer engagement. This study aims to bridge the gap between traditional business operations and current digital solutions by providing a practical, user-friendly e-commerce system personalized to the needs of small businesses.

An e-commerce system improves business efficiency and offers several advantages, such as reduced manual errors, improved data management, and enhanced customer interactions [14]. Customers can accessibly browse available products, place orders, and receive instant confirmations, while business owners can efficiently manage inventory and sales records. Integrating a web-based platform allows businesses to expand their market reach beyond local customers, enabling more significant revenue potential [15].

The findings of this study will contribute to the growing body of knowledge on e-commerce system development for small businesses. By demonstrating the practical application of the Waterfall Model, this research provides insights into the challenges and benefits of adopting a structured development approach. The usability testing results will also offer valuable feedback on system effectiveness, guiding future improvements and refinements.

2. Research Methods

This study explores the implementation of the Waterfall Model in developing a web-based e-commerce system for Anisha Klapertart and Cake. This research aims to create an efficient, user-friendly digital platform that enhances business operations and customer satisfaction by addressing the business's existing challenges and incorporating usability testing. The following sections will discuss the methodology, system implementation, testing results, and overall impact of the developed system.

This study adopts the Waterfall Model, a structured and sequential approach to software development that ensures each phase is fully completed before progressing to the next, as illustrated in Figure 1. The development process comprises five key stages: requirements analysis, system design, implementation, testing, and maintenance. This methodology offers a clear and systematic framework, ensuring all requirements are documented and effectively implemented [16].

2.1. Requirement Analysis

The first phase, requirements analysis, involved identifying the system's functional and non-functional requirements. Data collection was conducted through observations and interviews with the owners of Anisha Klapertart and Cake to understand the challenges faced in managing product inventory, handling customer orders, and processing transactions manually. The findings revealed that the existing manual approach resulted in inefficiencies, making it difficult for the business to track product availability and customer interactions effectively.

This analysis established several functional requirements, including customer and administrator user authentication, product management capabilities, order processing, invoice generation, and customer management [17]. These features

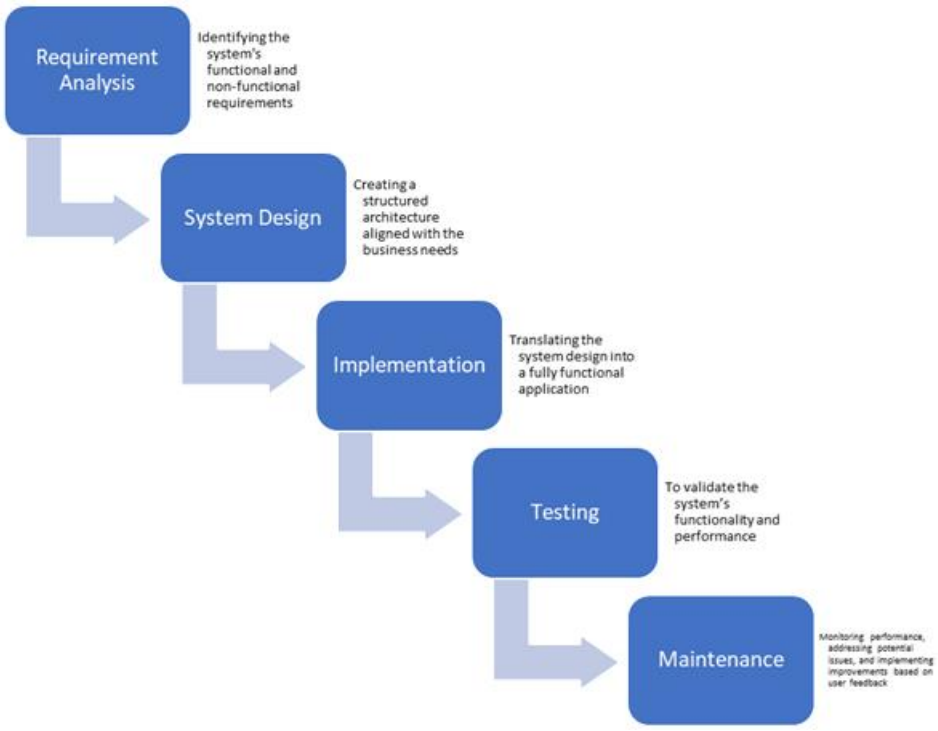

Figure 1. Waterfall Method

were essential for ensuring smooth and efficient business operations. Additionally, non-functional requirements such as system security, performance optimization, and usability were defined to enhance system reliability. The system must be secure, responsive, and user-friendly to facilitate seamless interactions between administrators and customers.

2.2. System Design

Once the requirements were clearly defined, the system design phase focused on creating a structured architecture aligned with the business needs [18]. The system was developed as a web-based application to ensure accessibility from various devices. The backend was designed using PHP and MySQL for efficient data storage and management, while the front end utilized HTML, CSS, and JavaScript to create an interactive and responsive user interface.

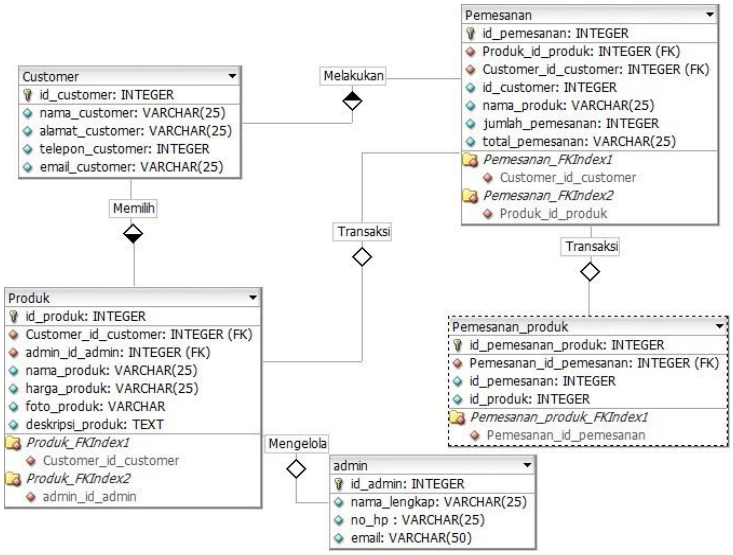

Figure 2. Entity-Relationship Diagram (ERD) of the E-Commerce

The database structure was carefully designed using an Entity-Relationship Diagram (ERD) to establish relationships between key data components, such as products, customers, orders, and transactions, as shown in Figure 2. This relational database model ensured that data was stored efficiently and could be retrieved quickly. A use case diagram was developed to visualize system functionalities, outlining the interactions between users and system components. The

system featured two primary user roles: the administrator, who managed product listings and processed customer orders, and the customer, who browsed products, placed orders, and received transaction confirmations.

A key aspect of system design was developing an intuitive and user-friendly interface. The user interface (UI) was designed using Figma, following usability principles to enhance navigation and ease of use. The layout was structured to provide precise product categorization, simple order placement, and quick access to essential features. A responsive design approach ensured the system functioned seamlessly across different screen sizes, improving user accessibility on various devices.

2.3. Implementation

The implementation stage involved translating the system design into a fully functional application [19]. The backend development used PHP for server-side processing, while MySQL managed the database. The front end was built using HTML, CSS, and JavaScript to provide an interactive user experience. The system was hosted on Apache XAMPP for local development and testing, enabling developers to test system functionalities before deployment.

Security measures were implemented during development to protect user data and prevent potential vulnerabilities. Password hashing techniques were applied to secure authentication processes, ensuring that user credentials remained confidential. Input validation was integrated to avoid SQL injection and cross-site scripting (XSS) attacks, enhancing overall system security. Session management was also implemented to regulate user access, preventing unauthorized actions within the system.

The system was structured with reusable components to ensure modularity, allowing for easy maintenance and future scalability. Each module, including authentication, product management, and order processing, was developed independently to enable efficient debugging and modifications. The implementation adhered to best coding practices to maintain system stability and efficiency.

2.4. Testing

To validate the system's functionality and performance, rigorous testing was conducted using Black Box Testing and usability evaluation through the System Usability Scale (SUS) [20]. Black Box Testing assesses system outputs based on different inputs without analyzing internal code structures. Various test cases were designed to verify key functionalities, including login authentication, product addition and removal, order processing, and invoice generation [21]. Each test case was evaluated to ensure the system met predefined requirements and functioned as expected.

Usability testing was conducted to assess the overall user experience and ease of navigation. A group of 30 respondents participated in the SUS evaluation, providing feedback on system usability, efficiency, and accessibility. The results were analyzed to determine the system's effectiveness in facilitating user interactions. A higher SUS score indicated a more user-friendly system, providing insights into potential improvements for future updates. Functional testing and usability evaluation ensured the system met technical and user experience expectations.

2.5. Maintenance

Following system deployment, the maintenance phase focused on monitoring performance, addressing potential issues, and implementing improvements based on user feedback [22]. Continuous system evaluation was conducted to identify and resolve technical or usability-related concerns. Regular updates were planned to enhance system capabilities and ensure compatibility with evolving technological requirements [23].

The system was designed with scalability in mind to facilitate long-term usability and allow for the integration of additional features. Future improvements included payment gateway integration to enable online transactions, automated order tracking for real-time status updates, and AI-driven product recommendations to enhance customer engagement—these enhancements aimed to optimize the business's operations further and improve customer satisfaction.

Another critical aspect of maintenance involves user training and documentation. Administrators were provided with instructional materials and tutorials to help them manage the system effectively. Clear product updates, order processing, and data management guidelines were included to ensure seamless system operations. Additionally, security measures continued to be reinforced through periodic updates and vulnerability assessments, safeguarding customer data and business transactions.

3. Results and Discussion

Developing and implementing the web-based information system for Anisha Klapertart and Cake has significantly improved ordering and product management efficiency. The system, designed using the Waterfall model, has undergone requirement analysis, design, implementation, and testing to ensure that each feature functions as specified. With this system, administrators can easily manage product data, track customer orders, and provide more transparent information to buyers.

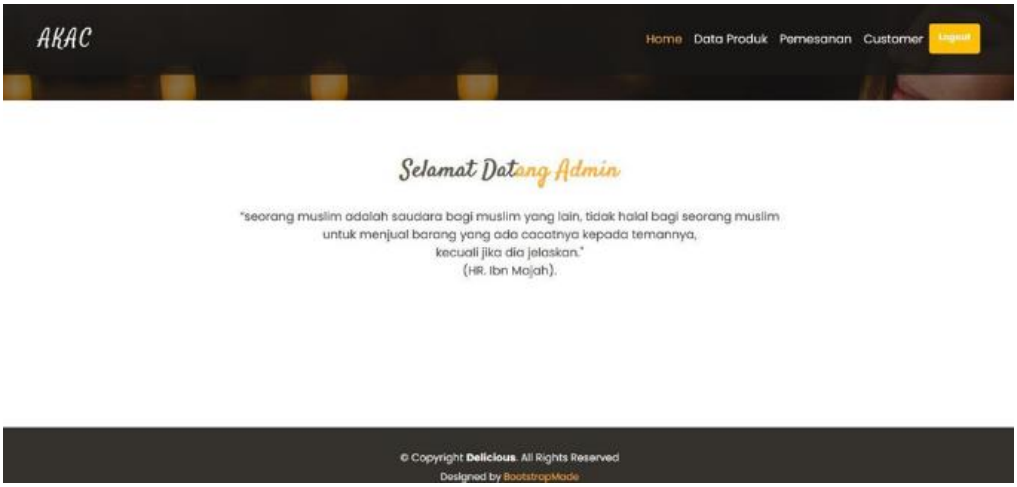

Figure 3. Admin Login Page of the E-Commerce System

In this system, the admin plays a crucial role in store management, including logging in, managing product data, handling orders, and viewing customer lists. The admin login page, as shown in Figure 3, is designed to ensure secure access, allowing only authorized users to enter the system. Once logged in, the admin can navigate various sections such as product management, order processing, and customer records. The dashboard provides a user-friendly interface with key functionalities accessible through buttons and menus, making the management process more efficient.

The product management page enables the admin to add new products, update product details, and remove items from the catalog. This feature helps maintain an up-to-date product inventory, ensuring customers only see available items. The order management section allows the admin to track customer orders, view order details, and confirm payments. This feature is crucial for ensuring smooth transaction processing and minimizing errors in order fulfillment.

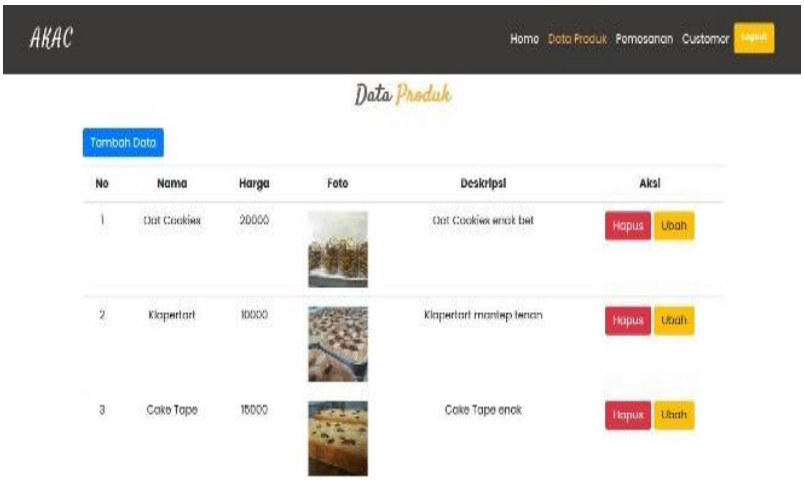

Figure 4. Product Menu Interface for Customers

On the customer side, the system provides an intuitive interface for browsing products, adding items to the shopping cart, and placing orders. The homepage serves as the main entry point, offering navigation to various sections such as the product catalog, shopping cart, and contact page. As shown in Figure 4, the product menu displays all available items, descriptions, prices, and images, allowing customers to make informed purchasing decisions.

The shopping cart feature enables customers to review their selected items before checkout. Customers can update the number of items, remove unwanted products, and finalize their orders. The checkout process requires customers to provide their personal information, including name, email, phone number, and shipping address. Once the order is placed, the system generates an invoice and sends it to the customer's registered email. This ensures a smooth and transparent purchasing experience.

Black Box Testing was conducted to evaluate the system's performance and verify the functionality of different features. The test results confirmed that the system operates correctly and meets all functional requirements. The admin functions performed as expected, such as adding and removing products, updating customer orders, and managing invoices. Similarly, customer-side functionalities, including product browsing, adding items to the cart, and completing purchases, worked without any issues.

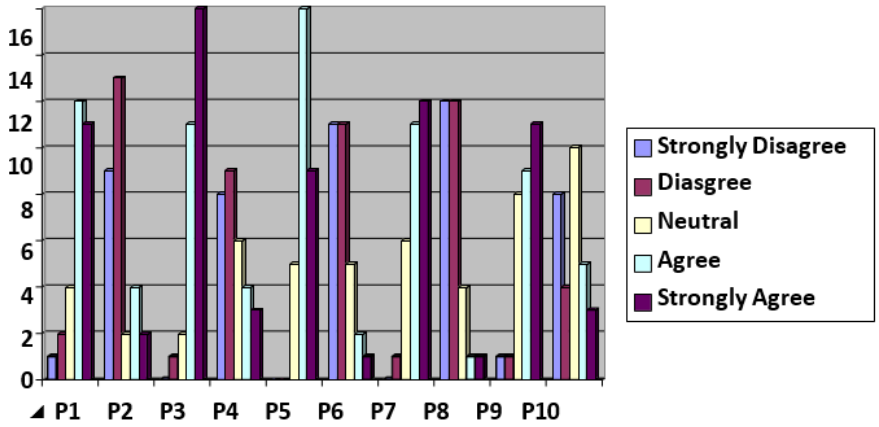

Figure 5. System Usability Scale (SUS) Evaluation Results

Usability Testing using the System Usability Scale (SUS) was conducted to assess user satisfaction and ease of use, as shown in Figure 5. The SUS test involved multiple respondents who rated different aspects of the system, including navigation, feature complexity, and overall user experience. The system achieved an average SUS score of 70.16, which falls under the "Good" category and is considered acceptable for end users. This indicates that the system is user-friendly and meets the expectations of both admins and customers.

Furthermore, implementing the Contact Us page enhances customer engagement by providing essential business information such as store location, working hours, email, and phone number. This feature allows customers to reach out with inquiries or feedback, fostering better communication between the business and its customers.

The system has successfully streamlined the ordering process, reduced manual errors, and improved operational efficiency. Integrating PHP and MySQL ensures a robust and scalable platform for managing online transactions. Future improvements may include adding payment gateway integration for online transactions, enhancing security features, and expanding the system's capabilities to support promotional campaigns and customer loyalty programs. By implementing this web-based ordering system, Anisha Klapertart and Cake have taken a significant step toward digital transformation. Their products are now more accessible, and their customers' overall shopping experience is improved.

4. Conclusion

Developing the web-based ordering system for Anisha Klapertart and Cake has successfully enhanced product management efficiency and customer transactions. Implementing the waterfall model ensures a structured development process that covers requirement analysis, design, implementation, testing, and maintenance. The system provides essential functionalities for administrators and customers, including product management, order processing, and an intuitive shopping experience. The integration of PHP and MySQL offers a reliable platform for handling transactions, while usability testing confirms its effectiveness in meeting user expectations.

The results of Black Box Testing demonstrated that all system features function correctly, ensuring smooth operations for administrators and customers. Additionally, the System Usability Scale (SUS) test yielded a score of 70.16, categorizing the system as "Good" and "Acceptable" for users. This indicates that the system is user-friendly and effectively supports business operations. The ability to manage product availability, track orders, and generate invoices has significantly improved the business process, reducing manual workload and minimizing errors in order fulfillment.

Further enhancements can be made to improve the system's functionality in the future, such as integrating an online payment gateway, enhancing security features, and implementing marketing tools like promotions and customer loyalty programs. By adopting this digital transformation, Anisha Klapertart and Cake can expand their reach, improve customer engagement, and remain competitive in the evolving e-commerce landscape.

5. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

6. References

[1] B. Aditya, S. H. Al Ikhsan, and B. Wulandari, "Development of a Solar System Learning Application Using Markerless Augmented Reality Based on Android," *Jurnal Informatika*, vol. 11, no. 2, pp. 49–54, Aug. 2024, doi: 10.31294/inf.v11i2.19084.

[2] T. H. Pudjiantoro, S. Anggoro, and D. Destiani, "The Effect of Knowledge Sharing and Enrichment on Lecturer Innovation Performance in General Achmad Yani University," *Jurnal Informatika*, vol. 11, no. 2, pp. 95–102, Oct. 2024, doi: 10.31294/inf.v11i2.20503.

[3] A. Rakhmadi and K. M. Yusrifa, "Information System of Teacher Assignment Journal in Wooi State Junior High School Sistem Informasi Jurnal Penugasan Guru SMP Negeri Wooi," *MESTRO*, vol. 6, no. 01, pp. 22–27, 2024.

[4] Y. D. D. Y. Khwuta, M. A. Londa, and Y. A. Wee, "Designing and building a business data collection application using the waterfall method," *MATRIX : Jurnal Manajemen Teknologi dan Informatika*, vol. 13, no. 1, pp. 42–51, Mar. 2023, doi: 10.31940/matrix.v13i1.42-51.

[5] S. Suhirman, A. T. Hidayat, W. A. Saputra, and S. Saifullah, "Website-Based E-Pharmacy Application Development to Improve Sales Services Using Waterfall Method," *International Journal of Advances in Data and Information Systems*, vol. 2, no. 2, pp. 114–129, Oct. 2021, doi: 10.25008/ijadis.v2i2.1226.

[6] A. Jannah, A. M. Meuraxa, and A. Azzahrah, "Web Based E-Commerce System Design at EXO Shop Using The Waterfall Method," *Hanif Journal of Information Systems*, vol. 1, no. 1, pp. 1–5, Aug. 2023, doi: 10.56211/hanif.v1i1.3.

[7] S. S. Ramadani, H. Kurniawan, and R. F. Wijaya, "Online Attendance System Website-Based at the Village Hall Office Paya Bakung Using the Waterfall Method," *Journal of Applied Engineering and Technological Science*, vol. 4, no. 1, pp. 505–511.

[8] S. Herawati, Y. D. P. Negara, H. F. Febriansyah, and D. A. Fatah, "Application of the Waterfall Method on a Web-Based Job Training Management Information System at Trunojoyo University Madura," in *E3S Web of Conferences*, EDP Sciences, Dec. 2021. doi: 10.1051/e3sconf/202132804026.

[9] M. Al Fajar, M. H. Dar, and R. Rohani, "Application of Waterfall model in development of family planning participants information system," *Sinkron*, vol. 7, no. 2, pp. 679–686, May 2022, doi: 10.33395/sinkron.v7i2.11387.

[10] Ethan, C. Daphne, M. Stanley, V. Augustine, M. S. Anggreainy, and A. S. Setiawan, "Developing an Application to Recommend Major Based on Personality Test using Waterfall Method," in *2022 5th International Conference on Computer and Informatics Engineering, IC2IE 2022*, Institute of Electrical and Electronics Engineers Inc., 2022, pp. 220–224. doi: 10.1109/IC2IE56416.2022.9970189.

[11] Y. A. Pratama, P. W. Laksono, and E. Liquiddanu, "Web Design: Develop the Decision Support System for Judgement Additional Order (JAO) Using Waterfall Method," in *Proceedings of the 6th Asia Pacific Conference on Manufacturing Systems and 4th International Manufacturing Engineering Conference*, C. N. Rosyidi, P. W. Laksono, W. A. Jauhari, and M. Hisjam, Eds., Singapore: Springer Nature Singapore, 2023, pp. 257–269.

[12] M. Dursun, N. Goker, and H. Mutlu, "Evaluation of Project Management Methodologies Success Factors Using Fuzzy Cognitive Map Method: Waterfall, Agile, And Lean Six Sigma Cases," *International Journal of Intelligent Systems and Applications in Engineering*, vol. 2022, no. 1, pp. 35–43, doi: 10.1039/b000000x.

[13] R. Mokhtar and M. Khayyat, "A Comparative Case Study of Waterfall and Agile Management," *SAR Journal - Science and Research*, pp. 52–62, Mar. 2022, doi: 10.18421/sar51-07.

[14] M. S. Rumetna, T. N. Lina, I. S. Rajagukguk, F. S. Pormes, and A. B. Santoso, "Payroll Information System Design Using Waterfall Method," *International Journal of Advances in Data and Information Systems*, vol. 3, no. 1, Apr. 2022, doi: 10.25008/ijadis.v3i1.1227.

[15] F. Mahardika and M. L. Abdillah, "Design of Unified Modeling Language Information System for Motorcycle Unit Selling and Buying Transactions using the Waterfall Method," *Hanif Journal of Information Systems*, vol. 1, no. 2, pp. 37–48, Feb. 2024, doi: 10.56211/hanif.v1i2.15.

[16] W. Kartika, M. M. A. Hafida, and S. Widadi, "Simple Patient Registration with The Waterfall Method," in *Proceedings - 2022 2nd International Conference on Electronic and Electrical Engineering and Intelligent System, ICE3IS 2022*, Institute of Electrical and Electronics Engineers Inc., 2022, pp. 237–241. doi: 10.1109/ICE3IS56585.2022.10010117.

[17] N. Fajriati and K. Budiman, "Web-Based Employee Attendance System Development Using Waterfall Method," *Journal of*

Advances in Information Systems and Technology, vol. 3, no. 2, 2021, [Online]. Available: https://journal.unnes.ac.id/sju/index.php/jaist

[18] T. Natarajan and S. Pichai, "Transition from Waterfall to Agile Methodology: An Action Research Study," *IEEE Access*, vol. 12, pp. 49341–49362, 2024, doi: 10.1109/ACCESS.2024.3384097.

[19] F. Aldi, "Web-Based New Student Admission Information System Using Waterfall Method," *Sinkron*, vol. 7, no. 1, pp. 111–119, Jan. 2022, doi: 10.33395/sinkron.v7i1.11242.

[20] M. Abdurrahman, T. N. Adi, M. Lubis, and D. W. Jacob, "E-Ticketing System to Accelerate Car Terminal Indonesia Port of Tanjung Priok Activities Using Waterfall Method," in *Proceedings - ICCTEIE 2023: 2023 International Conference on Converging Technology in Electrical and Information Engineering*, Institute of Electrical and Electronics Engineers Inc., 2023, pp. 79–84. doi: 10.1109/ICCTEIE60099.2023.10366547.

[21] st Elvis Pawan *et al.*, "Using Waterfall Method to Design Information System of SPMI STIMIK Sepuluh Nopember Jayapura," 2021. [Online]. Available: https://ijcis.net/index.php/ijcis/index

[22] T. Thesing, C. Feldmann, and M. Burchardt, "Agile versus Waterfall Project Management: Decision Model for Selecting the Appropriate Approach to a Project," *Procedia Comput Sci*, vol. 181, pp. 746–756, 2021, doi: https://doi.org/10.1016/j.procs.2021.01.227.

[23] A. Sinha and P. Das, "Agile Methodology Vs. Traditional Waterfall SDLC: A case study on Quality Assurance process in Software Industry," in *2021 5th International Conference on Electronics, Materials Engineering and Nano-Technology, IEMENTech 2021*, Institute of Electrical and Electronics Engineers Inc., 2021. doi: 10.1109/IEMENTech53263.2021.9614779.