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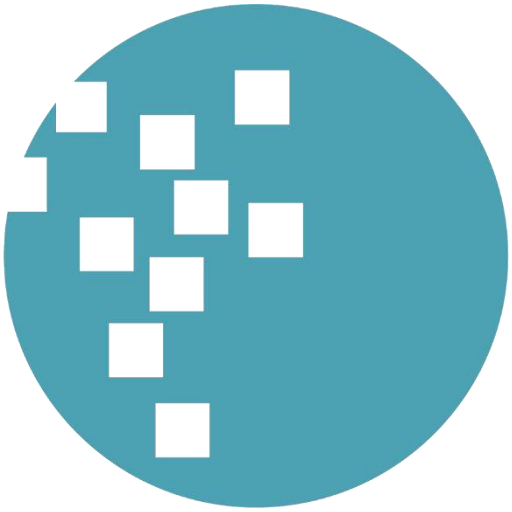

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Universitas Multimedia Nusantara (UMN)
Jl. Scientia Boulevard
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Indonesia
Phone. (021) 5422 0808
Fax. (021) 5422 0800
Email : ultimacomputing@umn.ac.id

IJNMT (International Journal of New Media Technology) is a scholarly open access, peer-reviewed, and interdisciplinary journal focusing on theories, methods and implementations of new media technology. Topics include, but not limited to digital technology for creative industry, infrastructure technology, computing communication and networking, signal and image processing, intelligent system, control and embedded system, mobile and web based system, and robotics. IJNMT is published regularly twice a year (June and December) by Faculty of Engineering and Informatics, Universitas Multimedia Nusantara in cooperation with UMN Press.

Call for Papers

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FOREWORD

Greetings!

IJNMT (International Journal of New Media Technology) is a scholarly open access, peer-reviewed, and interdisciplinary journal focusing on theories, methods and implementations of new media technology. Topics include, but not limited to digital technology for creative industry, infrastructure technology, computing communication and networking, signal and image processing, intelligent system, control and embedded system, mobile and web based system, and robotics. IJNMT is published regularly twice a year (June and December) by Faculty of Engineering and Informatics, Universitas Multimedia Nusantara in cooperation with UMN Press.

In this December 2025 edition, IJNMT enters the 1st Edition of Volume 12 No 2. In this edition there are ten scientific papers from researchers, academics and practitioners in the fields covered by IJNMT. Some of the topics raised in this journal are: News Management Application Development, Constructivism Analysis on the Influence of Practical Implementation on Computer Networks Course in Informatics Class, A Web-Based Network Device Inventory and Dynamic QR Code Tracking System: Design, Development, and Evaluation PT. XYZ, Triangulation Approach Using K-Means, Hierarchical Clustering, and DBSCAN for Beef Production Analysis, Waste Processing and Recycling Product Marketplace Application Using Tensorflow and Midtrans API Technology, Expert System for Diagnosing Human Psychological Disorders Using the Forward Chaining Method, Development of a Web-Based Agricultural E-Marketplace Using Laravel, Measurement of the Usability of the Posyandu Information System for Teenagers using the System Usability Scale (SUS) at the Seruni Posyandu in Tangerang City, The The Impact of Super Golden Ratio Implementation on User Satisfaction: A Study of Horizontal Scrolling in Bacana User Interface (UI) Design, Implementation of Ergonomic Criteria for Evaluating the Logistic Mobile App User Interface Design, Android Shortcut Application Development as a Medium for Religious Information using the Appsgeyser Platform.

On this occasion we would also like to invite the participation of our dear readers, researchers, academics, and practitioners, in the field of Engineering and Informatics, to submit quality scientific papers to: International Journal of New Media Technology (IJNMT), Ultimatics : Jurnal Teknik Informatics, Ultima Infosys: Journal of Information Systems and Ultima Computing: Journal of Computer Systems. Information regarding writing guidelines and templates, as well as other related information can be obtained through the email address ultimaijnmt@umn.ac.id and the web page of our Journal here.

Finally, we would like to thank all contributors to this June 2025 Edition of IJNMT. We hope that scientific articles from research in this journal can be useful and contribute to the development of research and science in Indonesia.

December 2025,

David Agustriawan, S.Kom., M.Sc., Ph.D.
Editor-in-Chief

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News Management Application Development

Muhammad Adryan Syahputra[1], Rizqa Raaiqa Bintana[2*], Dewi Lestari[3]
[1,2,3] Information Systems Study Program, Universitas Jambi, Jambi, Indonesia
[*]rizqa.raaiqa.bintana@unja.ac.id

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***Abstract*— This study aims to develop a news management application at institution X that has been running previously, into an interactive application that can be used as a means of writing, reviewing and collecting news articles which are then published to daily newspaper pages. The application development model used in this study is the waterfall model. The waterfall model involves stages such as communication, planning, modeling, construction, and deployment. This study succeeded in developing a news management application from the previous version into a new application with the implementation of all its functional requirements. Testing was carried out using the black box method and system usability scale (SUS). The results of the black box test showed that the news management application had successfully carried out all functions correctly and in accordance with expectations. In the SUS test, two measurements were taken, namely before and after development. The SUS score before development was 71.3, while after development it increased to 78.8. This shows an increase in user perception of the usability of the application after development was carried out. Structured work and a clear flow from initiation to end can minimize errors because it has clear details and final descriptions.**

***Index Terms*— black box testing; news application; system usability scale; waterfall model**

I. INTRODUCTION

Institution X seeks to improve public services, especially in terms of providing various information related to statistical developments in various sectors in one area where institution X is located. Information is presented regularly and transparently so that the public can easily find out or obtain the data or information needed. Information is distributed from institution X to the public through the daily news page in the area where institution X is located. News articles that will be published on the daily news page are written directly by employees at institution X. Before being published, the news articles must go through a review stage, where the news articles will be reviewed by reviewers from the institution itself.

Previously, institution X had an application that could be used to collect and manage news articles from employees who had been assigned until the review process before the news articles were published on the daily news page. The news management application is website-based. The application has a primary role as an application that is expected to facilitate the process of managing news articles written directly by employees. News articles are created with the help of third-party applications such as Microsoft Word and the like, which are then uploaded to the application in the form of files with the doc and docx extensions. The news writing can be managed by the reviewer by downloading the file first. Then, the reviewer reviews the content of the news, the completeness of the news writing, until the news writing can be said to be ready to be published by the daily newspaper.

This news management application aims to meet several needs. One such need is the ability to write news directly within the application without having to use a third-party application like Microsoft Word. Therefore, the purpose of this development is to refine the process so that all news management activities can be done only within a single news management application, including writing news text, editing news files and reviewing news articles without the need to upload and download documents. Development here means activities to create a new system or application that can replace the old system as a whole or improve the existing system [1].

Application development can use various forms of models, one of which is using the waterfall model. The waterfall development model is a model that provides a sequential or ordered software life flow approach starting from analysis, design, coding, and testing like a waterfall [2]. The waterfall model is suitable for use in projects that have clear and well-defined requirements and needs. This model is also easy to organize tasks and processes and development results are well documented [3]. This waterfall development model has been used in previous studies, one of which was conducted by Rifai & Mailasari [4] regarding the use of the waterfall method in the sales and purchase data processing information system. This study aims to create a system that can facilitate sales activities and data collection of goods at the Fang Fifi Cell cellphone store by adapting the waterfall model in its development to ensure that the development process was systematic and organized.

A similar study using the waterfall model was conducted by Septyanto et al [5], who aimed to develop a website-based e-learning system and determine the feasibility of the resulting product. Purwati et al [6] successfully designed a website-based news

information system by regenerating the layout of an old news website with a new design, resulting in a more modern layout and ease of use.

The development of a news management application for institution X has clear needs, namely the need for several features such as news writing features and several supporting features for news management that are not available in the previous application. Therefore, the selection of the waterfall model is suitable for the development of this application because the waterfall model has a fixed (definite) development process stage, is easy to apply, is orderly and is suitable for software products or programs that have clear requirements from the start so that errors are minimal [7].

TABLE I. COMPARISON OF SOFTWARE DEVELOPMENT MODELS

Waterfall	Prototype	Rapid Application Development	Scrum
Sequential	Iterative	Iterative	Iterative
For software projects with clear requirements from the outset	For customized software	For software projects that require a short time	For various sizes and types of software projects and those requiring short turnaround times
The development process stages are fixed, easy to apply and the process is regular	Shorten software product development time	Can reuse existing components	Working with time constraints called sprints
Cannot proceed to the next stage if a stage has not been completed	Provide a prototype as an illustration of the system to be built	Only compatible with modularizable software	Focus on team spirit and communication
It is difficult to experience changes in the needs desired by clients	Changes can be made while the system or software is still in prototype	If there are changes in the middle of the work, a new contract must be made between the developer and the client	Hold frequent meetings to get feedback from clients and stakeholders

Table I shows a comparison of software development models summarized from previous research [7][8]. Based on the characteristics and comparison of several development models described in Table I, the waterfall model was chosen for this application's development. This model was chosen because the goals and needs of the news management application were clearly defined at the beginning of development. The waterfall model also has fixed stages, is easy to apply, and has a structured process. Furthermore, the application being developed is relatively small.

Previous applications will be measured for their usability level using the system usability scale (SUS). Then, the application that has been developed will be tested using two types of testing methods, namely black box and SUS. In black box testing, the focus is on checking whether the application functions as expected. The tester tests the application by testing predetermined input conditions to verify whether the application behaves according to its functional specifications [9]. Meanwhile, the system usability scale is a questionnaire that can be used to measure the usability of a computer system from the user's subjective perspective [10]. The results of the SUS test on the previous application will be compared with the results on the latest application to determine whether there is an increase in usability after the application is updated. After being tested, the application that has been developed is then implemented on the server belonging to institution X and receives feedback from users on the application that has been developed. With the development of this application, it is hoped that it can become a website-based application that can be used to facilitate the process of writing, managing and reviewing news articles at institution X. This research adopted the waterfall model in its development. All the stages of the waterfall model process will be presented in detail throughout this article, helping readers understand the details of the stages within the waterfall model.

II. METHOD

The research framework begins with identifying the problem, then conducting a study literature and developing a news management application using the waterfall model. The research framework can be seen in Figure 1.

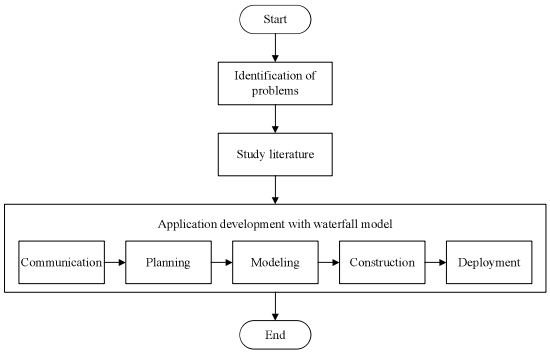

Fig. 1. Research framework

A. Communication

At the communication stage, a discussion was held with institution X to understand the objectives and

needs of the development of the news management application. This discussion was conducted directly, where this discussion resulted in a description of the flow and features of the previous news management application and what shortcomings needed to be fixed in this development.

B. Planning

At the planning stage, planning is carried out to develop a news management application by considering the time and resources available. Discussions are carried out with relevant stakeholders to determine the estimated time needed to develop the application. Furthermore, a development schedule is made. The entire planning process is carried out in a structured and systematic manner to ensure the success of the development of the news management application.

C. Modeling

Requirement analysis is a very important stage in software development. If there is an error in describing the system requirements, it can result in the failure of software development [11]. Requirements are classified as functional requirements and non-functional requirements [12]. At the modeling stage, analysis and design of news management applications are carried out. First, a requirements analysis is carried out to determine the functional and non-functional needs of the news management application to be updated.

After analyzing the required needs, the next step is to design the news management application. This stage is more focused on the design of the updated application, which includes the database structure, the updated appearance of the application, and the updated application workflow. The design will be described in the form of UML and wireframe.

Use case diagrams are used to determine the behavior of the system to be implemented. Use case diagrams consist of actors, use cases, and their relationships. Diagrams are used to model the system/subsystem of an application. Use case diagrams fulfill certain functionalities of a system [13]. Classes represent the fundamental building blocks of any object-oriented software system. UML class diagrams offer a clear and effective means of illustrating these components. In addition to detailing individual classes, class diagrams demonstrate the relationships among multiple classes, thereby depicting the overall architecture of the system. A class is characterized by a unique name, a set of attributes, and a list of methods [14].

Activity diagrams are valuable behavioral diagrams that illustrate the internal processes of various program operations using nodes and edges. These diagrams have been widely utilized across different domains to represent workflows effectively. An activity diagram serves to depict various activities, sub-activities, transitions, decision points, guard conditions, concurrent activities, branches, merges, swim lanes, joins, forks, and more. Typically, an activity diagram begins with a single starting activity and culminates in a single final activity [15]. The new design produced will still adopt several elements of the old design that are considered still suitable for use.

D. Construction

At the construction stage, program code and testing are carried out on the development of news management applications. The creation of program codes is adjusted to the results of the requirements analysis and design that have been carried out in the previous stages, so that the input and output produced in the development of website-based news management applications can be implemented using web programming properly. The programming language and type of database will be adjusted to the type that has been implemented in the application that has been running previously.

The news management application that has been developed will be tested in terms of functionality and the level of usability of the application from the user's perspective. The application's functionality is tested using the black box testing method, while the level of usability of the application is tested using the system usability scale (SUS) method.

- Black Box Testing. The purpose of conducting black box testing on the news management application is to find out whether each function works well by determining the test case data being tested. Furthermore, determining the test scenario used to evaluate the output produced in the news management application. This testing is documented in the form of a table with the format in Table II [16]. The black box questionnaire will be distributed to respondents from institution X representing each role in the news management application, including 1 respondent as a news writer, 1 respondent as a news reviewer, 1 respondent as a publisher and 1 respondent as an admin.

TABLE II. BLACK BOX TESTING FORMAT

No	Test Scenario	Test Case	Expected Results	Test Results
1	The scenario that is executed	Specifications of the data used	Expected test scenario results	As expected or not

- System Usability Scale (SUS). The level of usability of the news management application was tested by providing 10 statements that had to be answered by respondents. These statements were adopted based on research conducted by Bangor [17]. The SUS questionnaire will be distributed to 18

respondents from institution X who had previously used the previous version of the news management application. The SUS test was conducted twice, the first for the previous news management application and the second for the application that had been developed, to compare the level of usability in each application. The System Usability Scale is a usability evaluation method that can provide adequate results based on considerations of small sample sizes, time and costs [18]. In calculating the SUS score, a five-point Likert scale (1-5) is used, consisting of Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree. Each statement item has a contribution score ranging from 0 to 4. For items 1, 3, 5, 7 and 9 (positive statement items), the contribution score is the scale position minus 1. For items 2, 4, 6, 8 and 10 (negative statement items), the contribution score is 5 minus the scale position. Then multiply the total SUS score by 2.5 to obtain the overall SUS score, which ranges from 0 to 100 [10]. The following are the steps taken in converting respondent responses [19]:

- Odd statements, namely: 1, 3, 5, 7 and 9, the score given by the respondent is minus by 1.

  Odd SUS score = ∑Px-1, where Px is the x-th odd statement scale.

- Even statements, namely: 2, 4, 6, 8 and 10, the scores given by respondents are used to minus 5.

  Even SUS score = ∑5-Pn, where Pn is the n-th even statement scale.

- The results of the conversion are then added up for each respondent and then multiplied by 2.5 to obtain a value range of 0-100.

  (Odd SUS Score + Even SUS Score) x 2.5

- Once each respondent's score is known, the next step is to find the average score by adding all the respondents' scores and dividing by the total number of respondents. This calculation can be seen in (1).

$$X = \sum x / N \quad (1)$$

Description:
X : Average score
∑x : Total system usability scale scores
N : Number of respondents

E. Deployment

At this stage, the news management application that has been developed is then implemented to the server owned by institution X and data migration occurs as the news management application is used. Migration occurs on news data that was originally in the form of files, then converted into text that can be stored in the database.

TABLE III. SUS SCORE ASSESSMENT AND EXPLANATION

Acceptability Ranges		
Score	**Term**	**Meaning**
70-100	ACCEPTABLE	Shows good levels of acceptance and usability, although there is still improvement
63-69	MARGINAL HIGH	Although there are still shortcomings, the product can still be improved and is considered to have a limited level of usefulness
50-62	MARGINAL LOW	The product has many serious flaws that need to be fixed immediately and is considered to have a low level of usability
0-49	NOT ACCEPTABLE	Products with this score have many weaknesses in use and need significant improvement
Grade Scale		
90-100	A	Very good
80-89	B	Good
70-79	C	Sufficient
60-69	D	Lacking
0-59	F	Very lacking
Adjective Ratings		
85.58 - 100	BEST IMAGINABLE	The best quality imaginable
72.76 - 85.57	EXCELENT	Very good quality
52.02 - 72.75	GOOD	Good quality
39.18 - 52.01	OK	Quite good quality
25.01 - 39.17	POOR	Poor quality
0 - 25.00	WORST IMAGINABLE	The worst quality imaginable

Reference: Bangor et al. [17]

III. RESULTS AND DISCUSSION

A. Communication

In the early stages of developing a news management application, a project initiation was carried out with related parties, namely institution X as the owner of the application. Communication was carried out to find several weaknesses in the old application, such as the lack of features needed by users. These things make the old application inefficient and do not meet the needs of managing news writing. Therefore, it is necessary to develop a news management application that aims to overcome these weaknesses and provide more complete features.

The previous news management application used by institution X consisted of four main roles, namely news writers, news reviewers, and news publishers along with the admin role. News writers are tasked with writing news and uploading it in the form of doc or docx files into the news management application. News

reviewers are tasked with reviewing news articles that have been uploaded by news writers before being published. Meanwhile, news publishers are tasked with selecting news articles to be published, where the news articles have previously been reviewed by news reviewers. The publisher role is given to the daily newspaper. Each role has features that they can run as listed in Table IV.

TABLE IV. ROLES AND FEATURES IN PREVIOUS APPLICATIONS

Features	Role			
	Writer	Reviewer	Publisher	Admin
Add news	✓			✓
Edit news	✓			✓
Reject news		✓	✓	✓
Upload review results		✓		✓
Cancel news review		✓		✓
Download news files and photos		✓	✓	✓
Add and edit published news links			✓	✓
News monitoring	✓	✓	✓	✓
Download monitoring results		✓		✓
Search for news	✓	✓	✓	✓
News details		✓	✓	✓
Login and logout	✓	✓	✓	✓
Edit account profile	✓	✓	✓	✓
Manage system				✓

In previous news management applications, writers uploaded news articles in doc or docx file format by filling in input such as title, photo (optional), news file, author's name, and work unit as supporting data. News articles entered the application with the status "Ready to Review". The reviewer selected the news to be reviewed and downloaded the news file because the content of the news could not be displayed by the application. After conducting the review, the reviewer uploaded the review result file. The reviewed news articles were saved with the status "Ready to Publish". The publisher selected the news articles that were ready to be published and published them on the daily newspaper page. After being published, the publisher entered the news link so that the news status became "Published".

There are several weaknesses found in the previous application. The weaknesses found are as follows:

- The news writing process does not occur in the news management application, causing the writing process to be inefficient and time-consuming.
- The news review process cannot be done in the application. The process is still carried out manually by reviewers outside the news management application.
- There is no feedback or comments given when a news article is rejected, so that news writers do not know what mistakes are made in their news articles.
- There is no notification and comment feature that can notify the status of the news article, so that writers do not know that their news articles have been rejected along with the reasons.
- The application does not display statistical data on news management that is appropriate for each role.
- News is still uploaded in file form so that the contents of the news article cannot be displayed in the news management application.

B. Planning

In the planning stage, planning and scheduling are carried out before the development stage begins. In this stage, information is collected and analyzed regarding the objectives, scope, and estimated time for application development. Application developers collaborate with institution X as the application owner to ensure that business requirements are met and time targets can be achieved.

The purpose of developing news management application is to improve the efficiency and quality of news writing management at institution X. In addition, the development objectives also include the development of new features needed by users, such as news writing features, notifications, and ease of application accessibility. The development objectives also include improving weaknesses in previous applications that have been previously identified. By achieving these objectives, it is hoped that the news management application can provide more optimal benefits for users and application owners.

The scope of development of the news management application includes:

- Redesigning the application workflow.
- Redesigning the appearance that needs improvement.
- Adding new features that make it easier for users to manage news articles, such as writing, commenting and notification features.
- Fixing some program codes that are considered less efficient.

The scope of development is intended to improve the performance and effectiveness of the news management application in managing news articles and providing a better user experience. Table IV is an estimate of the time needed to develop a news management application. After getting an estimate of the time needed to develop a news management application, a structured time management is needed to complete the development on time. Therefore, during the development process, tracking is carried out once a week to monitor progress and evaluate whether there are any delays or obstacles that can hinder development. With this tracking, the development of the news management application can be carried out according to the predetermined schedule and avoid delays in development.

TABLE V. ESTIMATED DEVELOPMENT TIME

Activity	Estimate (Day)
Design:	
Requirements analysis and UML	2
Create a new database design	1
Creating a new interface design	2
Total days	5
Coding:	
Database implementation and coding	14
Testing:	
Black box testing	1
System usability scale	1
Total days	2
Deployment	1
Total application development days	23

C. Modeling

At the modeling stage, the analysis is carried out by producing several functional and non-functional requirements for the development of news management applications. These requirements are the basis for the design stage. The following are the results of the analysis and design of the developing news management application.

- Requirements Analysis

Analysis of news management application development requirement is obtained from the results of observations and evaluations of previous applications. This analysis includes identification of functional and non-functional requirements in the application, as well as improvements needed to overcome weaknesses that have been found in previous applications. The results of this analysis are the basis for designing and developing a new version of the news management application. The functional requirements needed in the development of the news management application are listed in Table VI and the non-functional requirements needed are listed in Table VII.

TABLE VI. FUNCTIONAL REQUIREMENTS

Code	Functional Requirements
KF-01	The application can display complete statistics based on user roles and news writing and review activities on the dashboard
KF-02	The news writing process can be done in the application
KF-03	The application can edit the contents of news articles
KF-04	The application can provide notifications when there is a rejection of a news article
KF-05	The application has a feature to save drafts of news articles
KF-06	The application has a feature to cancel news articles that have been uploaded
KF-07	The news writing review process can be done within the application
KF-08	The application can display news content in detail
KF-09	The application can convert news articles into docx files
KF-10	The application has a comment/feedback feature

TABLE VII. NON-FUNCTIONAL REQUIREMENTS

Code	Non-Functional Requirements
KNF-01	The application has a good appearance and is easy to use
KNF-02	The application uses a responsive web design view
KNF-03	The application must be accessible to users at all times

- Database Design

Database design in the development of news management applications is focused on the mst_berita table only because the mst_berita table is a table used to store news data such as news titles, news authors, news status, and so on. The tables in the news management application database include mst_berita, satker, akses_menu, akses_submenu, akses_user_level, menu, submenu, user, and level. Changes were made to the mst_berita table by adding 3 new fields, namely the isi_berita field which is used to store news content in text form, the komen field is used to store comments given by reviewers and publishers, and the islihat field is used for notification purposes. The design results that occur in the mst_berita table can be seen in Table VIII. Then, Figure 2 shows the relationship between tables in the news management application database.

- Use Case Diagram

Use case diagrams are used to describe the interaction between users and news management applications. Use case diagrams will be divided based on the roles in the news management application and then compared based on the previous application to the application to be developed.

TABLE VIII. NEW MST_BERITA TABLE STRUCTURE

No	Field	Type	Information
1	id	Integer (6)	Unique id of news article
2	user_id	Integer (11)	Id of the user who wrote the news article
3	judul_berita	Varchar (100)	News title

No	Field	Type	Information
4	penulis	Varchar (50)	Author name
5	isi_berita*	Text	The content of the news is stored in HTML text
6	komen*	Text	Comments from publishers and reviewers
7	islihat*	Tinyint (1)	Stores a value if the notification has been seen by the user
8	satker_kd	Varchar (5)	Save the work units of the author
9	tgl_upload	Datetime	Date the article was uploaded by the author
10	status_kd	Integer (2)	Save the status of a news article in the form of numbers
11	tgl_publish	Datetime	Date when the news was published by the publisher
12	link_publish	Varchar (255)	Links to news that has been published
13	editor	Varchar (50)	Name of the reviewer who conducted the review
14	tgl_mulai_review	Datetime	Review start date
15	tgl_selesai_review	Datetime	Review completion date
16	file_draft	Varchar (50)	Save the name of the old news file which is still in file form
17	file_review	Varchar (50)	Save the name of the old news file which is still in file form
18	image_upload	Varchar (200)	Saves the name of the photo uploaded by the user

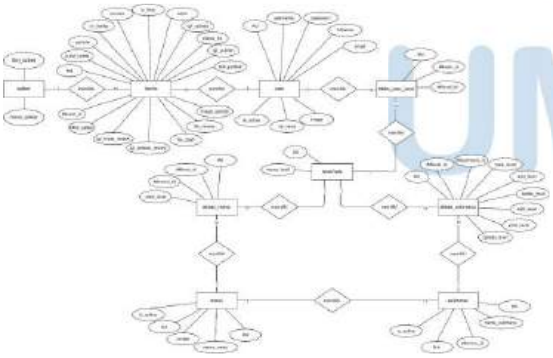

Fig. 2. Database relations

In the use case diagram of the previous news management application, it can be seen that the admin role still has access to all features. Because the news management application has a multirole feature, where one account can have more than one role. Thus, the admin role should not be able to carry out the process of adding news articles, reviewing news articles to publishing news articles. Therefore, the admin role can be focused on taking relevant actions.

After being developed, there are significant differences in the use case diagram between the news writer and admin roles. News writers can write news articles, access news article details, and add news drafts. While the admin is now more focused on the application management function. For the reviewer and publisher roles, their tasks in the previous news management application remain the same as those developed, but differences are seen in the activity diagram because changes occur in the workflow. Figure 3 and Figure 4 are use case diagrams for the news writer and admin roles in the previous news management application. Meanwhile, Figure 5 and Figure 6 are use case diagrams for the roles of news writers and admins in the latest version of the news management application.

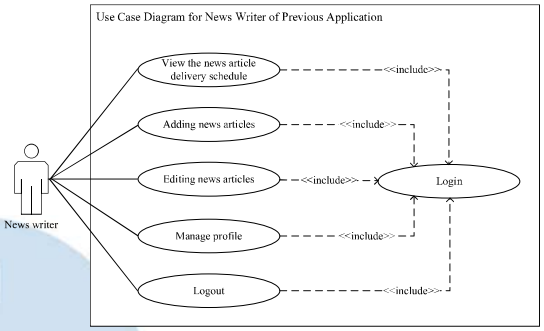

Fig. 3. Use case diagram for news writer of previous application

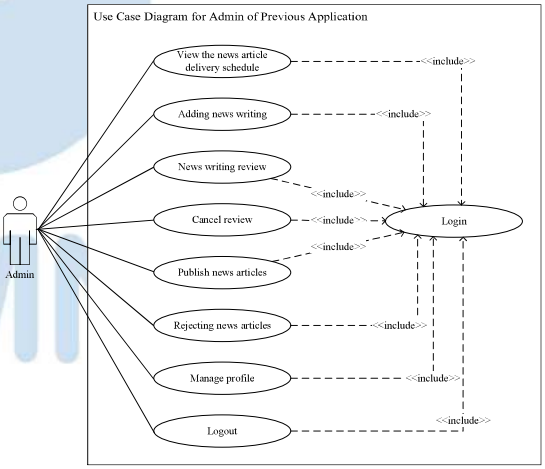

Fig. 4. Use case diagram for admin of previous application

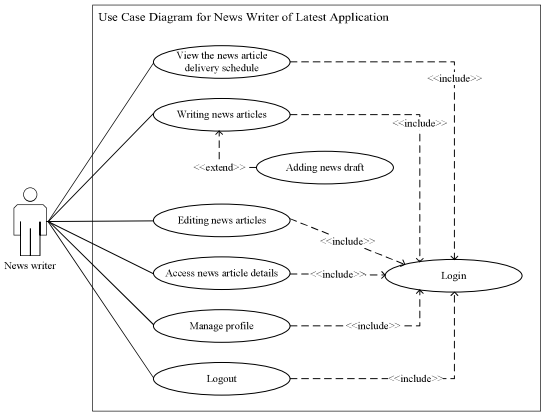

Fig. 5. Use case diagram for news writer of latest application

- Class Diagram

At the design stage, a class diagram is created to describe the class structure used in the application. The design of the class diagram will be focused on the developed part only, namely the masterBerita and masterDashboard sections. The class diagram is also the basis for the program code used in developing a news management application. This class diagram can be seen in Figure 7.

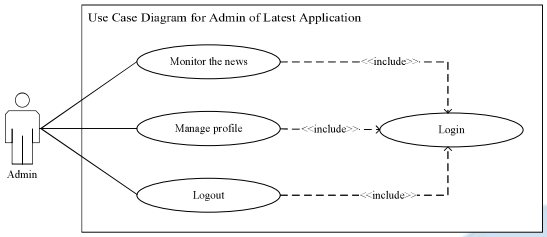

Fig. 6. Use case diagram for admin of latest application

Fig. 7. Class diagram

- Activity Diagram

In the application design stage, activity diagrams are used to describe the process flow that occurs in the application. Activity diagrams show all stages from data input to the final process carried out by the application. In the case of news management development, the activity diagram of the previous application is compared to the latest application. Activity diagrams that have changed in the previous process flow include the process of adding news articles, editing news articles, reviewing news articles, publishing news articles and the process of rejecting news articles. The results of the process changes are shown in Figures 8 to 12. There are new activities such as adding draft news articles as shown in Figures 13 and 14.

- User Interface

In the interface design stage, improvements were applied to parts that were considered less than optimal and needed development in the previous news management application. Pages that did not change during development such as the login page, profile page, author news list page and reviewer news list page.

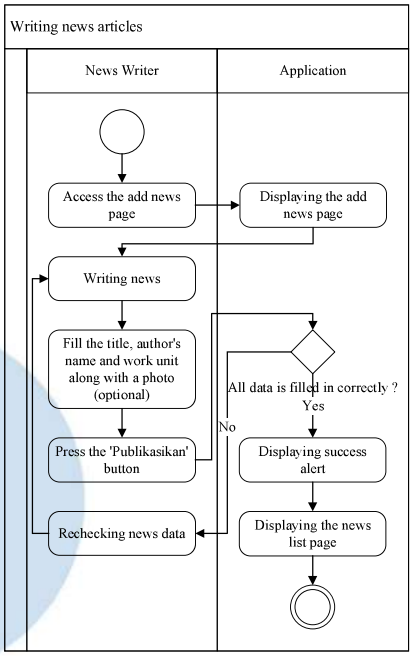

Fig. 8. Activity diagram for writing news of updated process flow

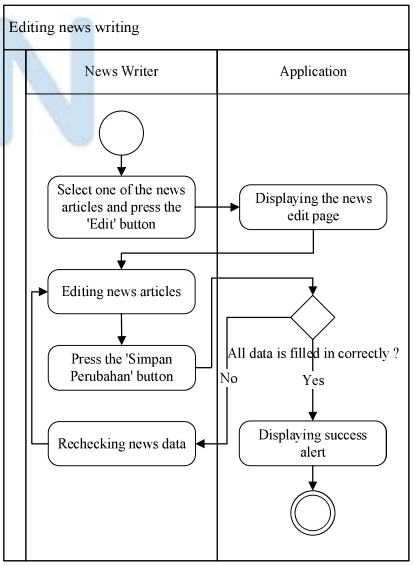

Fig. 9. Activity diagram for editing news of updated process flow

The design of the developed news management application interface focused on rearranging the appearance of pages that needed improvement and designing the appearance of several new features. Some

of the displays that experienced the most significant changes were the appearance of the dashboard page, the add news page, the final review page and the news detail page. Previously, the dashboard page for each role had the same appearance. Now the dashboard has a different appearance for each role. This is because the statistics displayed on each role are also different, especially the admin role which uses the dashboard page as a page to monitor news writing management activities. Therefore, the statistics that need to be displayed are much more than other roles.

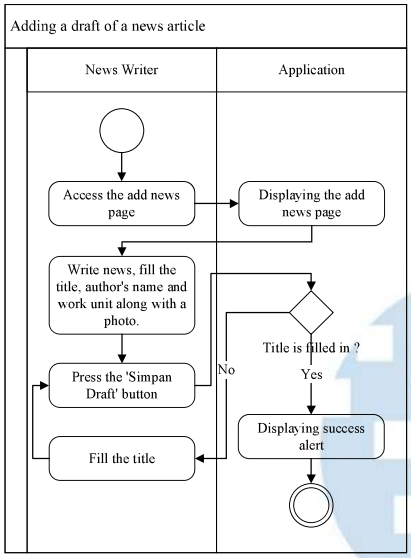

Fig. 10. Activity diagram for adding a draft of a news article of updated process flow

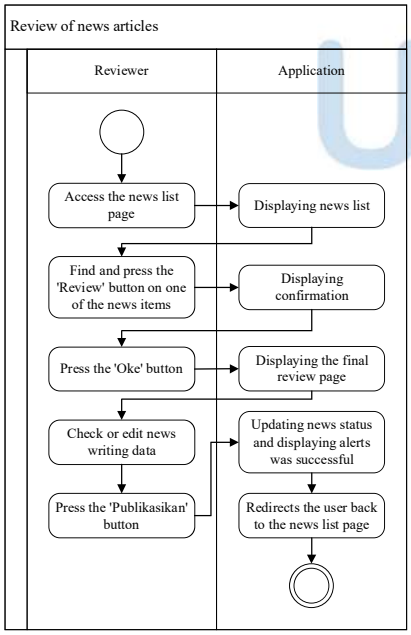

Fig. 11. Activity diagram for reviewing of news article of updated process flow

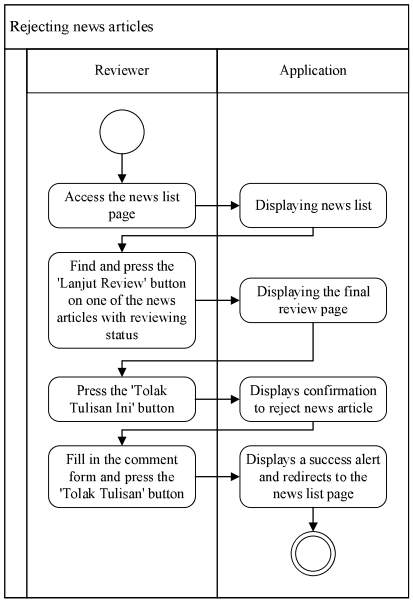

Fig. 12. Activity diagram for rejecting news article (reviewer) of updated process flow

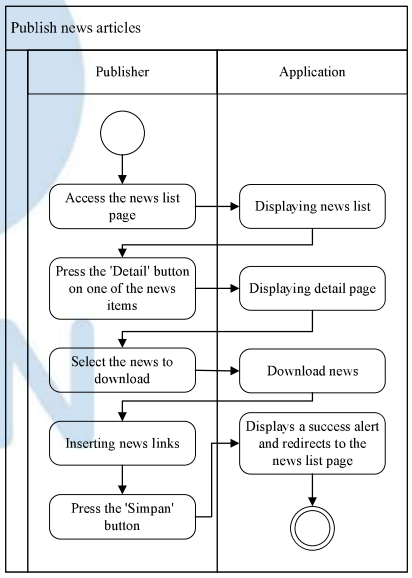

Fig. 13. Activity diagram for publishing news article of updated process flow

In addition to the dashboard page, another page that has changed its appearance is the add news page. According to needs, on the add news page after development, news writers must be able to carry out the news writing process. Therefore, there are changes on that page, where there is a text editor used to write news. Similar to the add news page, the final review page and the news content detail page must be displayed on the page. So it is necessary to redesign the interface. To present the basic scheme of the proposed application display, wireframing techniques are used as a visualization tool.

In this article, only two sample figures are shown from the results of the user interface design that will be applied in the development of this application. Figure 15 is an example of the initial display of the interface design results on the dashboard in the admin role. On the page there is statistical data displayed for the purpose of monitoring news management. Figure 16 is the initial display for the add news page in the news writer role. It has a difference with the previous application, now there is a text editor to write news.

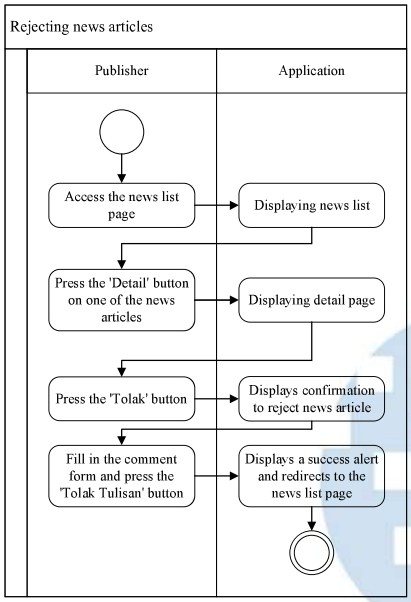

Fig. 14. Activity diagram for rejecting news article (publisher) of updated process flow

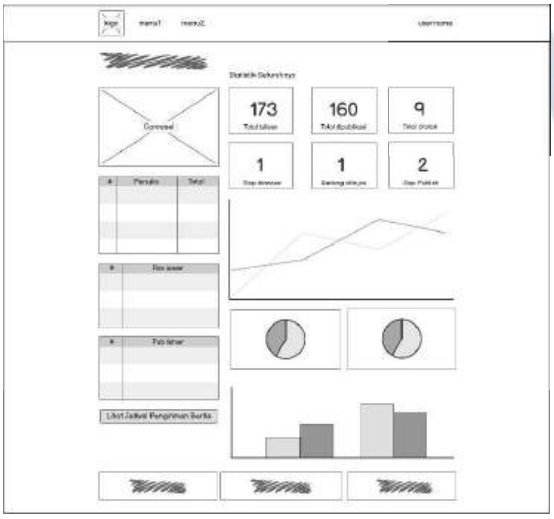

Fig. 15. News monitoring dashboard wireframe

D. Construction

At this stage, the implementation and testing of the news management application that has been carried out in the design stage is explained. Implementation consists of two stages, namely database implementation and program implementation. While testing is carried out using two methods, namely black box and system usability scale.

Fig. 16. Wireframe of page adding news

- Database Implementation

As an initial step in the implementation, modifications were made to the mst_berita table in the previously used news management database. Modifications were made by adding three new fields, namely isi_berita with the TEXT data type, komen with the TEXT data type, and isLihat with the Boolean data type. The addition of these three fields aims to improve the process flow in the application being developed, where previously doc or docx files were used to store news content. With this isi_berita field, news content can be stored in text form in the database so that it is easier to access and manage. The komentar field is needed to store comments from publishers and reviewers in cases where news is rejected so that the author can find out the reason for the rejection. In addition, the isLihat field is used for the notification feature in the application being developed. Meanwhile, the file_draft and file_review fields are not deleted with the aim that users can still access old news articles in the form of files.

- Program Implementation

The implementation of this program includes several parts, namely the development of the application interface display and the implementation of new features proposed at the news management application design stage. After implementing, which uses the codeigniter framework, the role changes and features that can be accessed based on the role can be seen. The application features and roles after development can be seen in Table IX.

- Testing

In the testing phase, the news management application underwent two different types of testing. First, black box testing was carried out to test the functionality of the application. This testing aims to validate whether the application operates according to the specified specifications. Furthermore, testing was carried out using the system usability scale (SUS) to evaluate the level of usability of the application. SUS testing was carried out twice, namely on the previous

application and the latest application, to compare the improvements that had been made.

TABLE IX. FEATURES AND ROLES IN THE UPDATED APPLICATION

Features	Role			
	Writer	Reviewer	Publisher	Admin
Login & logout	✓	✓	✓	✓
Dashboard	✓	✓	✓	✓
Add news	✓			
Edit news	✓	✓		
News draft	✓			
Cancel news	✓			
Notification	✓			
Review news		✓		
Reject news		✓	✓	
Comment on the news		✓	✓	
Fill the news link			✓	
Convert to docx	✓	✓	✓	
Profile	✓	✓	✓	✓
Search news	✓	✓	✓	
News details	✓	✓	✓	
Monitoring				✓
Manage the system				✓
Manage users				✓

For the black box testing process of the news management application that has been developed, the functions to be tested are determined based on functional and non-functional requirements (Tables VI and VII), test scenarios, and the expected results of the test scenarios. All test requirements are written in the black box testing form (Table II). Based on the black box testing that has been carried out, all test scenarios and functions in the news management application have run according to the expected results. All test scenarios have successfully validated the application's functionality, this indicates that the application is able to process data correctly and provide appropriate output.

After the black box testing is completed, it is continued with testing the usability scale of the previous and the latest news management application systems. The results of the comparison of the SUS scores of the news management application before and after development can be seen in Table X.

TABLE X. COMPARISON OF SUS SCORE CALCULATION RESULTS FOR NEWS MANAGEMENT APPLICATIONS

Average SUS Score of News Management Applications	
Old Version	Updated Version
71.3	78.8

Based on testing using SUS, a score of 71.3 was obtained on the previous application and a score of 78.8 on the latest application. From these results, it can be seen that there was an increase in the SUS score of 7.5 points after the development of the news management application. This increase illustrates the improvement and increase in the usability of the application after going through the development process that has been carried out.

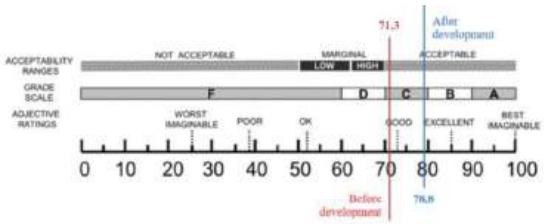

Fig. 17. SUS score comparison results

Based on measurements using a scale developed by Bangor et al. [17] (see Figure 17), in the user acceptance ranges, the previous and latest news management applications received the category "ACCEPTABLE" which means that the both of application version can be well received by users. However, there was a 7.5 point increase in acceptance ranges for the latest application compared to the previous one, indicating a significant improvement in user perception. On the grade scale, both applications have a predicate of "C" or sufficient which shows that the application is not too difficult for respondents to use. But, for the latest applications, it nearly achieved "B" scale or good rating.

There was an increase in the application rating (adjective ratings), where the previous application received a rating of "GOOD" which means that the application has good quality, while the application after development received a rating of "EXCELLENT" which means that the application has very good quality. Although both versions of the application received a predicate of "C" on the grade scale, the change from the rating "GOOD" to "EXCELLENT" in the adjective ratings on the application after development indicates an increase in the quality and performance of the application. This change indicates that development has had a positive impact on improving the user experience and providing a more positive feeling towards the application.

The SUS score for the latest application could potentially be increased, given that respondents only interacted with the application once, during the assessment process. The results could differ if respondents had used the application more than once, allowing us to determine whether the application is easy to understand and use, and whether it offers top-quality results. This allows us to determine what needs to be improved or developed in the future.

E. Deployment

The news management application that has been developed is then implemented on the server of

institution X. In addition, there is a data migration process from files to the database for news data as the application is used. In the news management application, there is a difference in the storage format of news articles between the previous application and the updated application. The previous news management application stores news in Microsoft Word document format (docx), while the updated application stores it in HTML text format. To maintain the existence of data, old document files are not deleted from the application. Therefore, it is necessary to migrate news content from doc or docx files to text so that it can be saved in the database. For the migration scenario, see Figure 18.

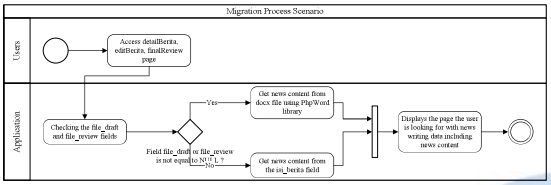

Fig. 18. Migration process scenario

The news content migration scenario occurs when users access news articles via the editBerita, detailBerita, and finalReview pages because on these pages news content in the form of text is needed to be displayed to users. The controller will check the file_review and file_draft fields in the database. If there is content between the two fields, the application will display the news content from the doc or docx files. Conversely, if both fields are empty (null), the application will display the news content stored in the isi_berita field in the database. The process of converting doc and docx files into HTML text using the help of the PhpWord library, then taking paragraphs from the file and saving them into variables containing HTML code which are finally displayed on the editBerita, detailBerita and finalReview pages.

The news management application has been successfully deployed to the X institution server. The data migration process has also been carried out successfully, allowing news data previously stored in files to be accessed and stored in the database. In addition, receiving feedback from application users is an important part of identifying the need for improvements that need to be made to the application. The results of this process provide direction and guidance for further improvement steps to improve the quality and user experience of the news management application.

IV. CONCLUSION

The development of a news management application for institution X using the waterfall model has been successfully carried out. Through a structured development process, the news management application was successfully updated for new features that improve interactivity and performance. All functional requirements of the application have been successfully implemented and run well. Black box testing and system usability scale (SUS) were carried out to test the functionality and usability of the application. The results of functional testing showed that all test scenarios and functions in the updated application ran as expected. In addition, the level of usability of the application showed that the news management application after being developed experienced an average score increase of 7.5 points from the previous score of 71.3 to 78.8. This means that there was an increase in the usability of the application. After development, the news management application got good results from three assessment approaches in usability. On the scale of acceptance, the application was well received by users, showing a significant increase. The assessment scale showed that the news management application after development was considered sufficient and received a very good rating. This shows that application development has a positive impact on the acceptance, feasibility, and quality of the application. Overall, structured work and a clear flow from initiation to end can minimize errors because it has clear details and final descriptions. This is in accordance with the characteristics of the waterfall model in the software development cycle.

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Constructivism Analysis on the Influence of Practical Implementation on Computer Networks Course in Informatics Class

Ahmad Fauzan [1], Puteri Novariqa[2], Fransiscus Halim[3]
[1,2]Dept of Informatics, Universitas Multimedia Nusantara, Tangerang, Indonesia
[3]Dept of Information Systems, Universitas Multimedia Nusantara, Tangerang, Indonesia
[1]ahmad.dhavi@student.umn.ac.id, [2]puteri.novariqa@student.umn.ac.id, [3]fransiscus.ati@lecturer.umn.ac.id

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***Abstract*— Learning by practicum has been well accepted as a critical approach in technical and vocational teaching; however, there is a lack of empirical research that examines both practicum-based teaching methods and non-practicum teaching methods objectively based on performance, particularly in higher educational institutions in developing nations. The impact of integrating a practicum for enhancing the results of students in a computer networking course at an under-graduate Information program will be explored in this research paper. The research adopted a quantitative comparison model for data obtained from two student cohorts, with one cohort exposed to a teaching approach that included a practical-based model, while for other students a theory-based model was adopted. Statistical description, morphometric, chi-square, U-test, T-test techniques, as well as linear regression, were used for inferential analyzing techniques. Conclusions from this research work show that there is a greatly positive impact for students in practical-based classes, where students obtained a better grade distribution compared to students from non-practicum classes. Despite some issues pertaining to methodology, particularly for cohorts and teaching applied, there is a clear practical approach towards applying a practical-based program for computer networking classes.**

***Index Terms*— Computer Networking Education; Practicum-Based Learning; Hands-on Laboratories; Learning Outcomes; Informatics**

I. INTRODUCTION

In today's digital era, information and communication technology plays an important role in various aspects of life. Progress in this field is very rapid and requires human resources that have high competence in the field of information technology, especially in Computer Networking. The Informatics study program is directed to produce graduates who do not only have a strong theoretical understanding but also practical skills that can meet industry needs.[1]

Rapid development of information and communication technology dictates that Informatics graduates have to be endowed with both robust theoretical knowledge and hands-on networking competencies to satisfy the needs of this industry. International studies recently conducted (2021-2024) demonstrate that hands-on laboratory approaches raise learning outcomes by 10-25%, compared to traditional lecturing, which is most pronounced in the aspects of protocol configuration and network troubleshooting. The effectiveness of practicum in blended learning settings, however-especially comparing online with onsite delivery-was not well explored yet after the pandemic. This paper compares academic performance between practicum and non-practicum classes, which has been used to validate H1, practicum superiority, against H0, no difference.[1]

The drawback of traditional lecture courses in terms of their capacity for skill development in applied subjects has long been identified. In response to concerns about the applicability and effectiveness of traditional lecturing, the emphasis on practical work in the form of "practicum" or practical activities in the science or laboratory practical context is being encouraged as best practice. Even if existing literature provides proofs that practicum activities positively engage and enhance student understanding, objective comparisons related to the effect on academic results remain uninvestigated.

Its uniqueness lies in comparing the practicum classes using blended learning in 2019-2020 with practicum classes using onsite learning in 2023-2024, where the influence of practicum classes to the understanding of theory in a post-pandemic situation has never literally been explored in existing recent literature in its entirety before, where previous similar research only emphasized simulation lab classes in the context of linear regression to quantify the influence of practicum classes attendance, where there is no empirical research existing in the context of Indonesian Networking Informatics on practicum classes in a global context benchmarks.[2]

A. Bridging the Theory-Practice Gap in Informatics Education

The courses of study in informatics have been designed with the goal of creating informed students

with excellent theoretical foundations and practical skills that meet industry requirements directly. Nevertheless, it has always been a challenge in technical education, including a technical and complex field such as Computer Networking, to effectively overcome the existing gap between theoretical foundations and practical application.[3] Even the practical efficiency of conventional learning theories in bridging the critical junction between theory and practical application has been left a matter of further research.

Unquestionably, the assumption of the efficiency of practical learning in improving comprehension has become an accepted truth in conventional theories and practices of education. Nevertheless, its further ability to optimize learning efficiency in Computer Networking courses, including compared efficiency with conventional learning approaches, has not been well established. Therefore, an empirical study such as the proposed research becomes absolutely necessary to cross the boundary of mere conventional wisdom into the approximate realm of informed truths.

Through understanding how well the practicum is incorporated in understanding and developing skills, there is hope that better approaches can be discovered for preparing learners for what is encountered in the world of work. [4]

B. *Research Objectives and Central Question*

The overall purpose of the study being conducted is to systematically assess the impact of the Practicum on increasing the outcome levels for Computer Networking subjects offered at the Informatics Study Program. Additionally, the study attempts to show that there indeed are levels and impacts of difference for the outcome levels for students enrolled at the Informatics Study Program who participate in Practicum classes compared to those that do not participate in Practicum classes. This impact of difference between the two groups will be systematically assessed through two hypotheses: that of the null hypothesis (H_0) and that of the alternative hypothesis (H_1), wherein the null hypothesis suggests that there indeed is no impact difference for the outcome levels between the two groups, and that the alternative hypothesis suggests that there indeed are differences.

The results that emerge from the evaluation of this study are expected to provide substantial additions within the realm of educational pedagogy. In establishing a full comprehension of the contribution of the practicum exercise towards the students' comprehension and skills, this study is expected to open the way for the detection and application of better teaching practices. This is not only vital for the students' needs, but it is also important for their preparation towards the diversified challenges of the real world upon graduation. The applications of this study not only relate within the boundaries of the educational institution but have practical applications as well, since it serves as substantial evidence towards the application of appropriate measures regarding the pedagogical approach, application of investments within the construction of laboratory infrastructure, and faculty development programs.

II. THEORETICAL FOUNDATIONS AND THE ROLE OF PRACTICUM

A. *Defining Practicum and Its Application in Computer Networking*

A computer network, also known as a data network, is a telecom network that facilitates data exchange among various computer systems. Networked computer systems transfer data from one computer to another via data connections in computer networks. The connections, also known as network links, from nodes are created either using a cable medium or a wireless medium [5]. These computer networks led to the ARPANET, forerunner to the Internet. On 3 June 1968, the proposal for a project was delivered by ARPA; this project was accepted a few weeks later. "Resource Sharing Computer Networks," as a project, allowed a resource-sharing exchange for data, examining various topics, both for military as well as scientific reasons.[6]

"Practical learning" or "practicum" refers to an "educational methodology that serves specifically the purpose of giving learners hands-on learning experiences." Practicum experiences are expected to positively affect self-efficacy in preservice physical education teachers with regards to teaching strategies, classroom management, and student engagement[7]. Gaining experiences and skills has always become an important factor in teacher education. Being an integral part of teacher education, it takes place in an actual "environment where scholarly and didactic knowledge and practical skills manifest themselves in teaching." "The basic goal of learning in a university setting via 'practicum' is to develop skills and gain an 'in-depth knowledge' of the subject under study." [8]Practicum in the more technical field of Computer Networking involves working directly with hardware and software components with the goal of creating, managing, and maintaining computer networks. Examples of which include actual "access to the destination hosts via remote accessing, analyzing messages carefully using packets, and setting up TCP/IP in Linux or Windows operating systems." These activities truly play an important part in giving students hands-on learning experiences where actual manipulation of computer systems happens, "allowing students to see firsthand the effects of their actions and thereby consolidating their theoretical foundations".

B. *Constructivist Teaching Key Principles*

Constructivist teaching is based on constructivist learning theory, Constructivist is based on the belief that learning occurs as learners are actively involved in

a process of meaning and knowledge construction as opposed to passively receiving information. Learners are the makers of learning and knowledge. Constructivist teaching fosters critical thinking, creates motivated and independent learners. This theoretical framework holds that learning always builds upon knowledge that a student already knows; this prior knowledge is called a schema, because all learning is filtered through preexisting schemata. Constructivists suggest that learning is more effective when a student is actively engaged in the learning process rather than attempting to receive knowledge passively.[9]

While there are different interpretations of constructivist learning theory, Hord's article cites six key principles identified by Mary Burns, Marylu Menchaca, and Vicki Dimock as being important to constructivist learning theory. They are as follows:[10] 1) Learners bring unique prior knowledge, experience, and beliefs to a learning situation. 2)Knowledge is constructed uniquely and individually in multiple ways, through a variety of authentic tools, resources, experiences, and contexts. 3) Learning is both an active and reflective process. 4) Learning is a developmental process of accommodation, assimilation, or rejection to construct new conceptual structures, meaningful representations, or new mental models. 5) Social interaction introduces multiple perspectives through reflection, collaboration, negotiation, and shared meaning. 6) Learning is internally controlled and mediated by the learner.

The effectiveness of practicum is deeply rooted in established learning theories, each offering a unique perspective on how students acquire and process information. For example, behavioristic learning theory focuses on observable changes in behavior as a result of the interaction between motivation and response. In Computer Networking education, this can be put to practice by offering immediate feedback and rewards for successfully learned concepts, thus reinforcing learned behaviors.[7] On the other hand, cognitive learning theory has concentrated on the inner mental processes that take place during learning, such as information processing, storage, and recall. This theory argues that using diagrams, concept maps, and other visualization techniques during the creation of teaching materials can assist students greatly in organizing and retaining complex information concerning Computer Networking. [11]

The theory underlining the constructivist approach to teaching is the constructivist learning theory. Constructivism theory hinges on the premise that learning happens through a learner being actively engaged in constructing meaning during a knowledge-building experience, rather than merely being a receiver of knowledge. The learner is the learner's own knower. [9] The theory proposes that in the practicum experience, the learner does construct knowledge from direct experience, such as TCP/IP setup and analysis, which is immediately related to the activities in a Class B computer science program topography deals with visual processing for networks. Behaviorism justifies immediate feedback from software such as Packet Tracer to assure learning behaviors, while the cognitive theory emphasizes visual processing for topography in networks.[12], [13]

Practicum sessions provide just this type of immersive environment, where students can apply theoretical concepts in Computer Networking through practical projects or hands-on simulations. This direct involvement with the work allows them to solve real-life problems, which naturally fosters a deeper understanding and mastery. [8] As a research study, this empirical validation lends credence to constructivist pedagogy. Constructivism lays great emphasis on active learning and application; hence a very sound theoretical rationale is developed for expecting the effectiveness of practicum. If this research indicates that practicum significantly enhances learning outcomes, then it confirms not only a generally held belief but also gives empirical evidence that shores up such a claim for the adoption of constructivist approaches in technical education-that the learning improves from mere theoretical assertions to best practices. This is essential from an academic standpoint to further the cause of pedagogical design for skills-intensive courses.[12], [13]

Practicum represents one of the dynamic learning activities that help students develop an objective feel and application of theories learned in the classroom through experiments and exposure to real-life activities. This serves to develop important skills: observation, classification, planning an experiment, collection of data, interpretation, and summarizing findings. It is to be noted that these skills are not academic in nature but play an integral part in a person's technical career.

The success of the practicum, however, does not rest on the direct experience obtained from the practical tasks alone. There are a number of external factors that play a very important role in having a positive impact on the success of the practicum. The experience and knowledge of the instructors who supervise the students during the practicum exercise can have a very important role in ensuring that the students have obtained the required support and guidance from the experience. In addition to that, the manner in which the learning strategy is implemented to the students can have a very important effect in enhancing the understanding of the students on the specific topic of the practicum.

C. Research Methodology

The proposed project utilized a quantitative paradigm with a comparative design in analyzing the secondary data. The data sets included the scores of the Midterm Exam (UTS), Final Semester Exam (UAS), and Assignments among the students studying at Multimedia Nusantara University (UMN). The objective was to compare the results among two different classes with varying approaches in their

learning process based on their scores. Use of midterm (UTS) and final assignment scores in two classes: Class B (blended practicum, online 2019-2020, n=20) and Class H (theory only non-practicum, onsite 2023-2024, n=51). "Grade_numeric" variable derived from participation/effort that uses linear regression of average assignment grades, 0 to 100 scale Similar bias due to different years and different modes could affect results, a limitation due to external forces such adaptation to online instruction due to pandemics

The participants included two groups of students who were enrolled in the Computer Networking course at UMN:

• Class H: Students in this group belonged to the 2023/2024 academic year and received a traditional theory-based class without integrated practicum sessions. Their learning was conducted in an onsite class system.

• Class B: In this group were students from the 2019/2020 academic year who received instruction via a blended learning methodology, in which theoretical classes were combined with regular sessions of practicum in laboratories. The learning in this class took place in the online class system.

This comparative setup allowed for the investigation of the differences in academic performance between students exposed to a practicum-integrated curriculum and those not exposed to practicum in the Computer Network Subject.

III. Data Collection and Analysis Procedures

A. Data Collection

The type of data that has been employed in this particular study is purely secondary data in the forms of UTS, UAS, and Assignment results for students in the two classes previously mentioned in this study held in UMN. These data had been previously recorded in this academic info system held in the university, implying that data collection was not carried out in this particular study since these results portrayed students' performance based on their particular modes adopted in learning.

For the purpose of evaluating the collected data to determine significance in the results obtained, various statistical methods were used. These include:

• Statistical Description: For summarizing the measures of central tendency and dispersion of scores on each class.

• Normality Test (Shapiro-Wilk): This test was employed in checking if the data distributions were normally distributed.

• Mann-Whitney U Test: A non-parametric test to determine the differences in the two independent groups. This test can be used when the data isn't normally distributed.

• t-tests: Two-sample t-tests were performed on the two classes to compare the means, as well as the individual t-tests on each class to compare their mean scores to a standard score of 75.

• Breusch-Pagan Test: This test is used to test heteroscedasticity, which reveals the constancy of variance of residuals in a regression model for all levels of independent variables [13].

• Chi-Square Test: The purpose was to check if there was a significance in the distribution of Grades observed in both classes.

• Linear Regression: To examine the individual impact of practicum experience (indicated by 'Grade numeric') on outcomes in these classes.

B. Research Limitations

Although this study yields useful information, some intrinsic limitations need to be acknowledged in regard to its generalizability and attributability to specific, ultimate causes. For this study, which was dependent on secondary data, the investigators had nothing to do with other variables, some of which may be decisive in affecting learning outcomes. Some of these variables, which cannot be controlled, pertain to the motivational level of students, their socioeconomic backgrounds, as well as their aptitude prior to the course. Failure to consider such factors may sometimes distort the intrinsic effect of practicum on learning outcomes.

Secondly, the results obtained from the study are limited to the scenario presented in the two classes at UMN. Therefore, the level of generalizability within the results obtained can at best be applied in similar settings. The distinct variables that exist within the environment may not be similar or representative in other scenarios.

Thirdly, other possible contributing factors, such as the standard of the educational material used or the particular impact and teaching manner of the tutors, are not examined because the secondary data selected is limited. These might have been contributing towards the differences found in the results.

Most Importantly, a major methodological issue emerges considering the data generated in both groups are from different academic years, and they involved different class systems too, since Class B (the practicum groups) involved classes from the 2019-2020 academic year and involved online classes, compared to Class H (the non-practicum groups) that involved classes from the 2023-2024 academic year and the onsite classes. The differences in the academic year and the nature of the classes (online or onsite) present major variables whose impact on the performance might independently exist and thus cannot be easily accredited to the absence or presence

of practicum. The study clearly shows a direct relationship between practicum and higher scores but cannot prove that the practicum caused the variation. This particular limitation brings out a critical point: this initial study is a vital exploratory phase that provides a preliminary indication of the impact of practicum. However, at the same time, it also underlines the urgent need for future studies that are more rigorously controlled in their experimental design. Only these, perhaps conducted within the same academic year, with consistent modalities, or using advanced statistical controls for those variables, could be considered necessary to isolate the true, causal effect of practicum. This foundational research thus justifies the expenditure of resources in more definitional and resource-intensive studies.

IV. Results and Discussion

A. Key Findings on Practicum's Impact on Learning Outcomes

This section presents the empirical findings derived from the comparative analysis of student learning outcomes between the practicum class (Class B) and the non-practicum class (Class H) in the Computer Networking course

TABLE I. TABLE 1: COMPARATIVE DESCRIPTIVE STATISTICS OF LEARNING OUTCOMES

Statistic Practicum	***Class B (Practicum Group)***	***Class H (Non-Practicum Group)***
Mean	86.29	74.33
Median	87	77
Mode	84	76.77

Descriptive statistical analysis also showed that there was a distinction in the academic performances between the two classes. Class B, the practicum-integrated class, had consistently better results. Its mean was 86.29, median was 87, and mode was 84. Most grades in Class B fell within 84 to 91, with the highest frequency of 6 students at 84.1 On the other hand, Class H, the non-practicum class, had generally lower scores, with a mean score of 74.33, a median of 77, and modes of 76 and 77. The scores of most students in Class H were between 72 and 92, although with higher frequencies of 1 student at 76 and 77.1. From these preliminary descriptive statistics, it may be inferred that students who belong to practicum classes tend to get higher grades compared to those who are in classes without practicum.

B. Statistical Evidence of Significant Differences

To ascertain the statistical significance of these observed differences, several inferential tests were conducted. See Table II.

TABLE II. SUMMARY OF KEY STATISTICAL TEST RESULTS

Test Name	***Class B (Practicum Group)***	***Class H (Non-Practicum Group)***	***Interpretation***
Shapiro-Wilk Normality Test	0.7437	0.0003654	Class B: Normally distributed; Class H: Not normally distributed
Mann-Whitney U Test	1.107e-06 (Overall)	-	Significant difference in learning outcomes (Class B > Class H)
Two-Sample t-test	1.451e-06 (Overall)	-	Significant difference in mean scores (Class B > Class H)
One-Sample t-test (vs. 75)	1.518e-13	0.7579	Class B: Significantly higher than 75; Class H: Not significantly different from 75
Chi-Square Test	0.001125 (Overall)	-	Significant difference in grade distribution (Class B: more concentrated higher grades)
Breusch-Pagan Test	0.04281	0.2581	Class B: Heteroscedasticity present; Class H: No heteroscedasticity

The Shapiro-Wilk normality test was employed to determine the distribution of data in every group. [13]. The findings revealed that data from the practicum class (class B) followed a normal distribution, having a p-value of 0.7437 (which is greater than 0.05).1 On the contrary, data from the non-practicum class (class H) failed to satisfy the condition for normal distribution, having a p-value of 0.0003654 (which is less than 0.05).

The Mann-Whitney U test, a non-parametric test used when the data is non-normally distributed, was used to compare the two classes. [14]. The test produced a p-value of 1.107e-06, which is smaller than the significance level of 0.05. This clearly shows there are statistically significant differences between the scores obtained by Class H and Class B in the area of learning outcomes, since Class B obtained higher scores.

To further validate these results, a two-sample t-test was also conducted to compare the mean scores of the two classes, and the results showed that there was a significant difference in the average scores of the two classes.[14] The calculated t-value was 5.2748 for 69 degrees of freedom, with a p-value of 1.451e-06. The fact that the calculated p-value of 1.451e-06 was well below the significance level of 0.05 indicates that the mean score of the students who participated in the practicum (86.29) was significantly higher compared to

the mean score of the students who did not participate (74.33), hence accepting the hypothesis that there was a significant increase in the knowledge gain of the students who participated in the practicum activity.

A t-test was done to measure the performance against this standardized mark with a reference mark of 75. For Class B, the t-test yielded a t-statistic of 11.29 with a p-value of 1.518e-13. This low value accentuates the fact that the mean marks obtained by Class B (86.29) were substantially greater than the standard mark of 75.1 On the other hand, for Class H, the t-statistic was -0.31091 with a p-value of 0.7579.1 Since this value is greater than 0.05, this marks the fact that the mean marks of Class H (74.33) were not significantly different from the standard mark of 75.1 These results substantiate the fact that students of the practicum group not only performed well but also maximized their deficiencies to a greater extent than the other group who almost performed around the expected mark.

A chi-squared test was employed to check for the significance in frequency distribution. [14] Of Grades, in comparison between Class B and Class H. The results obtained a value for X-squared of 24.03, with a p-value of 0.001125, which is lower than 0.05.1. It is, therefore, a clear indication that there is a significance in grade distribution for both classes. The distribution of Grades in Class B represented a more frequent occurrence in the latter grade scales, indicating that there is a contribution towards a balanced and highly positive outcome for the group of students by practice.

The Breusch-Pagan test was employed to test for heteroscedasticity; this is a situation where the variance of residuals is not constant. A straightforward test for heteroscedastic errors in a linear regression model is proposed within the context of the Lagrangian multiplier test. In various forms of heteroscedasticity and random coefficients models, the test is expressed as an easily calculable function of the OLS residuals. Some finite sample results are offered to reinforce the general asymptotic properties of the Lagrangian multiplier tests [15], [16] . In Class B (practicum), the value of the p-test was 0.04281; this is less than 0.05 significance level; hence, there was heteroscedasticity[17]. This means that the distribution of grades among the practicum class was not evenly distributed among students, possibly due to differences in their individual involvement in the practicum. This inference means that though practicum increases performance, its overall effect could be more significantly varied among individual students. This could mean that some students gain a tremendous amount from the practicum experience, hence achieving outstanding grades, but some students may just fail to capitalize on the experience to the fullest, hence experiencing a wider distribution of grades. Additionally, Class H (non-practicum) had a p-value of 0.2581 (which is higher than 0.05), hence no presence of homoscedasticity. This means that the distribution of grades among the non-practicum class has more stability. This subtle but important inference means that merely implementing the practicum experience among the students may just be insufficient since their involvement in the practicum experience could be the key towards ensuring the practicum experience benefits the whole student mass.

TABLE III. LINEAR REGRESSION USING MANN-WHITNEY

Statistic	**Class B (Practicum)**	**Class H (Non-Practicum)**	**p-value (Mann-Whitney/t-test)**
Mean	86.29	74.33	1.107e-06 / 1.451e-06
Median	87	77	-
R^2 Regression	0.7515	0.9817	-

Results show the practicum class significantly outperformed (mean 86.29 vs. 74.33), confirmed by Mann-Whitney U (p=1.107e-06) and t-test (p=1.451e-06). Heteroscedasticity in Class B (Breusch-Pagan p=0.04281) indicates individual engagement variability in practicum. Regression shows higher coefficients in practicum (6.47 vs. 5.75)

C. Influence of Practicum Participation on Learning Outcomes (Linear Regression)

Linear regression analysis was performed to further analyze the quantitative impact of practicum participation (indicated by the 'Grade_numeric') on the learning outcomes in both classes [17]. In general, the results obtained indicated a positive impact on the grades influenced by the practicum in both settings, as shown in Table III

TABLE IV. LINEAR REGRESSION ANALYSIS RESULTS

Class	***Constant (Intercept)***	***Grade_numeric Coefficient***	***p-value***	***R-squared***
Class B (Practicum)	31.8333	6.4667	1.97e-12	0.7515
Class H (Non-Practicum)	36.6990	5.7497	< 2e-16	0.9817

In the case of the Class with Practicum (Class B), the result of the regression analysis included an intercept of 31.8333, a 'Grade_numeric' of 6.4667 with an extremely small p-value of 1.97e-12. This indicates

the significance of the 'Grade_numeric' factor since the increase in grades of 6.4667 units for every unit of participation or performance in the practicum activity was predictable when the p-value was 1.97e-12. The R-square for the study was 0.7515, which indicates the ability of the study to explain 75.15% of the variability of the grades among students of the class B.

For the class without Practicum (Class H), the results for regression analysis yielded an intercept of 36.6990 and a grade corresponding to the 'Grade_numeric' as 5.7497 with a strongly significant p-value of less than 2e-16. This indicates that for the class without Practicum, with each increment in the variable 'Grade_numeric' (presumably reflecting overall class performance or engagement), there was an accompanying increment in the grade by 5.7497 points. It is pertinent to note that the R-squared value for class H was 0.9817, which indicates that this particular regression model was able to explain an incredible 98.17% of the data fluctuations pertaining to the grades of students in the class without Practicum.

Comparing both models, although the effect of participating in the practicum was more significant in Class B, having a greater coefficient, the R-Squared value was surprisingly much higher in Class H. This data offers an intriguing finding: theoretically, it appears that the distribution and variation among student grades can be more easily predicted based on the 'Grade_numeric' variable. Conversely, although the presence of a practicum setting translates to better overall results, it also brings with it a greater level of randomness that could not be adequately represented by one singular factor. This indicates that other variables, potentially the individual efforts of students participating in hands-on exercises, their previous exposure, or even the quality of a 'lab science' education, could have a disproportionately more significant, more irregular effect within the practicum setting. This result not only iterates the importance of pursuing a more thorough theoretical comprehension of the manner in which learning in real-world settings brings with it a more robust, but potentially more complicated, web of variables that interact with learning theory, it again emphasizes that effectively teaching students involves more than jump-starting their scores—it involves an appreciation of the complicated interplay of variables within such settings.

This research was necessary, as its findings provide strong empirical evidence with direct implications for informing and necessitating changes in educational practice and policy, in particular within technical disciplines such as Computer Networking. Clearly, this study shows that integrating practical activities, or practicum sessions, into theoretical subjects is not desirable but very important for proper learning. That means this could be one of the clear mandates to education institutions: schools should clearly focus on and provide room systematically in their Computer Networking courses to include practicum components.

The results obtained in the improved performance of the students offer a persuasive justification for assimilating the practicum approach into the program offered to these students. The group represented in the practicum recorded a distinctively high mean performance, a marked consistency in the scores recorded, and a measurably lower variance compared to other students not in the practicum program. It should be noted that these factors can be traced to a direct positive impact in the overall performance recorded in academics, not to mention a measurable positive impact in the retention of knowledge and skills acquired. The role of practicum in developing not only a high-level understanding but also a practical working ability to apply these concepts is highly important in accounting for the demands in the rapidly changing landscape offered in the information technology industry.

Moreover, the above research work is capable of providing the required impetus and justification for the design and implementation of even better lecturing methodologies in that it seeks to go beyond the theory and implement practical as well. Moreover, the mentioned pedagogical design change will have critical resource implications. In fact, the results and outcomes from the above research work would go on to provide the critical justification and impetus for the investment in educational resources. The institutions would need to invest more resources, such as improving their laboratories and providing the required resources and staffing in that they would require employing more resources and staff for the effective execution and delivery of practical in class.

Aside from its utility in the immediate future, this research had been a moving force in the theoretical acquisition in learning processes. Specifically, this had a great impact in technical subjects where the learning processes are more complex. On a more general perspective, the findings had a strong inclination towards the validation of the Constructivism theory on learning. Practicum learning had been demonstrated in this experiment to improve the mastery and comprehension of the subject matter by actively taking part in the constitution of their knowledge.

In addition, this study points out how the practicum uniquely engages with learning in a manner that supplements, as well as extends in some respects, beyond the fundamental premises of traditional behavioristic or cognitive learning constructs. Where the cognitive or behavioristic approach is largely concerned with behavioral modification through motivational as well as response mechanisms, the practicum approach is directly concerned with the crucial elements of application as well as practical problem-solving. This can, in itself, lie beyond the realms of theoretical constructs. This study aptly supports how, in subjects as complex as Computer Networking, practical application is a key integral part, in itself, of comprehensive learning, thereby establishing how practical experience impacts upon theoretical constructs.

The positive effect of the practicum observed in this study implicitly supports the theoretical understanding that it also depends on experience and subject matter

knowledge of the instructor and methods of learning that are effective for such subject matter in question. Although these two aspects are related in this study but could not been quantified for this particular study due to limitations, it indicates that it had some effect on the successful outcome of this practicum group.

From the linear regression test, specifically looking at the fact that a higher R-square is found in the non-practicum group with a corresponding low overall grade, there is a theoretical implication in understanding how predictable learning outcomes can be in a theoretical setting versus a practicum setting. Essentially, what this indicates is that practicum makes a substantive positive impact on outcomes, but what is seen in grades in a theoretical setting is potentially more predictable, perhaps because of fewer factors affecting this outcome as opposed to a practicum setting. This result suggests that there needs to be further theoretical investigation with regard to the nature of learning and the type of pedagogical method that will work best, and that for technical areas such as that studied, an integrated pedagogical method will outperform all other pedagogical models. This study is critical because it allows for the empirical validation and development of existing models of learning to include technical skills acquisition within its framework, which will advance educational theory as such.

V. CONCLUSION

By doing so, this current study brings empirical evidence to the fact that practicum-based instruction significantly enhances learning outcomes in undergraduate Computer Networking courses. Students from practicum activities achieved higher academic performances with more favorable grade distributions than their peers in non-practicum classes.

To enhance the effectiveness of the curriculum further, recommendations are made to include practicum modules systematically related to lecture topics; invest in laboratory infrastructure and instructor training; incorporate formative assessment into practicum sessions, and explore other blended models of a hybrid laboratory combining physical and virtual environments.

Future studies should try to surmount some of the current methodological limitations by using consistent instructional modalities, including qualitative measures that capture student engagement and learning experiences.

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A Web-Based Network Device Inventory and Dynamic QR Code Tracking System: Design, Development, and Evaluation PT. XYZ

Desi Fitriana[1], Viving Frendiana[2], Budi Utami[3]
[1,2,3] Program Study of Broadband Multimedia, Department of Electrical Engineering, Jakarta State Politechnic, Depok, Indonesia
[1]desi.fitriana.te21@mhsw.pnj.ac.id, [2]viving.frendiana@elektro.pnj.ac.id, [3]budi.utami@elektro.pnj.ac.id

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***Abstract*— PT. XYZ is an internet service provider that owns various network devices such as routers, switches, and servers. Device management is still performed manually without digital record-keeping, leading to inefficiencies, particularly in the process of requesting and checking device availability. This study aims to develop a web-based inventory information system to manage network devices systematically and efficiently. The system is developed using the Laravel framework and PHP programming language, and it is equipped with a dynamic QR Code feature that is automatically generated for each recorded device. The inventory information system website was tested through a Contract Acceptance Test involving three user roles: Admin, NOC, and CTO, with an average evaluation score of 97.5. In addition, system functionality testing of the system was conducted using the black-box testing method on 75 scenarios, all of which were successfully executed. Security testing results indicated a low security risk level. These overall testing results show that the system functions as intended and capable of meeting user needs optimally.**

Index Terms*— *Inventory Information System; Laravel; Network Devices; Web-based Application;

I. INTRODUCTION

Storage and management play an important role in supporting the smooth operation of a company. One effort that can be made is the implementation of an inventory information system, which provides information on the availability of goods. With the implementation of an inventory information system, the risk of loss and theft of goods can be minimized [1], [19].

PT XYZ is a company engaged in providing internet services and utilizes various network devices such as routers, switches, access points (AP), and servers. However, the company currently lacks a digital information system to support the management of these network devices. Device management including routers, switches, access points, and servers is still performed manually and documented physically in the warehouse without any centralized data storage. Device requests from customers are still delivered directly to the Chief Technology Officer (CTO), requiring manual and repetitive checks of device availability. This results in inefficiency, longer processing times, and a higher risk of data inconsistencies.

To address these issues, this study develops a web-based inventory information system designed to replace the previous manual process. The system supports structured, systematic, and real-time management of network devices and supporting components such as LAN cables, SFP modules, fiber optic (FO) cables, and patch cords.

To support device identification in the field, the system is equipped with a dynamic QR Code feature. Each recorded device is assigned a unique QR Code that can be scanned to display updated information such as the device name, type, and placement location [2], [17], [18], [29]. This QR Code serves as a digital label to facilitate faster and more accurate physical checking.

Previous studies show that inventory systems can improve efficiency by reducing human error, automating data retrieval, and facilitating report generation [3], [4]. Systems with access control improve data security and ensure that only authorized users can manage inventory data [5], [25].

Based on these problems, this study aims to design and develop a web-based inventory information system for network devices using the Laravel framework. The system is implemented at PT XYZ as a strategic solution to improve inventory governance and digital transformation in device management.

I. LITERATURE REVIEW

A. Inventory Information System

An inventory information system is a digital mechanism for recording, controlling, and monitoring stock items [6], [19], [21]. It increases efficiency, minimizes human error, and supports systematic stock management [18], [27]. Modern inventory systems

often include transaction recording, access management, and automated reporting [25], [26].

The inventory information system is designed to facilitate the monitoring process of stock availability efficiently. To support its function, the system can be equipped with features for recording incoming and outgoing item transactions based on date, item code, and item name. To maintain data security and order, the system can also implement user access rights controlled by the administrator [7].

B. *Network Devices*

Networking devices are hardware components used to connect, manage, and facilitate communication between computers or other devices within a computer network. These devices include various types such as routers, switches, access points (AP), and servers [8], [21], [24]. Efficient management of these devices ensures service continuity and reduces operational risks.

C. *QR Code*

QR Codes are two-dimensional barcodes that can store static or dynamic data [2], [9], [10]. Dynamic QR Codes redirect users to updated online information, making them suitable for inventory systems requiring continous data updates [17], [18], [29]. QR Codes have four error correction levels (L, M, Q, H) that allow scanning even when partially damaged.

In this system, one of the features developed is the generation of dynamic QR Codes for each inputted device data, which contains a link to the device detail page based on its ID so that it remains valid even if the device data is updated. The QR Code generation uses the Simple QrCode library with the error correction level set to H (High), enabling the QR Code to still be scanned even when damaged—such as from scratches or dirt—up to 30% [2]. This facilitates the physical identification process of devices in the field.

D. *Website*

A website is a collection of pages that contain various types of information and can be accessed via the internet by users around the world. In general, there are two types of websites: static and dynamic. A static website displays fixed information and can only be updated by a webmaster or developer, without requiring a database. Meanwhile, a dynamic website requires information updates by multiple users and needs a database to manage its content [11]. In the development of this inventory information system, a website is needed that allows users to store and manage devices effectively.

In developing this website, there are three main components required, namely frontend, CRUD, and backend. The frontend is the user interface (UI) that directly interacts with the users. The CRUD component (Create, Read, Update, Delete) functions to handle the processes of adding, reading, updating, and deleting data within the system [11]. Meanwhile, the backend is the part of the system that operates on the server side and is responsible for processing data, executing application logic, and communicating with the database.

E. *Laravel*

Laravel is a PHP-based framework that was first developed by Taylor Otwell. Laravel is built by applying the Model-View-Controller (MVC) concept, which is a programming architecture that divides the system into three main components: model, view, and controller. This concept separates the logic process, user interface, and data management (database), making application development more structured. The main purpose of using MVC is to separate the process from the user interface, allowing developers to more easily update or modify one component without affecting the others [12], [25].

F. *Contract Acceptance Test (CAT)*

Contract Acceptance Testing is conducted to evaluate whether the developed system meets user requirements and expectations [13]. This evaluation is carried out by distributing questionnaires to end users to measure their level of satisfaction with the inventory information system website. In this study, CAT focuses on two main aspects: the user interface and the system process. The system process aspect is intended to evaluate how well the website performs its functions, while the user interface aspect aims to evaluate the ease of navigation and visual comfort from the perspective of end users.

G. *Functionality Testing*

In the aspect of functionality testing, the black-box testing method is used, which is a type of testing that evaluates the functionality of the system based on input and output without considering the internal structure of the program code. The testing is carried out by preparing a number of test cases that include inputs, expected outputs, and the final results produced by the system [14], [27].

To measure the success rate of feature implementation, the Feature Completeness Matrix is used, which is a matrix that calculates the extent to which the designed features have been successfully implemented [15]. This matrix is calculated using the formula:

$$X = \frac{1}{P} \quad (1)$$

where:

I = the number of functions that have been successfully implemented

P = the total number of functions that were designed

The value of X is in the range of $0 \leq X \leq 1$. The closer the value is to 1, the higher the success rate of feature implementation in the system. The system can be considered to run well if the value of X is close to or equal to 1.

H. *Security Testing*

Security testing is a process aimed at assessing the extent to which a website is able to protect information from unauthorized access. This testing ensures that the system has the capability to prevent various threats, including potential vulnerabilities, unauthorized access, and data leaks. The testing process is conducted using supporting tools, one of which is Sucuri SiteCheck, a software used to detect system weaknesses and evaluate the overall security level of the application [16], [26], [27].

II. METHODOLOGY

This study aims to design and develop a Website-Based Inventory Information System for Network Devices at PT. XYZ. The primary objective is to assist in managing network devices more effectively through digital and systematic processes of recording, monitoring, and management.

A. *System Block Diagram*

In this study, a website-based inventory information system was developed to digitally and efficiently record and manage network devices at PT. XYZ. In building this system, the PHP programming language was used with the Laravel framework to support system development, and MySQL was used as the database to store all device information.

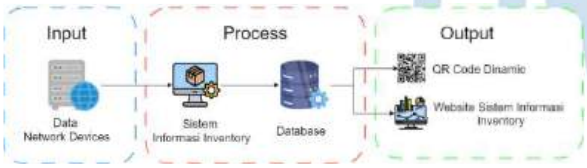

Fig. 1. System Block Diagram

Figure 1 shows the system block diagram, which illustrates the main components involved in the realization of this inventory system. The system receives input in the form of network device data, such as device name, purchase date, or warranty period. This data is then stored in the database. In the final stage, each recorded device will automatically be assigned a dynamic QR Code that redirects to the device's detail page, and all device information is displayed through the system's website interface.

B. *System Design and Development*

The development process of the network device inventory information system consists of the following stages:

- Planning: The initial stage involves conducting interviews and literature studies, as well as identifying system requirements and the functions to be developed to address the issues faced by the company in managing network devices [7]. This includes the login page, dashboard, device entry and exit records, and user management pages.
- System Design: In this stage, the user interface (UI) is designed in detail using mockups, along with the database structure design to store device or user information.
- Development: The system was developed using PHP version 8.2 and the Laravel 11 framework. All data is stored in a MySQL database. This process includes implementing secure login features, device data management, device entry and exit logging, and user management according to their access rights. In addition, a responsive and user-friendly web page display is created to make it easier for users to operate the system.

C. *Use Case Diagram*

The system workflow model, which describes the interaction between users and the system, is illustrated using a use case diagram. As shown in Figure 2, the system supports three types of user accounts: Admin, Network Operation Center (NOC), and Chief Technology Officer (CTO). Each role has different responsibilities that reflect the actual workflow in PT XYZ. The involvement of these three actors is based on the organizational structure of the company and the real-world business processes related to device management.

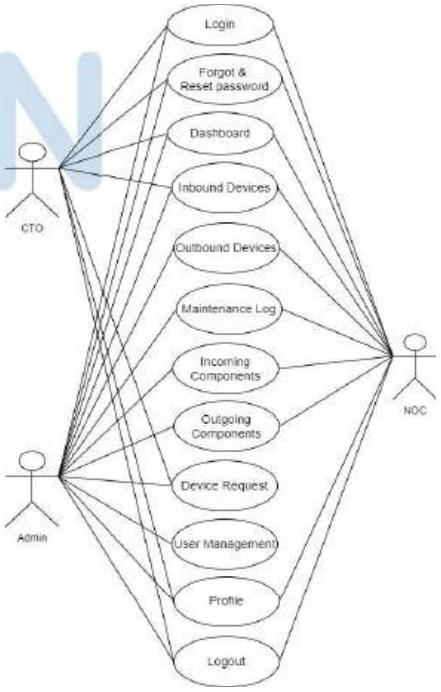

Fig. 2. Use Case Diagram

The Administrator is the primary system manager responsible for maintaining all operational data within

the inventory system. This role is assigned to the warehouse or IT support staff who handle data input, system configuration, and user account management. The NOC team is responsible for monitoring and maintaining the company's network infrastructure. They require access to device data in real time when performing installation, troubleshooting, or device replacement activities in the field. The CTO is responsible for high-level decision-making related to device procurement and ensuring the availability of critical infrastructure. In the existing workflow, device requests are communicated directly to the CTO, which often leads to manual and unrecorded decisions. The new system aims to formalize this decision-making process.

Based on Figure 2, users can log in to the inventory information system and perform the following actions:

Log in to the system and be redirected to their respective dashboards based on their user roles.
Reset the password when it's forgotten.
Manage data in Inbound Device, Outbound Device, and Maintenance Log.
Manage data in Incoming Component and Outgoing Component.
Manage device requests through the Device Request menu.
Manage users through the User Management menu.
Access and update their personal profile, including changing their password.

D. *Business Process Background & System Purpose*

Before the system was developed, PT XYZ relied on manual documentation for managing network devices. Device availability checks were conducted using paper forms or direct physical verification in the warehouse. This resulted in several issues: lack of centralized digital records, slow verification when devices were needed for deployment, no real-time monitoring of device placement, no structured approval mechanism for procurement, potential for data loss, duplication, and errors, difficulty tracking devices once deployed in the field. The system was developed to eliminate these limitations and establish a standardized, digitized, and traceable workflow.

E. *System Testing Methods*

Several types of testing were conducted to ensure that the system meets the defined standards and requirements, including:

Contract Acceptance Test: The testing was carried out in the form of questionnaires distributed to end users, namely Admin, NOC, and CTO. This test covered two main aspects: the system processes and the user interface appearance.
Functionality Testing: The testing was conducted using the black-box method based on 75 test cases covering various scenarios, including login, device management, device requests, user management, and other features.
QR Code Testing: This testing aimed to ensure that the QR Code feature functions properly. The test was conducted 6 times, both when device data was added and when it was updated.
Security Testing: The testing was conducted using the Sucuri SiteCheck tool to detect potential malware, system vulnerabilities, and to evaluate the website's security configuration [16].

III. RESULT AND DISCUSSION

A. *Website Realization*

The following is the implementation result of the web-based network device inventory information system developed using Laravel and applied at PT. XYZ. Each menu in the system has specific functions and access rights that are adjusted according to the user's role, such as Admin, NOC, and CTO.

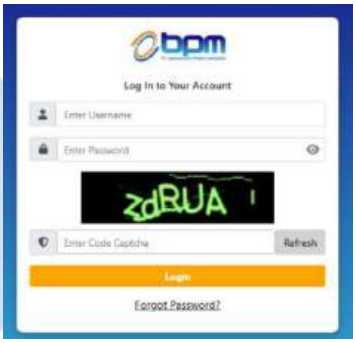

Fig. 3. Login Page

Figure 3 displays the Login Page, where users must first log in by entering their registered username, password, and captcha code. If successful, users will be redirected to the dashboard page according to their respective roles.

Fig. 4. Forgot Password Page

Figure 4 shows the Forgot Password Page, which is used when users cannot remember their password in order to regain access to the system. On this page, users can enter their username and email, and the system will send a password reset link to the provided email. Additionally, a function called handleForgot() is implemented to handle the password reset process on the website. This function works by receiving the user's

username and email address, after which the system sends an email containing a link to reset the password.

Fig. 5. Admin Dashboard Page

Figure 5 displays the Dashboard Page for users with the Admin role. The appearance of this dashboard page is adjusted based on the user's role. This page presents a summary of information such as the number of inbound and outbound devices, device requests, and the total number of users. In addition, it displays information related to maintenance schedules and device warranty periods that are nearing their end.

Fig. 6. Inbound Device Page

Figure 6 displays the Inbound Device Page. This page is used to record data of devices entering the system. Users can input details such as device name, serial number, device type, placement location, warranty period, purchase date, device status, and entry date. This page is also equipped with a report feature that can be downloaded in PDF format, containing detailed information about the recorded devices. Additionally, each time device data is saved (after the user inputs the data and clicks the Save button), the system automatically generates a QR Code for that device.

The entire process, including data saving, automatic QR Code generation, and PDF report download, is managed within the DeviceInController.php file. The generated QR Code is dynamic, meaning it contains a URL that directly links to the device's detail page within the system. By scanning the QR Code, users can instantly access the device information without having to search manually.

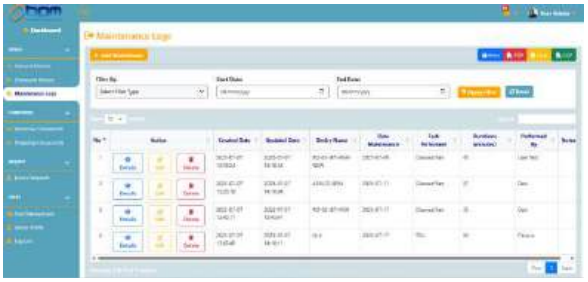

Fig. 7. Maintenance Page

Figure 7 shows the Maintenance Log Page. This page is used to record device maintenance schedules. The data entered includes device name, maintenance date, tasks performed, and the name of the technician who performed the maintenance.

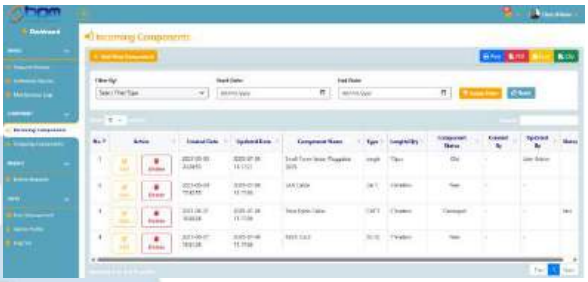

Fig. 8. Incoming Component Page

Figure 8 presents the Incoming Component Page. This page is used to record components entering the system. The recording process includes information such as component name, entry date, component quantity (in meters or pieces, depending on the type of component), and component status. On this page, there are reporting features available that can be downloaded in PDF, Print, Excel, or CSV formats, and can be customized for daily, weekly, or monthly views. The reports can also be filtered based on created date, updated date, start date, and end date.

The component units such as meters or pieces on this page will automatically decrease if the component is used on the Outgoing Component Page. As a result, the quantity displayed will adjust according to the remaining stock available.

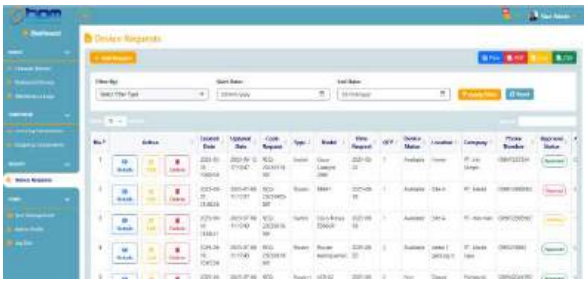

Fig. 9. Device Request Page

Figure 9 displays the Device Request Page. On this page, the admin can input device procurement requests into the system, which include information such as device type, device category, quantity, and request

date. Once the request data is entered, the information is saved in the system and automatically sent to the CTO's email for approval processing. The CTO can approve or reject the request directly through the system by selecting either Approved or Rejected. The result of the approval will then be automatically sent back to the admin's email as a notification.

Additionally, a request report is available for download in PDF format, containing detailed information about the device request and its approval status. This report serves as a formal record of the agreement between the client and the company.

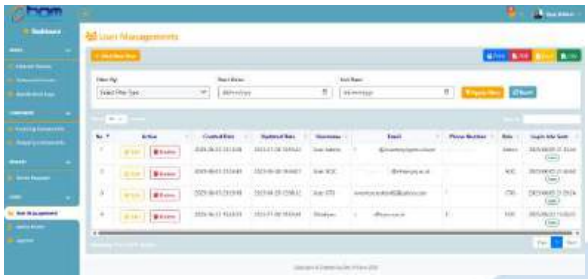

Fig. 10. User Manage Page

Figure 10 displays the User Management Page. This page is used to create user accounts, which consist of information such as name, email, phone number, access rights (role), and password for logging into the system. The account information is then sent to the user's email.

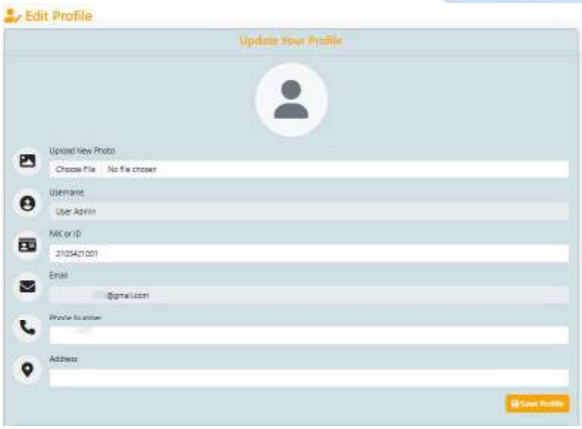

Fig. 11. Admin Profile Page

Figure 11 displays the Admin Profile Edit Page. On this page, users can update their personal information, such as phone number and address, as well as upload a profile photo.

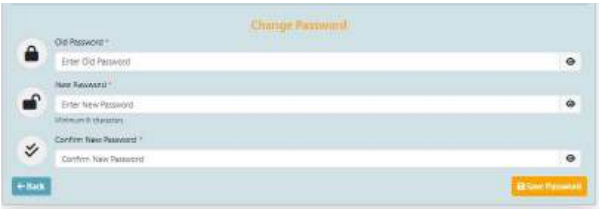

Fig. 12. Change Password Page

Figure 12 displays the Change Password Page. This page allows users to update their previously provided password. The form consists of input fields for the old password, new password, and confirm new password, ensuring security during the password update process.

To implement the password change process, the changePassword() function is used within the AdminProfileController. This function is responsible for validating the input, verifying the current password, and saving the updated password to the database. The view for the change password page is created in the resources/views/admin/profile directory with the filename edit.blade.php. Furthermore, to display and process this page, a route is defined in the routes/web.php file. This route handles the flow from the page to the controller, enabling all related functions to be properly executed when a user attempts to change their password.

B. Contract Acceptance Test

The Contract Acceptance Testing was conducted by distributing questionnaires to three user roles, namely 1 Admin, 4 NOC, and 1 CTO. The testing was conducted to evaluate two main aspects: the system user interface (UI) and the system process. Each user role was provided with a set of questions corresponding to their system access rights. Each question was evaluated based on five categories: Highly Appropriate (5), Appropriate (4), Less Appropriate (3), Not Appropriate (2), and No Response (1).

TABLE 1. RESULT OF THE CTO QUESTIONNARE

No	Question	HA	A	LA	NA	NR
	User interface					
1	Is the appearance of the inventory information system website attractive and user-friendly?	5	-	-	-	-
2	Is the login page of the inventory information system website easy to understand and as expected?	5	-	-	-	-
3	Is the dashboard page of the inventory information system website easy to understand and as expected?	5	-	-	-	-
4	Is the inbound device page of	5	-	-	-	-

No	Question	HA	A	LA	NA	NR
	the inventory information system website easy to understand and as expected?					
5	Is the device request page of the inventory information system website easy to understand and as expected?	5	-	-	-	-
6	Is the user profile page of the inventory information system website easy to understand and as expected?	5	-	-	-	-
System Process						
7	Is the login process functioning as expected?	5	-	-	-	-
8	Is the inbound device process functioning as expected?	5	-	-	-	-
9	Is the device request process functioning as expected?	5	-	-	-	-
10	Is the user profile process functioning as expected?	5	-	-	-	-
11	Does the QR Code on the inbound device page facilitate easier device identification and monitoring?	5	-	-	-	-
Total		**55**	-	-	-	-

Table 1 shows the result of questionnaire completed by one of the user roles, namely the CTO. In this test, the CTO was given 11 questions covering the user interface and system processes. The questionnaire results indicate that the CTO achieved the maximum score with a total of 55 out of 55. Meanwhile, the Admin answered 19 questions with a maximum total score of 95 and achieved a full score. The NOC answered 15 questions per person with a maximum score of 300 for the four individuals, and the average score obtained was 69.5 out of 75.

If the assessment is converted to a scale of 0–100, the Admin and CTO scores are 100 each, while the NOC obtained an average score of 92.6. With an overall average of 97.5, the system is rated as very good and has met the needs of the company' users.

C. Web Application Testing

Web Application Testing is used to test websites to identify errors before they are used and accessed by the public. In this study, software evaluation was conducted to ensure that the website was fit for use. The evaluation consisted of functionality and security.

1. Functionality Testing

Functional testing is conducted to ensure that all features operate according to the requirements. The testing covers various pages within the network device inventory information system, including login, dashboard, device inbound and outbound, device requests, user management, and user profiles. In total, 75 test scenarios were executed. Table 2 presents six sample scenarios selected from the total 75 test cases performed.

TABLE 2. RESULT OF BLACK-BOX TESTING

No	Scenario Test	Expected Result	Test Result
1	Login with a registered username and password	Redirected to the dashboard page according to the user's role	Success
2	Login with an unregistered username and password	Displayed login error message	Success
3	Add inbound device data	Data successfully added	Success
4	Edit inbound device data	Data successfully edited	Success
5	Delete inbound device data	Data successfully deleted	Success
6	Click the logout button	Logged out and redirected to the login page	Success

The result of functionality testing showed that all 75 test scenarios were successfully executed. The system's functional success rate was calculated using (1), as follows:

$$X = \frac{75}{75} = 1$$

A value of X equal to 1 indicates that all functions are running as expected, thus it can be concluded that the system is functioning properly.

Additionally, testing was conducted on the QR Code feature. This testing aimed to ensure that the QR Code could be automatically generated and scanned correctly every time device data was added or updated. The testing was conducted six times, and the results showed that the QR Code was successfully generated and directed to the corresponding device data without any errors.

2. Security Testing

System security testing was carried out using the Sucuri SiteCheck tool to detect potential vulnerabilities or weaknesses in the system and to comprehensively evaluate its security level before the system is officially launched. The testing process begins by accessing the website https://sitecheck.sucuri.net/, then entering the URL of the inventory information system (using either http or https protocol) into the available input field. After that, the user clicks the "Submit" button and waits for the analysis process to complete. The test results will display information related to the website's security status, including potential threats, malware, and insecure configurations.

Fig. 13. Result of Security Testing

Based on the security testing results shown in Figure 13, it was found that the security risk level of the inventory information system website falls under the Low Security Risk category. The analysis results indicate that the inventory information system website for network devices was not detected to contain any malware and is not included in the blacklist. The low security risk category shows that the inventory information system website has a good security system and is safe for user to access. Therefore, the system has met website security requirements with a low risk level.

D. System Deployment Status

The developed web-based network device inventory system has been deployed in a pilot environment within PT XYZ. During this pilot implementation, the system is being used by selected Admin and NOC personnel to evaluate its performance in real operational conditions. This evaluation includes validating the accuracy of device data recording, monitoring the reliability of the dynamic QR Code scanning process, and assessing the effectiveness of the digital procurement approval workflow. Full deployment will follow after the pilot phase receives final management approval.

IV. CONCLUSION

Based on the results of testing on the developed inventory information system, it can be concluded that the system was successfully designed and implemented to support the management of network devices at PT. XYZ effectively and efficiently. The system was developed using the Laravel 11 framework with PHP version 8.2, and is equipped with a dynamic QR Code feature built using the Simple QrCode library. This QR Code feature has been tested and is capable of automatically generating a code when device data is added, which can then be scanned correctly to display the appropriate device information.

The Contract Acceptance Test (CAT) was conducted by involving all user roles who directly interact with the system, namely 1 Admin, 4 NOC, and 1 CTO. The results test showed that the Admin and CTO each obtained the maximum score of 100 after being coverted to a scale of 0-100, while the NOC achieved an average score of 92.6. Thus, the overall average score from all three roles was 97.5. This result demonstrates that the system is considered highly feasible and has successfully met the users' needs within the company environment.

The Web Application Testing was focused on functionality and security aspects. Based on th result of functionality testing using the black-box testing method, 75 test scenarios were conducted, all of which produced results as expected with no functional errors found. From the security perspective, testing using the Sucuri SiteCheck tool showed that the system falls under the Low Security Risk category, with no indications of malware or blacklist blocking. Therefore, it can be concluded that the system is secure for use and accessible appropriately.

This study has several limitations. The system is optimized for internal operational workflows and has not yet been integrated with external platforms such as automated network monitoring or asset management systems. In addition, the system's role structure and workflow are tailored specifically to PT XYZ's organizational processes, and adjustments may be required when implemented in different environments.

Future research can focus on integrating the system with SNMP-based or API-driven monitoring tools to enable automatic updates of device status and condition. Furthermore, applying data analytics or machine learning models for inventory forecasting may provide added value for long-term device management optimization.

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Triangulation Approach Using K-Means, Hierarchical Clustering, and DBSCAN for Beef Production Analysis

Nurfia Oktaviani Syamsiah[1], Indah Purwandani[2], Mia Rosmiati[3], Siti Nurwahyuni[4]
[1, 2, 3, 4] Faculty of Engineering and Informatics, Bina Sarana Informatika University, Indonesia
[1] nurfia.nos@bsi.ac.id, [2] indah@bsi.ac.id, [3] mia.mrm@bsi.ac.id, [4] siti.swu@bsi.ac.id

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***Abstract*— This study implements a methodological triangulation approach for clustering highly skewed data using three algorithms with distinct paradigms: K-Means (partitional-based), Agglomerative Hierarchical Clustering with Ward Linkage (hierarchical-based), and DBSCAN (density-based). Applied to beef production data from 38 Indonesian provinces in 2024, the dataset exhibited extreme characteristics with a coefficient of variation of 171.89%, skewness of 2.87, and a maximum-minimum ratio of 664:1. Data were standardised using Z-score transformation to address scale dominance. Evaluation using the Silhouette Score for K-Means and Hierarchical Clustering, alongside qualitative outlier detection with DBSCAN, revealed high consistency across all algorithms in identifying k=2 as the optimal structure (Agreement: 99.7%). The algorithms consistently isolated three provinces (East Java, West Java, and Central Java) as a high-production cluster, distinctly separated from the remaining 35 provinces. Bootstrap resampling (B=100) confirmed the stability of this structure with a standard deviation of 0.0089. These findings demonstrate that relying on a single algorithm for skewed data is methodologically risky, whereas triangulation provides robust validation for policy formulation.**

***Index Terms*— DBSCAN; Hierarchical Clustering; Outlier Detection; Silhouette Score; Triangulation Algorithm**

I. INTRODUCTION

As an archipelagic nation with a population exceeding 270 million, Indonesia faces considerable challenges in ensuring food security, particularly regarding the availability of animal protein, a vital component of public health. The domestic demand for beef continues to rise alongside population growth and shifting consumption patterns increasingly oriented toward high-quality protein intake. Pressure to enhance livestock sector productivity has intensified, yet efforts to achieve sustainable beef self-sufficiency remain constrained by production disparities across regions [1]–[3].

The 2024 beef production data reveal a pattern in which a small number of provinces on Java Island, historically established as livestock centres, continue to dominate the national supply. As shown in Table I, the three major provinces (East Java, West Java, and Central Java) contribute significantly to the national output, while the majority of other provinces scattered across various islands contribute only marginally. This dominance pattern has persisted for several decades [4], [5].

Production inequality results from the accumulation of various interacting factors, ranging from differences in cattle genetic quality and the availability of modern slaughterhouse infrastructure to variations in the availability of adequate pastureland and regional-level resource allocation policies [6], [7]

In computational analysis, uneven data distribution poses methodological challenges when Euclidean distance-based clustering algorithms like K-Means are applied to real-world data. K-Means' sensitivity to initial centroids and the presence of outliers can easily distort clustering quality, indicating that these challenges are consistently encountered across different data analysis contexts [8]–[10].

Research Gap and Significance Although the value of triangulation and ensemble methods in clustering analysis is increasingly recognised for mitigating algorithmic bias [11], [12], no prior study has applied a robust cross-validation approach specifically to Indonesian beef production data. This data demonstrates extreme imbalance (CV > 170%) and unprecedented regional disparity (ratio 664:1), characteristics that often lead to convergence failures in standard algorithms [13]. Existing studies have been limited to single-algorithm applications, such as Ningsih [14] who utilized K-Means on raw data, or have failed to systematically validate findings through cross-paradigm triangulation [15], [16]. This represents a critical methodological gap given the proven sensitivity of clustering results to method selection [17]. Furthermore, previous research has not addressed the challenge of parameter optimisation for density-based algorithms in the context of agricultural data with extreme outliers. Recent literature emphasises the need for careful parameter adaptation to avoid misidentifying structural noise [18]. This research gap is crucial because policy interventions based on unvalidated clustering structures may lead to resource

misallocation or a failure to address genuine production disparities.

TABLE I. BEEF PRODUCTION DATA PER PROVINCE IN INDONESIA, YEAR 2024

Province	Production (Tons)	Province	Production (Tons)
ACEH	11,006.40	SOUTH KALIMANTAN	5,272.95
NORTH SUMATRA	18,245.02	EAST KALIMANTAN	6,466.78
WEST SUMATRA	14,901.15	NORTH KALIMANTAN	632.91
RIAU	13,457.10	NORTH SULAWESI	1,840.64
JAMBI	3,571.72	CENTRAL SULAWESI	3,848.72
SOUTH SUMATRA	11,810.70	SOUTH SULAWESI	13,722.50
BENGKULU	1,762.84	SOUTHEAST SULAWESI	5,985.22
LAMPUNG	18,625.00	GORONTALO	1,900.72
BANGKA BELITUNG ISLANDS	2,490.59	WEST SULAWESI	1,174.18
RIAU ISLANDS	2,202.23	MALUKU	1,279.24
DKI JAKARTA	14,925.20	NORTH MALUKU	1,530.33
WEST JAVA	85,241.70	WEST PAPUA	742.54
CENTRAL JAVA	83,275.69	SOUTHWEST PAPUA	325.41
DIY	6,700.69	PAPUA	683.22
EAST JAVA	96,907.31	SOUTH PAPUA	439.03
BANTEN	19,259.70	CENTRAL PAPUA	667.16
BALI	4,882.25	HIGHLAND PAPUA	145.81
WEST NUSA TENGGARA	11,356.76	WEST KALIMANTAN	3,890.08
EAST NUSA TENGGARA	6,234.53	CENTRAL KALIMANTAN	1,448.19

Our study addresses this gap by implementing systematic triangulation across three clustering paradigms (partitional, hierarchical, and density-based). The selection of K-Means, Hierarchical Clustering, and DBSCAN is grounded in their fundamental differences. The theoretical complementarity of these three paradigms—partition-based optimisation, hierarchical structure discovery, and density-based outlier detection—provides a robust cross-validation unattainable by single-paradigm approaches [11], [12].

II. METHODOLOGY

The research followed a standard data mining methodology framework, encompassing data collection, preprocessing, algorithm implementation, and comparative evaluation, as illustrated in Figure 1.

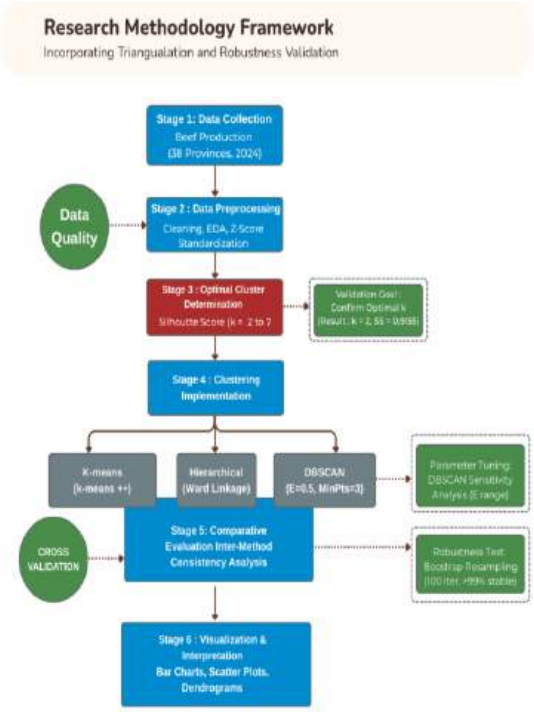

Fig. 1. Research Stages

A. Data Source and Preprocessing

The study utilised beef production data (in tons) from 38 Indonesian provinces in 2024, sourced from the Ministry of Agriculture. Given the extreme skewness (Skewness = 2.87), data preprocessing included Z-score standardisation to transform the data into a standard normal distribution**.** This step is critical to prevent provinces with large production volumes from dominating the Euclidean distance calculations in K-Means and Hierarchical clustering [19].

B. Clustering Algorithms Implementation

Three algorithms were implemented with specific configurations to ensure robustness:

1. K-Means: Implemented with k-means++ initialisation to select optimal initial centroids, accelerating convergence and reducing the probability of falling into local optima [20]. The optimal number of clusters (k) was determined using the Silhouette Score.
2. Agglomerative Hierarchical Clustering: Utilised Euclidean distance and Ward's linkage method, which minimises the total within-cluster variance. The cut-off point for the dendrogram was determined based on the largest vertical distance between merges.

3. DBSCAN: Selected for its ability to handle noise. Parameter selection was conducted systematically.

C. Algorithm Behavior on Highly Skewed Data

Each algorithm exhibits distinct sensitivities when applied to data with extreme outliers and high skewness. The Euclidean distance-based objective function in K-Means makes it inherently sensitive to outliers, as extreme values disproportionately influence centroid calculation and cluster assignment [13]. To mitigate this, k-means++ initialisation was employed. Hierarchical Clustering with Ward linkage minimises within-cluster variance, making it relatively robust compared to single or complete linkage. However, hierarchical methods are deterministic; once an outlier is merged, it cannot be reassigned. The density-based paradigm of DBSCAN differs fundamentally by not forcing every observation into a cluster. It defines clusters as dense regions and explicitly labels low-density observations as noise. This characteristic makes DBSCAN methodologically superior for highly skewed data, where outliers represent distinct production regimes rather than measurement errors [18], [21].

D. DBSCAN Parameter Selection

For the DBSCAN implementation, parameter selection was conducted systematically through exploratory analysis and sensitivity testing. The Epsilon parameter was initially estimated using a heuristic k-distance plot, plotting the distance to the k-th nearest neighbour (MinPts=3) for all observations sorted in ascending order [22]. The "elbow" in this plot suggested an initial epsilon range of 0.4–0.6. We selected MinPts=3 based on the rule of thumb MinPts dimensionality + 1 [21]; for univariate data (d=1), MinPts=3 provides sufficient density estimation while avoiding excessive noise labelling. The final parameters were validated through systematic sensitivity analysis.

E. Validation Stability via Bootstrap Resampling

To assess clustering stability against sampling variation, we implemented bootstrap resampling with 100 iterations. In each iteration, we generated a bootstrap sample by randomly sampling 38 observations with replacement from the original dataset. This resampling approach simulates the variability that would arise from repeated sampling from the population [20]. For each bootstrap sample, we applied K-Means and Hierarchical Clustering, recording Silhouette Scores and cluster membership consistency. A membership consistency near 100% indicates a highly stable clustering structure robust to sampling variations.

F. Software Environment

All computational analyses were implemented in Python 3.8.10 running on Windows 10 Pro (64-bit) with 16GB RAM. Data manipulation utilised Pandas 2.0.3 for structured data operations and NumPy 1.24.3 for high-performance numerical array computing. Clustering algorithms were implemented using Scikit-learn 1.3.0, specifically the KMeans (with k-means++), Agglomerative Clustering (Ward linkage), and DBSCAN classes. Statistical analysis utilised SciPy 1.11.1, particularly for dendrogram generation. Data visualizations were created using Matplotlib 3.7.2 for publication-quality figures and Seaborn 0.12.2 for enhanced statistical graphics. All analyses were executed within a Jupyter Notebook 6.5.4 environment to ensure full reproducibility.

III. RESULT

A. Descriptive Analysis

The descriptive statistics of the beef production data, summarised in Table II, reveal a fundamental structural imbalance in the national supply chain. The mean production stands at 12,195.26 tons, a figure that is mathematically pulled upward by extreme outliers, whereas the median is significantly lower at 5,629.58 tons. This substantial divergence between the mean and median confirms a heavy right-skewed distribution, indicating that the "average" province does not represent the typical production capacity. Furthermore, the Coefficient of Variation (CV) reached an extreme 171.89%, suggesting that the disparity among provinces is not merely a variation but a sign of high heterogeneity. The maximum-minimum ratio of 664:1 provides the clearest picture of the production gap's magnitude, necessitating differentiated policy interventions.

This structural gap is vividly illustrated in Figure 2. The distribution plot displays a distinct "long-tail" characteristic, where the three leading provinces form a high-production plateau that sharply drops off to a flat consolidation line for the remaining 35 provinces. This visual evidence supports the statistical indication of a dualistic production structure.

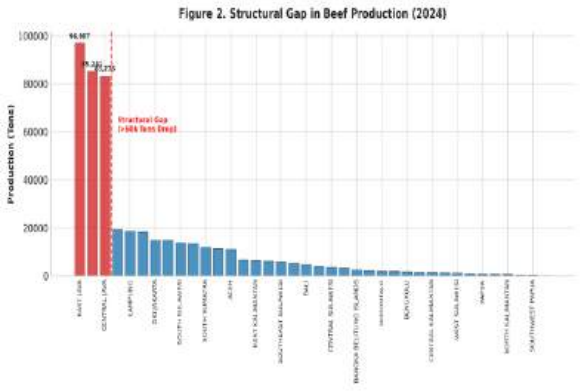

Fig 2. Visualisation of Structural Gap in Beef Production

TABLE II. DESCRIPTIVE STATISTICS OF 2024 BEEF PRODUCTION DATA

Statistical Metric	Value (Tons)	Interpretation
Mean (μ)	12,195.26	Average production per province
Median	5,629.58	Distribution midpoint
Standard Deviation (σ)	20,967.83	Very high variability level
Minimum	145.81	Highland Papua (lowest)
Maximum	96,907.31	East Java (highest)
Range	96,761.50	Huge max-min difference
Skewness	2.87	Positively skewed distribution
Kurtosis	8.45	Heavy-tailed distribution
Coefficient of Variation	171.89%	Very high heterogeneity
Max/Min Ratio	664:01:00	Extremely high disparity

B. *Optimal Cluster Number Determination and Parameter Sensitivity*

The determination of the optimal number of clusters for K-Means and Hierarchical Clustering was rigorously guided by the Silhouette Score validation. As detailed in Table III, the analysis produced a remarkably high score of 0.9155 at k=2. This value is significantly higher than the scores for k=3 (0.7842) or k=4 (0.7123), providing empirical evidence that the natural structure of the data partitions most cleanly into two distinct groups. A score exceeding 0.7 typically denotes a "strong" structure; achieving > 0.9 suggests that the separation between the production centres and the rest of the country is nearly absolute in the feature space. This distinct peak at k=2 is visually demonstrated in Figure 4, which charts the Silhouette Scores across different cluster numbers, highlighting the sharp drop in validation quality for k > 2.

To validate this partition through a density-based paradigm, we performed a sensitivity analysis on the DBSCAN algorithm. The critical challenge in DBSCAN is parameter selection, specifically Epsilon. The results in Table IV reveal a stable detection window at epsilon=0.5-0.55. Within this specific range, the algorithm consistently identified the three super-producer provinces as outliers while keeping the remaining provinces in a coherent cluster. At lower epsilon values (epsilon < 0.5), the algorithm became overly restrictive, fragmenting the main cluster into noise, whereas at higher values (epsilon > 0.6), the distinction collapsed as outliers were merged into the main group.

TABLE III. SILHOUETTE SCORE EVALUATION FOR VARIOUS K VALUES

K	K-Means SS	Hierarchical SS	Average	Category
2	0.9155	0.9155	0.9155	Very Strong
3	0.7842	0.7839	0.7841	Strong
4	0.7123	0.7118	0.7121	Strong
5	0.6845	0.6841	0.6843	Adequate
6	0.6492	0.6488	0.6490	Adequate
7	0.6201	0.6197	0.6199	Adequate

TABLE IV. DBSCAN PARAMETER SENSITIVITY ANALYSIS RESULTS

ε (Epsilon)	MinPts	Number of Clusters	Number of Noise	Interpretation
0.3	3	0	38	Too tight, all noise
0.4	3	0	38	Still too tight
0.5	3	1	3	Optimal: Clear outlier isolation
0.6	3	1	2	One outlier enters the central cluster
0.7	3	1	0	Too loose, no outliers

C. *Clustering Results and Inter-Method Consistency*

The clustering results demonstrate a complete consensus among the three paradigms. A comparative performance summary is provided in Table V, highlighting the structural agreement across methods. While Hierarchical Clustering required slightly more computational time due to dendrogram construction, all methods demonstrated high efficiency.

Table VI details the specific membership of the identified clusters. K-Means and Hierarchical Clustering identified identical partitions: Cluster 0 consists of the three major producers (East Java, West Java, Central Java), while Cluster 1 comprises the remaining 35 provinces. DBSCAN provided a complementary validation by identifying the same three

provinces as "Noise" (Outliers) and the remaining 35 as the core cluster.

TABLE V. CLUSTERING RESULTS AND PRODUCTION CENTRE IDENTIFICATION

Method	k / Number of Clusters	Silhouette Score	Outlier / Noise	Time (ms)
K-Means	2	0.9155	N/A	12.4
Hierarchical	2	0.9155	N/A	45.8
DBSCAN	1	N/A	3 Provinces	8.7

TABLE VI. CLUSTERING RESULTS AND PRODUCTION CENTRE IDENTIFICATION 2024

Method & Cluster	Number of Provinces	Average (Tons)	Std Dev (Tons)	Cluster Members
K-Means Cluster 0	3 (7.89%)	88,474.90	6,979.82	East Java, Central Java, West Java
K-Means Cluster 1	35 (92.11%)	7,026.14	5,408.77	35 other provinces
Hierarchical Cluster 0	3 (7.89%)	88,474.90	6,979.82	East Java, Central Java, West Java
Hierarchical Cluster 1	35 (92.11%)	7,026.14	5,408.77	35 other provinces
DBSCAN Noise (-1)	3 (7.89%)	88,474.90	6,979.82	East Java, Central Java, West Java
DBSCAN Cluster 0	35 (92.11%)	7,026.14	5,408.77	35 other provinces

The hierarchical structure of this partition is illustrated in the dendrogram in Figure 3. The dendrogram shows a massive vertical distance before the first split, visually confirming that the data naturally divides into two distinct branches (production centers vs. others) before further granular sub-divisions occur.

The separation of these clusters is further confirmed in Figure 4. The scatter plot maps the provinces in the standardized Z-score space. The visual gap is striking: the top three provinces are located distinctly beyond the 3 sigma threshold (Z-score > 3.0), isolating them from the main consolidation group which is tightly clustered below Z-score < 1.0. This physical distance in the plot validates the mathematical separation found by the algorithms.

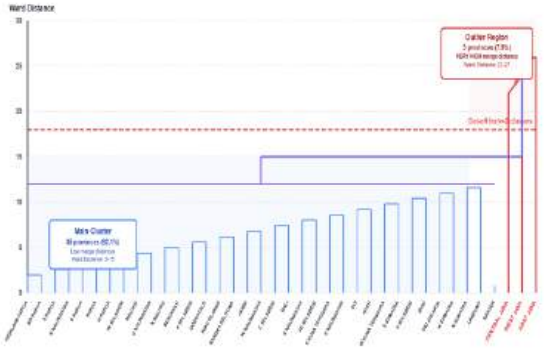

Fig. 3. Hierarchical Clustering Dendrogram (Ward Linkage)

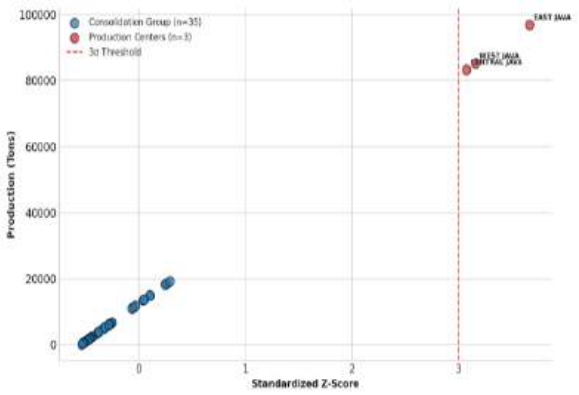

Fig 4. Scatter Plot of Cluster Distribution in Feature Space

D. Cluster Profiling and Sub-segmentation

A comprehensive profile of the identified clusters is presented in Table VII. The data underscores the depth of the disparity: Cluster 0 (Production Centres), despite containing only 7.89% of the provinces, commands a staggering 57.3% of the national beef production. The production ratio between the average province in Cluster 0 and Cluster 1 is approximately 12.6:1, highlighting a massive productivity divide that separates the industrial-scale producers in Java from the developing regions.

However, treating the 35 provinces in Cluster 1 as a monolith would be an oversimplification. To provide granular insights for policy targeting, we conducted a sub-segmentation analysis based on production ranges. Table VII breaks down this cluster into four sub-tiers (Upper-Mid to Low). This analysis reveals that even within the "developing" group, significant variation exists; the "Upper-Mid" tier (e.g., Lampung, Banten) shows potential to transition into higher production levels, whereas the "Low" tier requires fundamental capacity-building interventions.

TABLE VII. COMPREHENSIVE PROFILE OF BOTH CLUSTERS

Metric	Cluster 0 (Centre)	Cluster 1 (Consolidation)	Ratio (0:1)
Number of Provinces	3 (7.89%)	35 (92.11%)	0.09:1
Total Production (Tons)	265,424.70	197,995.18	1.34:1
National Contribution	57.3%	42.7%	1.34:1
Mean (Tons)	88,474.90	7,026.14	12.59:1
Median (Tons)	85,241.70	3,848.72	22.15:1
Std Dev (Tons)	6,979.82	5,408.77	1.29:1
CV (%)	7.89%	76.98%	0.10:1
Min (Tons)	83,275.69	145.81	571.04:1
Max (Tons)	96,907.31	19,259.70	5.03:1

TABLE VIII. SUB-SEGMENTATION OF CLUSTER 1 (CONSOLIDATION)

Sub-Segment	Number of Provinces	Production Range (Tons)	Average (Tons)
Upper-Mid	5	13,000 - 19,260	16,049
Mid	10	6,000 - 13,000	8,827
Lower-Mid	12	2,000 - 6,000	3,982
Low	8	145 - 2,000	993

E. Stability Validation

Finally, the reliability of these findings was stress-tested via bootstrap resampling. As shown in Table VIII, the results from 100 iterations demonstrated a mean Silhouette Score of 0.9142 with a negligible standard deviation of 0.0089. Furthermore, the membership consistency reached 99.7%, meaning that in almost every resampling scenario, the algorithms consistently assigned the same provinces to the same clusters. This level of stability is exceptionally high and confirms that the identified dualistic structure is a robust economic reality, resilient to sampling variations or minor data fluctuations.

TABLE IX. BOOTSTRAP RESAMPLING ANALYSIS RESULTS (100 ITERATIONS)

Metric	K-Means	Hierarchical	Interpretation
Mean Silhouette Score	0.9142	0.9148	High and consistent
Std Dev SS	0.0089	0.0076	Stable, minimal variation
Min SS	0.8973	0.9012	Remains in a strong category
Max SS	0.9278	0.9301	Not excessive, realistic

IV. DISCUSSION

A. Theoretical Interpretation of Convergence

The remarkable consistency among the three algorithmically distinct methods (99.7–100% agreement) reveals important theoretical insights into the data structure. In modern clustering theory, high ensemble agreement is recognized as the strongest indicator of natural structure, ensuring that results are not merely artifacts of algorithmic bias [23], [24]. The Silhouette Score of 0.9155 for k=2 substantially exceeds the 0.7 threshold categorized as "strong structure" in recent literature [25], approaching the theoretical maximum, which indicates nearly perfect linear separation.

This convergence can be mathematically explained by the extreme separation in the standardized feature space shown in Figure 3. The three super-producer provinces occupy Z-score positions > 3.0, creating a gap of approximately 2 standard deviations from the rest. In multivariate statistics, observations beyond 3 standard deviations represent the tail (<0.3%), effectively constituting a distinct population. This mathematical separation explains why algorithms with different optimisation criteria (variance minimization vs. connectivity vs. density) converged on identical solutions. The fact that DBSCAN independently identified the same three provinces as outliers provides non-circular validation that these observations are fundamentally different in density structure [18].

Furthermore, the stability evidence provided by the bootstrap results (see Table VIII) exceeds typical standards. While other ensemble studies typically report 85–90% agreement for outlier detection [23], our triangulation achieved near-perfect consistency. This confirms that the production dichotomy in Indonesia is a robust economic reality, not a statistical coincidence.

B. Comparison with Previous Research

Comparing our findings with previous research reveals critical methodological implications that extend beyond simple structural differences. Ningsih [14]identified k=3 as the optimal cluster number using K-Means on raw production data (2017–2022). In contrast, our triangulation approach consistently identified k=2. This discrepancy is not merely a difference in results but highlights the critical role of data preprocessing. Our analysis suggests that the third cluster identified in Ningsih's study likely emerged as an artifact of scale variance rather than a distinct production regime. Without Z-score standardization, the Euclidean distance function is disproportionately influenced by variables with large variances [19], potentially fragmenting naturally cohesive clusters. By standardizing the data, our study successfully mitigated this bias, revealing a more fundamental dualistic structure (Production Centres vs. Consolidation Group).

Our results align more closely with Indah [15], who utilized hierarchical methods and found a similar separation between major and minor producers. However, our study advances beyond Indah's findings by integrating DBSCAN for explicit outlier detection. While Indah's hierarchical approach effectively captured the global structure, it lacked a mechanism to distinguish between "extreme values within a cluster" and "true structural outliers." Our application of DBSCAN filled this gap by explicitly labeling the three super-producer provinces as "Noise," thereby providing a stronger, non-circular validation that these provinces constitute a structurally distinct entity [18].

Furthermore, compared to Ais et al. [16], who employed Fuzzy C-Means to analyze livestock meat production, our crisp clustering approach (K-Means and DBSCAN) offers a more definitive categorization necessary for clear policy formulation. While fuzzy clustering provides valuable insights into transitional memberships, policy interventions often require clear-cut segmentation to allocate resources effectively. The near-perfect stability of our results (99.7% consistency via bootstrapping) suggests that the ambiguity typically handled by fuzzy methods is minimal in this specific dataset, making our hard clustering approach both methodologically robust and practically actionable.

V. CONCLUSION

This study demonstrates that methodological triangulation across partitional, hierarchical, and density-based paradigms provides validation that is significantly more robust than single-algorithm approaches, particularly for data with extreme disparities like Indonesian beef production (CV=171.89%; ratio 664:1). All three algorithms consistently converged on the k=2 solution with 99.7–100% agreement and a Silhouette Score of 0.9155, statistically confirming that the dominance of the three Java provinces is a natural structure rather than an algorithmic artifact. The primary contribution of this study lies in demonstrating that integrating density-based outlier detection and bootstrap stability testing can mitigate the distortions often present in conventional methods. This provides a solid empirical foundation for policymakers to implement differentiated strategies between major production centers and developing regions, while recommending the adoption of this triangulation framework for future complex agricultural datasets.

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Waste Processing and Recycling Product Marketplace Application Using Tensorflow and Midtrans API Technology

Eko Budi Setiawan[1], Bayu Afriyadi[2]
[1,2]Informatics Engineering, Universitas Komputer Indonesia, Bandung, Indonesia
[1]eko@email.unikom.ac.id, [2]bayuafriyadi5@gmail.com

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***Abstract*— The increasing volume of waste that is not optimally managed is a serious challenge for sustainable development. Public education about waste processing and recycling is critical to increase their awareness and involvement. The recycling process can not only help reduce the amount of waste but also produce new products with economic value. In order to support this effort, information and communication technology, especially Android-based applications, can be an effective solution. This application can provide education, recommendations, and a marketplace platform for recycled products, hoping to allow the public to access information and market their products more efficiently. This study shows that Android-based waste processing and recycled product marketplace applications have great potential in helping to overcome waste problems. The test results of the application features show that all functions work well, which is my expectation. In addition, the user acceptance test shows that the majority of respondents agree that this application is effective in reducing waste accumulation (88%), facilitating the recycling process (93.36%), and providing economic value for recycled products (89.6%). This research provides innovative technology-based solutions to support the Sustainable Development Goals (SDGs) related to effective waste management and utilization.**

***Index Terms*— Waste; Recycled; SDGs; Application; Tensorflow**

I. INTRODUCTION

The use of information technology in the form of One of the complex problems faced by countries, both developing and developed throughout the world, is waste [1]. This problem is global and occurs in various countries. *Waste* is defined in the Great Dictionary of the Indonesian Language as a collection of goods or objects that are no longer used or have no use value. (http://kbbi.web.id/sampah). Based on the National Waste Management Information System (SIPSN) of Kementerian Lingkungan Hidul dan Kehutanan (KLHK) in 2022, the amount of waste stored nationally was recorded at 21.1 million tons based on input from 202 districts/cities throughout Indonesia has been achieved. Of the total state waste production, 65.71% (13.9 million tons) can be managed, while the remaining 34.29% (7.2 million tons) is not managed correctly.

Given that there is still unprocessed waste, the government is looking for solutions to overcome it by involving local communities in waste management. In addition to increasing public awareness of waste management, this initiative also aims to reduce the government's costs to overcome waste problems [2]. Low levels of education lead to a lack of knowledge about waste management. Therefore, socialization plays a vital role in disseminating knowledge about waste management to the community. The opposite can happen if the lack of community socialization and education about waste management results in less than optimal waste management [3].

Therefore, public education about waste processing must be improved, especially regarding waste recycling. This is because the waste can be converted into commercial waste or waste that can be sold and processed into other products, thus generating profits from further processing [4]. Inorganic waste can be sold and processed into household decoration materials, equipment, and art objects. Knowledge about sorting, selecting and placing storage locations, finding places to buy and recycle collected waste, and how to analyze sales results [5]. Recycling means changing the shape and reusing it [6]. This process creates new products that can be reused. After carrying out this process and already having a recycled product, a platform such as a Marketplace or E-Commerce for recycled products is needed to make it easier to market recycled products widely [7][8].

The problem related to the waste problem is based on the results of an interview conducted on December 23, 2023, with Fajar Ramadhan, a resident who lives in an area near the Bantar Gebang TPA. He said that the amount of waste in the TPA has exceeded capacity and is already mountainous. Because the people there are close to the TPA, they immediately throw their waste into the TPA, but there are also quite a few who still litter, which makes it scattered on the roads and rivers. According to him, the awareness of the people there

about waste management is still very lacking, and what is even more concerning is that they see firsthand the phenomenon of waste that has become very mountainous. However, their awareness is still significantly lacking in reducing this.

To overcome these problems, information and communication technology are needed to provide education about waste processing and recycling. Many human activities have now utilized technology to access information easily anywhere and anytime. One of them is the Smartphone, which utilizes the Smartphone and its features such as cameras, etc. It is expected to be able to create an application that can overcome this waste problem, mainly by providing education to the community. With proper education, the community is expected to be able to change its consumption patterns and behaviour in managing waste [9]. This will have an impact on reducing waste generation, increasing the amount of waste that can be processed, and increasing the economic value of waste.

Several studies have been conducted to support this research. Based on previous research an Android-based mobile device application needs to be developed to help the community uses sensors from smartphone [10]. It was found that this technology can provide education and recommendations to users regarding waste processing and recycling. The Android platform was chosen because it is an open-source licensed operating system, so developers can quickly develop it to support their daily activities and tasks [11].

Considering the problems mentioned above, it can be concluded that it is necessary to build an Android-based Waste Processing and Recycled Product Marketplace Application [12][13]. By building this application, it is expected to provide education to the public about waste processing and make it easier for the public to recycle and produce recycled products that have economic value where this application provides a marketplace feature to sell the results of recycled products that have been made by the public [14].

With this application, it is hoped that the public can better understand the importance of waste management and recycling, and can utilize waste into useful products. The results of this research can provide innovative technology-based solutions to support the Sustainable Development Goals (SDGs) in terms of Sustainable Consumption and Production related to effective waste management and utilization.

II. RESEARCH METHODS

This research consists of several critical stages. First, Problem Identification is carried out to understand the problem thoroughly. Next, Data Collection is carried out to obtain relevant information. After that, enter the System Analysis and Design stage to compile the right solution based on the data that has been collected. After the design, the implementation stage is carried out to apply the designed solution. Finally, Testing is carried out to ensure the system runs as expected and corrects errors. This stage flow ensures that the research results run systematically and effectively. Research flow and stages show in Fig1.

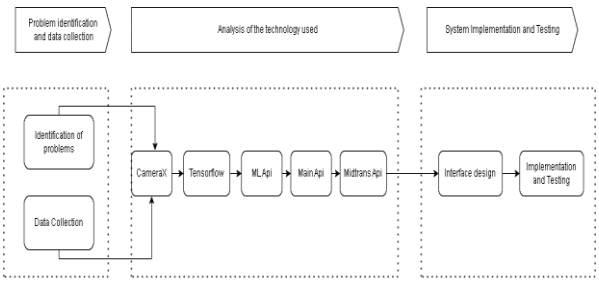


Fig. 1. Stage of research

2.1 Identification of problems

At this stage, researchers identify and understand various problems faced by the community related to waste management and recycling. Some problems found include low levels of public awareness and knowledge regarding the importance of proper waste management and difficulties in implementing the concept of recycling due to a lack of understanding. In addition, the community also faces obstacles in marketing recycled products because no particular platform can support the optimal marketing of these products. Identifying these problems is the basis for determining the focus and direction of research to find the right solution.

2.2 Data Collection

Once the problem has been identified in detail, the next stage is to collect the data needed to support the development of the solution. Data collection is carried out in various ways, such as literature review, direct observation, and interviews with residents around the Bantargebang TPA. The literature review includes the integration of payment gateway services and the development and use of APIs. Meanwhile, observations and interviews are conducted to gain a deeper understanding of user needs and expectations, including their preferences for the features presented in the developed application.

2.3 Analysis And Planning

In this analysis and design stage, an in-depth analysis of the data that has been obtained is carried out in order to develop a targeted solution. This process covers various aspects, from the study of the planned system, designing the optimal architectural structure, and selecting the technology to be used, such as CameraX, TensorFlow, Restful API, and Midtrans API. In addition, this analysis also considers non-technical needs such as hardware and software needed to support system performance. Not only that, this stage also includes the development of use cases and

interface design to ensure that the system is easy to operate and meets user expectations.

2.4 Implementation and Testing

The implementation process involves developing an application according to the designed design. The first step is to build a Restful API to support the exchange of data needed in the application. Next, integration is carried out with the Midtrans API as a payment gateway to handle payment transactions. In addition, the mobile application will also call all the APIs needed to ensure that all features function in an integrated manner. After the application is developed, the next stage is to conduct testing to assess performance, functionality, and user experience. This testing process ensures that all features function according to the specifications and meet user needs. In addition, testing also aims to identify and fix bugs or problems that may arise to ensure that the application can run smoothly and effectively.

III. Results And Discussion

The system built must meet the needs and provide solutions to existing problems; from the main problem, the picture of the system to be built has features to provide education about waste processing, provide recommendations for recycled products and procedures or stages in recycling waste based on waste that has been detected by the application, and provide a marketplace feature to market recycled products that users have made.

3.1 System Architecture

The image in Fig. 2 describes the system architecture in the Android-based waste processing and recycling marketplace application.

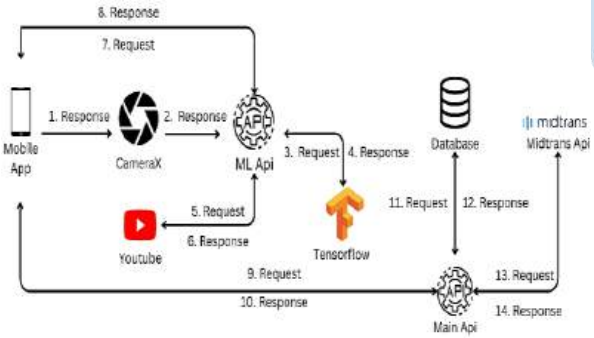


Fig. 2. Architecture of the system

Midtrans API is registered and holds a license from Bank Indonesia and the Payment Card Industry Data Security Standard, using the AES-256 electronic encryption standard so that from a security perspective it can ensure that sensitive data can be protected.

TensorFlow merupakan framework machine learning dan deep learning terpopuler yang dikembangkan oleh Google. Keunggulan utama TensorFlow terletak pada fleksibilitas, skalabilitas, dan performa yang baik.

3.2 CameraX Analysis

CameraX is a library designed to ease the use of cameras on Android devices, especially in dynamic applications involving cameras [15]. CameraX supports devices with Android 5.0 (API Level 21) and above and extends the capabilities of the Camera API, replacing the deprecated native Camera API [16]. With CameraX, various camera functions can be easily implemented in just a few lines of code, and compatibility issues with older devices have been resolved. In the applications built, CameraX takes pictures of objects or trash, which are then processed to find out how to manage and recycle them into products of saleable value. Fig. 3 show about CameraX analysis.

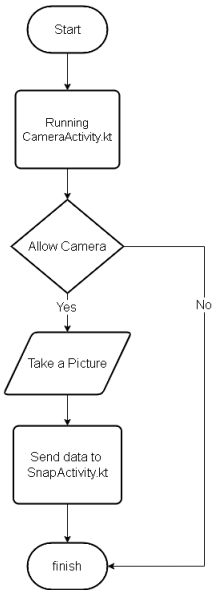


Fig. 3. CameraX Analysis On System

The process flow of using CameraX on the application to be developed:

1. The system runs CameraActiviy.kt to activate the camera.
2. The system asks for permission from the user to activate the camera connected to the device being used.
3. After getting permission, the system starts activating the camera to capture images of objects to be detected.
4. After getting an image of the detected object, the data is sent to SnapActivity for processing.

3.3 TensorFlow Analysis

TensorFlow is an open-source framework from Google for machine learning and deep learning. It provides tools for building and training AI models and supports multiple platforms and programming languages [17]. The analysis of TensorFlow usage in

this application focuses on how it detects objects in the form of garbage that appear in the application. The following is the process of object detection in the ML model.

Fig. 4 show how Tensorflow are use in this application.

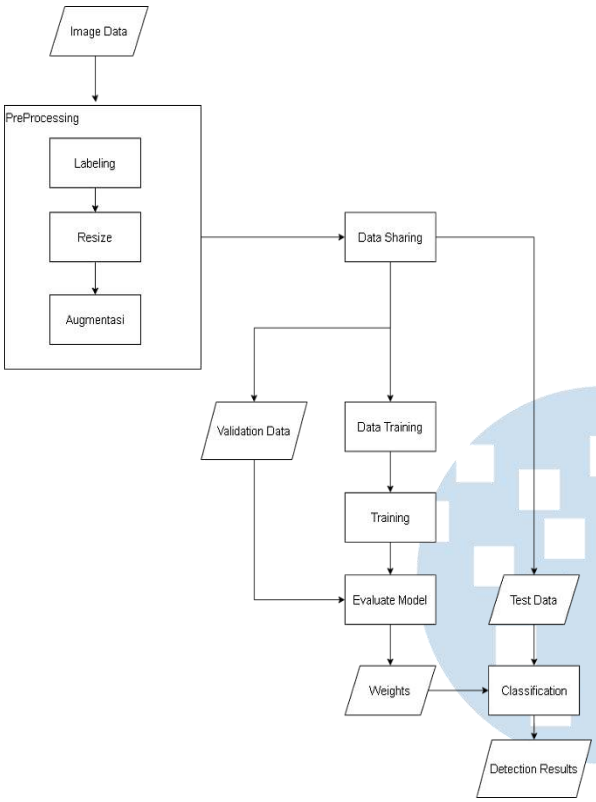


Fig. 4. Detection Object using Tensorflow

The following is an explanation of Fig.4 Object Detection Process using Tensorflow:

1. Image data is data used for preprocessing.
2. After collecting the image data, it enters the preprocessing section, which consists of three processes, including the following:
   a. image labelling to label the image data.
   b. resize, which is to adjust the image size to make it easier to process.
   c. Augmentation is a technique for increasing the diversity of your training set by applying random (but realistic) transformations, such as image rotation.
3. After preprocessing, the next step is data division. In this data division process, the data will be divided into three processes, namely:
   a. Validation Data is the process of validating data from preprocessing, which is then continued in the model evaluation stage.
   b. Training Data is the process of training data here using the CNN Method. After training, it is continued to model evaluation, and finally, the weights from the training results are obtained, which are continued for classification using the CNN method.
   c. Test data is data that will be used for the classification stage using the CNN method until finally, the object detection results are obtained

3.4 ML Api Analysis

ML API is an API where the trained TensorFlow model is converted into a flask app, which is then deployed to the cloud run to be accessed by the mobile app to be built [18][19]. The analysis of the use of ML API focuses on object detection in the application to be built. The following is the process of obtaining data from ML API.

1. Get a response containing the detected object in JSON format as shown in Fig.5.


```
{
    "answer": "Plastic Packaging.",
    "description": "Plastic packaging waste
refers to the type of waste resulting from the
use of various kinds of plastic packaging in
daily life.\n\tPlastic packaging is commonly used
to package food, beverages, household goods,
beauty products, and various other
items.\n\tPlastic packaging waste can have a
negative impact on the environment and
ecosystems. If not managed properly, plastic
packaging can pollute oceans, rivers, and
land.\n\tDiscarded plastic can damage natural
habitats and harm marine life that ingest it or
become entangled in it.\n\tCollective efforts
from individuals, governments, and industries to
reduce single-use plastic packaging, increase
recycling, \n\tand foster innovation in eco-
friendly packaging can help mitigate the plastic
packaging waste problem and preserve our
environmental sustainability.\n",
"file_urls": [
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Plastic%20Flowe
r.jpg",
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Keychain.jpg",
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Wall%20Decorati
on.jpg",
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Bag%20%281%29.j
pg",
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Tissue%20Holder
.jpg",
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Mat.jpg"
    ]
}
```


Fig. 5. ML Api Response

2. Convert objects to JSON representation. This is used to connect between JSON and Kotlin objects in the class as shown in Fig. 6.

```
data class TrashResponse(
   @field:SerializedName("answer")
   val answer: String? = null,
   @field:SerializedName("description")
   val description: String? = null,
   @field:SerializedName("file_urls")
   val fileUrls: List<String?>? = null
)
```

Fig. 6. JSON ML Api Representation

3. Displays object data that has been detected in the application. The data displayed is in the form of detailed information from the waste and recommendations for recycled products that can be made on. This process show in Fig. 7.

```
fun postSnapPlastic(file: File):
LiveData<Result<TrashResponse>> = liveData {
    emit(Result.Loading)
    val imageMediaType =
"image".toMediaTypeOrNull()
    val imageMultiPart: MultipartBody.Part =
MultipartBody.Part.createFormData(
        "file",
        file.name,
        file.asRequestBody(imageMediaType)
    )
    try {
        val response =
apiServiceML.uploadPlastic(imageMultiPart)
        emit(Result.Success(response))
    } catch (e: Exception) {
        e.printStackTrace()
emit(Result.Error(e.message.toString()))
    }
}
```

Fig. 7. Displays the detected garbage data.

3.5 Fire Play Analysis

The main API is a Restful API built using Express.js, a Node.js framework that makes it easy to create web applications and APIs [20]. And MySQL, a popular relational database management system [21]. This API serves as a connector for data exchange within the application being developed, facilitating communication between various system components and ensuring effective data integration [22]. The analysis of the use of Main Api focuses on the exchange of user and marketplace data within the application to be built. The following is the process of getting data from Main Api.

1. Get a response in the form of user data logged into the application in JSON format. This process show in Fig. 8.

```
{
    "payload": {
        "token":
"eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJpZF9wZW1
iZWxpIjozNCwaWF0IjoxNzI2A"
    },
    "status_code": 200,
    "message": "Login successful",
}
```

Fig.8. Displaying Login Response

2. Convert the object to JSON representation. This is used to connect between JSON and Kotlin objects in the LoginResponse class. This process show in Fig.9.

```
data class LoginResponse(
   @field:SerializedName("status_code")
   @field:SerializedName("pagination")
   @field:SerializedName("payload")
   @field:SerializedName("message")
)
data class Payload(
   @field:SerializedName("token")
)
```

Fig.9. JSON Representation of Main API Login

3. Method for sending a request to log in to the application. This process show in Fig.10.

```
suspend fun login(
    email: String,
    password: String
): LiveData<Result<LoginResponse>> = liveData {
    try {
        Log.d("UserRepository", "Attempting login
with email: $email")
val loginRequest = LoginRequest(email, password)
val response = apiService.login(loginRequest)
        Log.d("userRepository", "Login response:
$response")
        }
    } catch (e: Exception) {
        Log.e("UserRepository", "Login failed:
${e.message}")
        e.printStackTrace()
        val errorMessage = when (e) {
            is HttpException -> {
                when (e.code()) {
                 401 -> "Invalid email or
password"         404 -> "User not found"
else -> "Login failed, please try again later."
}
            }
```

Fig. 10. Method Login

3.6 Midtrans Api Usage Analysis

Midtrans API is a payment gateway service that enables the integration of payment systems into applications or websites [23]. Midtrans provides various payment methods, such as credit cards, bank transfers, and e-wallets, as well as features for managing transactions and payment verification. This API makes it easy for developers to implement secure and efficient payment solutions in their applications [24]. The Midtrans API payment gateway service is used in this study because it provides various payment methods for transactions within the application. API integration with Midtrans involves creating an invoice that allows users to choose the appropriate payment method. Fig.11 shows the response obtained from creating an invoice using the Midtrans API.

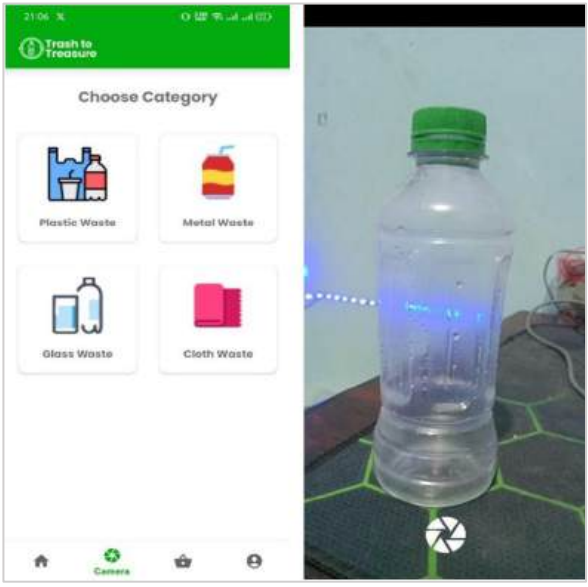
```
{
    "success": true,
    "message": "Successfully created invoice",
    "data": {
    "order_id": "b9e79430-92c-4112-8cd2",
    "invoice_number": "INV-172620065341",
    "published_date": "2024-09-13 11:17:48,
        "due_date": "2024-09-14 11:17:45,
        "invoice_date": "2024-09-13 11:17:45",
            "customer_details": {
            "id": null,
            "name": "Eko",
            "email": "eko@example.com",
            "phone": "62812345689"
        },
        "item_details": [
            {
                "item_id": null,
                "description": "midtrans pillow",
                "quantity": 1,
                "price": 50000
            }
        ],
        "id": "66e3bcecad0dd74431",
        "status": "pending",
        "gross_amount": 50000,
        "pdf_url":
"https://assets.midtrans.com/invoices/A3EvrJB",
        "payment_type": "payment_link",
        "virtual_accounts": [],
        "payment_link_url":
"https://app.midtrans.com/payment-links/14490b03"
    }
}
```


Fig.11. Response Midtrans Api

IV. Results And Discussion

The implementation of the interface is the result of the implementation stages of the research that have been designed previously according to user needs. So, in this case, the researcher intends to provide an overview of the implementation results that have been made for the waste processing application and recycling marketplace. The implementation of the application interface in Fig. 12 shows the process of selecting the category of waste type and the process of taking pictures of object.

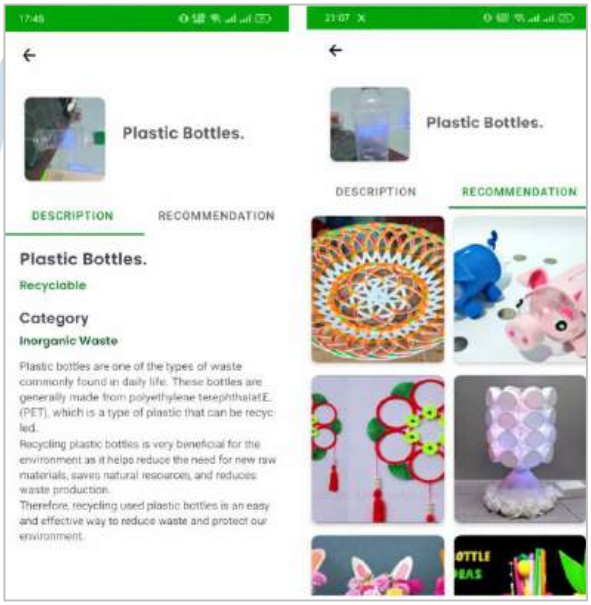
Figure 12 (a) shows the waste category selection page, where users can select the type of waste to be detected by the system. On this page, there are four categories of waste that can be identified through the TensorFlow model that has been deployed and converted into an API. The API is then integrated into the application to process and detect the type of waste selected by the user. This process allows the application to provide accurate detection results according to the selected waste category.



(a) (b)

Fig. 12. Select category (a) and Detect waste (b)

Figure 12 (b) shows the image capture process page using CameraX technology. On this page, users can take pictures of the waste objects they want to detect. After the image is taken, the image file is sent to the machine learning API (ML API) that has been prepared to detect and classify waste based on the TensorFlow model used. CameraX technology makes it easy for users to easily take pictures and send them to the API for further processing so that the entire process runs efficiently.



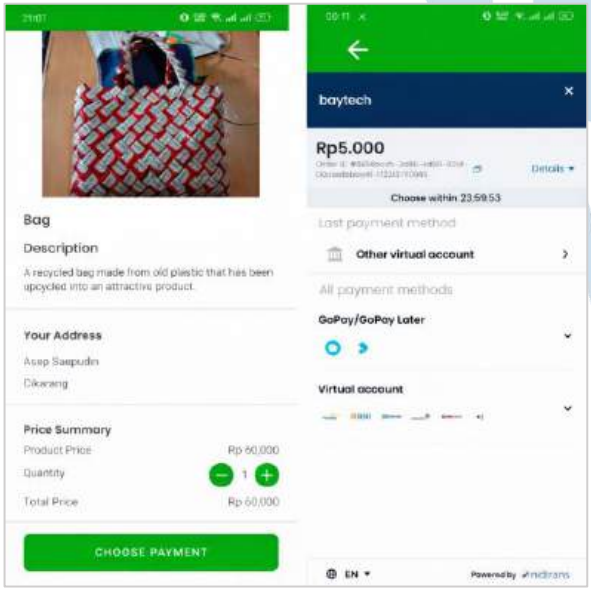
(a) (b)

Fig. 13. Waste Detection Results (a) and Product Recommendations (b)

Figure 13 (a) displays a page containing a complete description of the waste detection results, where users can see information about the type of waste detected,

the category of the waste, and a detailed explanation of the characteristics of the waste. These detection results are obtained from processing carried out by the TensorFlow model that has been deployed and converted into a Machine Learning API (ML API). After the waste image is uploaded and processed by the API, the system displays detailed and accurate results regarding the waste that has been analyzed. Users can understand more about the type of waste through the description provided, including what category the waste falls into and what its general characteristics are.

Figure 13 (b) shows a list of recommendations for recycled products that can be made from the detected waste. Based on the detection results from TensorFlow, the system provides various creative ideas on how the identified waste can be reprocessed into recycled products that have economic value. This list is compiled by considering the nature and category of waste, as well as its potential use in the recycling process. This not only helps users understand the type of waste produced but also provides practical guidance for utilizing the waste in an effort to protect the environment and produce useful products. This integration of waste detection with recycling recommendations provides added value for users, as it not only identifies environmental problems but also offers creative and sustainable solutions.



(a) (b)

Fig.14. Product Purchase Process (a) and Payment Process (b)

Figure 14 (a) displays a dedicated page for purchasing recycled products, where users can view a variety of important information related to the products they wish to purchase. The information displayed includes the product name, a brief description of the product, the buyer's shipping address, the product price, the purchase amount, and a button to proceed to the payment process. The product description provides a clear picture of the recycled materials used, the manufacturing process, and the environmental benefits generated. Users can also adjust the purchase amount as needed before proceeding to the payment stage. This page not only functions as a place for transactions but also as an educational tool for users about the benefits of recycled products, both from an economic and environmental perspective.

Figure 14 (b) displays the payment invoice page that appears after the user chooses to continue the transaction. On this page, users are presented with various payment methods available to complete the transaction. Integration with Midtrans allows users to choose the payment method that best suits their preferences, be it via bank transfer, e-wallet, or other payment methods. This simplifies the payment process while providing users with the flexibility to make transactions conveniently. This payment system also ensures security and speed in processing payments so that users can immediately complete their purchases of recycled products smoothly. Functional testing result show in Table 1.

TABLE I. FUNCTIONAL TESTING

Functional Tested	Test details	Testing Result
Register As Seller	Users fill out a form containing the bank name and account number.	Successfully seller registration process
Edit Seller Data	The user changes the data form containing the bank name and account number.	Successfully edited seller data
Order Information Incoming	The user presses the incoming order menu, then the system displays a list of incoming orders.	Successfully order menu
Displaying Marketplace Data	The user presses the marketplace navigation, after which the system will display the marketplace data.	Successfully display merketplace data
Performing Waste Detection	The user takes a picture of the trash and then the system detects the trash.	Succesfully take picture and detected the trash
Selling Products	The user presses the sell product button, then the system displays the product sales form.	Succesfully selling product
Showing my Products	The user presses the my product button, then the system displays a list of my products.	Successfully showing list product
Change my Product	The user clicks on one of the products displayed in the list, then the system displays a form to change the product.	Successfully change product data

Based on the testing that has been carried out using the black box method, the implementation of the various features that have been designed in this study was declared successful. It functioned according to

expectations [25]. Each feature was thoroughly tested to ensure that its functionality runs well without any significant errors or bugs [26]. This testing involves simulating the use of the application from the end user's perspective, where the system is tested in terms of input and output to ensure that all features, such as garbage detection, image capture, data processing, and payment processes, can run smoothly [27].

The test results show that the designed features have been implemented well, in accordance with the objectives of the study. This application was also tested directly by users through an User Acceptance Testing. for ensuring a system meets the real-world needs of its users [28]. Some questions related to the problems being solved are reducing waste accumulation, making it easier to recycle waste, making it easier to market recycled products, making waste have economic value, providing education about waste recycling.

Testing was carried out by distributing questionnaires to 25 respondents. User responses will be analyzed using a Likert scale to measure their perceptions of the performance and usability of the application [29]. The results of this analysis are expected to provide further insight into how well the application meets user needs and whether there are areas that need to be improved [30]. Table 2 show user testing result using a likert scale.

TABLE II. USER ACCEPTANCE TESTING RESULT

Questions	Result
Can the existence of waste processing applications and recycled product marketplaces help reduce the problem of waste accumulation?	88%
Can the existence of waste processing applications and recycled product marketplaces make it easier for people to recycle?	93,36%
Can the marketplace feature help people market their recycled products?	88,8%
Can the marketplace feature help turn waste that has no economic value into one that has economic value?	89,6%
Can the existence of waste processing applications and recycling marketplaces provide education about recycling to the public?	91,2%

IV. CONCLUSION

Based on the results of implementation, discussion, and testing, it can concluded that the Waste Processing Application and Recycled Product Marketplace have successfully provides innovative technology-based solutions to support the Sustainable Development Goals (SDGs) related to effective waste management and utilization. This application has succeeded in providing more knowledge to the public about waste management, which can help reduce waste problems. In addition, this application makes it easier for the public to recycle by providing appropriate recommendations based on the type of waste and also helps the public in marketing recycled products through the marketplace feature, so that these products can be promoted and sold more widely. Further research focus to develop a more comprehensive shipping and tracking delivery feature to improve the quality of service and customer satisfaction.

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Expert System for Diagnosing Human Psychological Disorders Using the Forward Chaining Method

Hesti Yulianingsih[1], Hetty Rohayani[2]
[1 2] Universitas Muhammadiyah Jambi, Indonesia
[1]hestiylia@gmail.com, [2]hettyrohayani@gmail.com

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***Abstract*— This study aims to develop an expert system for the early diagnosis of human psychological disorders using the Forward Chaining method. The knowledge base was constructed based on the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) and relevant psychological literature, and subsequently validated through an expert judgment process involving a psychology expert to ensure the appropriateness of diagnostic rules. The system is capable of identifying eight types of psychological disorders based on twenty main symptoms represented as IF–THEN rules. System evaluation was conducted using predefined test scenarios and accuracy measurement through a confusion matrix. The experimental results indicate that the system achieves an accuracy of 85%, demonstrating that the Forward Chaining method is effective as an inference mechanism for early mental health screening. This system serves as a decision-support tool and is not intended to replace professional psychological diagnosis.**

***Index Terms*— Expert System; Forward Chaining; Psychological Diagnosis; Mental Health; Knowledge Base**

I. INTRODUCTION

Psychological health is a fundamental aspect that influences a person's quality of life, mindset, behavior, and ability to carry out daily activities. In recent years, cases of psychological disorders such as depression, anxiety, severe stress, and personality disorders have continued to increase. However, public awareness of mental health screenings and consultations remains relatively low. Factors such as lack of education, limited availability of experts, high consultation costs, and social stigma make early detection difficult, resulting in many individuals only seeking treatment when their condition has already worsened [1].

The development of information technology provides a significant opportunity to provide early detection services for mental health through an expert system approach. Expert systems have been widely used in various health fields, for example, in the early detection of stunting using the Forward Chaining method, which has proven effective in gradually analyzing symptoms to produce a diagnostic decision [1]. A similar approach has also been applied to website-based early detection of asthma risk, demonstrating that Forward Chaining can work optimally in symptom-based initial consultation systems [2].

In addition to the health sector, expert systems have also proven effective in assisting technical diagnostic processes. For example, the Certainty Factor method was used to diagnose Android smartphone damage and was able to provide accurate results based on the level of confidence in rules and symptoms [3]. Another study applied the Forward Chaining method to diagnose computer hardware damage, and the results showed that this method was capable of systematic and consistent rule-based reasoning [4]. The success of these various studies shows that the application of expert systems, including Forward Chaining, has great potential for application in the psychological domain.

Furthermore, expert systems have also been specifically used to detect early anxiety disorders in adolescents using the Forward Chaining method. This study proves that expert systems can assist the early screening process for psychological disorders by adapting to the rules and symptoms entered by the user [5]. This reinforces the importance of developing an expert system for early diagnosis of psychological disorders, particularly for increasing access to independent, flexible, and easy-to-use early consultation services.

Although numerous studies have implemented expert systems and Forward Chaining methods in the healthcare domain, most existing research focuses on physical disease diagnosis or technical problem identification. Studies specifically addressing psychological disorder diagnosis remain limited, and many do not clearly describe expert involvement in knowledge validation or provide measurable system performance evaluation.

Therefore, this study addresses these limitations by developing a Forward Chaining-based expert system for early psychological disorder diagnosis that is

grounded in DSM-5 guidelines, explicitly validated through expert judgment, and evaluated using quantitative accuracy measurement. The main contribution of this research lies in the structured knowledge base design, expert-validated diagnostic rules, and measurable system performance for early mental health screening.

II. LITERATURE REVIEW

Expert systems are a branch of artificial intelligence designed to replicate the reasoning process of human experts in solving specific problems. These systems operate using a knowledge base and a set of rules that enable them to produce diagnoses or conclusions. One example of their implementation can be seen in a study that developed an expert system to diagnose Android smartphone damage using the certainty factor method, where the system was able to provide diagnostic results based on confidence levels assigned to user-provided symptoms [3]. The certainty factor method itself is a technique used to handle uncertainty in the reasoning process and is highly suitable for diagnostic cases that have similar or overlapping symptoms. This method has also been applied to a web-based expert system for diagnosing mental disorders in children, demonstrating that the combination of knowledge-based rules and certainty values can improve diagnostic accuracy [6].

In addition to the certainty factor, rule-based reasoning techniques such as Forward Chaining are widely utilized in expert system development. Forward Chaining works by tracing user-provided facts to find matching rules, then producing a conclusion based on those conditions. This method has proven effective in health-related applications, such as an early detection system for asthma risk that utilized Forward Chaining as its primary reasoning mechanism [2]. Its ability to process symptoms step by step has also been applied in the development of expert systems for diagnosing computer hardware damage, showing that Forward Chaining can be implemented flexibly across various problem domains [4].

In the context of mental health, understanding the symptoms and classifications of psychological disorders is essential as the foundation of building a knowledge base for expert systems. Several studies emphasize the importance of mental health education—especially among adolescents—to enhance awareness and the ability to identify early signs of psychological disorders. Mental health education programs have been proven to improve adolescents' understanding of risks and symptoms, enabling them to take appropriate early actions [7]. Similar efforts have been conducted through peer-education programs, which aim to provide knowledge regarding risk factors and prevention of mental disorders, while encouraging adolescents to support each other in maintaining psychological well-being within their communities [8].

Furthermore, knowledge of the types and characteristics of mental disorders is an important component in developing expert systems. Studies on mental disorders describe various types, causes, and symptoms that can be used as parameters in expert systems for psychological diagnosis [10]. This information serves as a basis for determining symptoms, rules, and diagnostic classifications within the developed system.

The application of expert systems in the field of psychology continues to grow, one example being the development of an expert system designed to detect early signs of anxiety disorders in adolescents. This study implemented Forward Chaining to trace anxiety-related symptoms and generate an initial diagnosis that could help users better understand their psychological condition before seeking professional assistance [5]. This demonstrates that expert systems can serve as an effective preliminary screening tool for psychological disorders, particularly for individuals who do not yet have direct access to mental health services.

III. RESEARCH METHODOLOGY

This study employs a knowledge-based expert system approach to perform early diagnosis of psychological disorders. The diagnostic knowledge was acquired from the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) and relevant psychological literature. The knowledge acquisition process focused on identifying key psychological symptoms and their relationships with specific psychological disorders to ensure diagnostic relevance and consistency.

The psychological symptoms used in this study were selected based on DSM-5 diagnostic criteria and subsequently reviewed through an expert judgment process involving a psychology expert. The expert evaluated the relevance and clarity of each symptom to ensure that the selected symptoms accurately represent the characteristics of psychological disorders. The finalized set of psychological symptoms used by the system is presented in Table 1.

TABLE I. PSYCHOLOGICAL DISORDER SYMPTOM DATA

Code	Symptom
G1	Loss of interest or pleasure in activities
G2	Sleep disturbances (insomnia/hypersomnia)
G3	Excessive anxiety without clear triggers
G4	Difficulty concentrating
G5	Easily irritated or emotionally reactive
G6	Intense fear of social situations
G7	Excessive fear of specific objects or situations

G8	Recurrent panic attacks
G9	Feelings of worthlessness or excessive guilt
G10	Avoidance of situations due to anxiety
G11	Extreme fatigue without physical cause
G12	Negative thoughts about oneself
G13	Difficulty controlling emotions
G14	Heart palpitations and shortness of breath
G15	Difficulty building interpersonal relationships
G16	Extreme mood swings
G17	Withdrawal from social environments
G18	Trauma and flashbacks of distressing events
G19	Increased stress over minor pressures
G20	Suicidal thoughts or desire to end life

Psychological disorders included in this study were determined based on DSM-5 classifications and expert validation. Each disorder represents a specific category of psychological conditions that can be identified through combinations of selected symptoms. The list of psychological disorders and their corresponding codes is shown in Table 2.

TABLE II. PSYCHOLOGICAL DISORDER DATA

Disorder Code	Disorder Name	Brief Description
P01	Anxiety Disorder	Persistent and intense anxiety accompanied by physical symptoms
P02	Major Depressive Disorder	Ongoing sadness, loss of interest, fatigue, pessimism
P03	Panic Disorder	Recurrent panic attacks with severe physical reactions
P04	Specific Phobia	Excessive fear towards certain objects or situations
P05	Social Anxiety Disorder	Intense fear in social interactions or performance situations
P06	PTSD (Post-Traumatic Stress Disorder)	Trauma flashbacks, nightmares, avoidance of triggers
P07	Bipolar Disorder	Extreme emotional changes between mania and depression
P08	Acute Stress Disorder	Mental and physical exhaustion due to high stress

Diagnostic knowledge was represented in the form of IF–THEN rules that define the relationships between psychological symptoms and disorder categories. These rules were formulated based on DSM-5 guidelines and refined through expert judgment to ensure logical consistency and diagnostic accuracy. The final set of expert-validated Forward Chaining rules applied in the system is presented in Table 3.

TABEL III. FORWARD CHAINING RULES (IF – THEN)

Rule Code	Rule
R01	IF G03 AND G04 AND G14 THEN P01 (Anxiety Disorder)
R02	IF G01 AND G02 AND G11 AND G12 THEN P02 (Major Depression)
R03	IF G08 AND G14 AND G19 THEN P03 (Panic Disorder)
R04	IF G07 AND G14 THEN P04 (Specific Phobia)
R05	IF G06 AND G10 AND G15 THEN P05 (Social Anxiety Disorder)
R06	IF G18 AND G19 AND G01 THEN P06 (PTSD)
R07	IF G16 AND G04 AND G15 THEN P07 (Bipolar Disorder)
R08	IF G11 AND G05 AND G19 THEN P08 (Acute Stress Disorder)

The Forward Chaining method was applied as the inference mechanism in this expert system. The reasoning process begins with psychological symptoms selected by users as initial facts. These facts are sequentially matched against the IF–THEN rules defined in Table III. When all conditions of a rule are satisfied, the system generates a diagnostic conclusion corresponding to the identified psychological disorder. This inference approach ensures transparent and systematic rule-based reasoning.

The performance of the proposed expert system was evaluated using predefined test cases derived from the constructed knowledge base. Each test case consisted of a combination of psychological symptoms and a corresponding diagnosis determined by a psychology expert.

The diagnostic results generated by the system were compared with expert diagnoses and summarized using a confusion matrix consisting of True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN) values. System accuracy was calculated using the following formula:

$$Accuracy = \frac{TP + TN}{TP+TN+FP+FN} \times 100\%$$

This evaluation approach was employed to measure the system's ability to generate accurate early

diagnostic indications and to assess the effectiveness of the Forward Chaining inference mechanism.

IV. RESULTS AND DISCUSSION

This chapter presents the results of the research obtained through the design of an expert system for diagnosing human psychological disorders using the Forward Chaining method, along with the discussion based on inference logic analysis and case simulation. This study focuses on the conceptual development of the expert system through the construction of a knowledge base and rule-based inference mechanism, without implementing the system into a software application or coding environment.

The results of the study indicate that the Forward Chaining method can be applied to perform early diagnosis based on psychological symptoms experienced by individuals. The decision-making process is carried out by matching factual symptom input with the rules available in the knowledge base. Each symptom acts as an initial fact, and the system traces the rules sequentially until a conclusion regarding the type of psychological disorder is generated.

The knowledge base was developed based on psychological literature sources and expert validation references. Rules were constructed in a tabular form describing the relationship between symptoms (G) and psychological diagnoses (D). The following table presents a portion of the rules used in the system:

Rule Code	Symptoms	Psychological Disorder Diagnosis
R01	G1, G2, G4, G6	Depression
R02	G3, G7, G9	Bipolar Disorder
R03	G2, G5, G8	Anxiety Disorder
R04	G4, G8, G10	PTSD (Post-Traumatic Stress Disorder)

Symptom descriptions:

G1 = Persistent sadness

G2 = Difficulty sleeping / insomnia

G3 = Extreme mood changes

G4 = Loss of interest and motivation

G5 = Excessive fear

G6 = Lack of enthusiasm for daily activity

G7 = High energy followed by extreme fatigue

G8 = Frequent anxiety or panic

G9 = Impulsive behavior and irritability

G10 = Deep trauma caused by a specific event

To evaluate the effectiveness of the Forward Chaining inference process, a simulation case was conducted to test whether the rules could produce conclusions accurately. The sample diagnostic scenario is presented below:

Simulation Case

A user reports the following symptoms:

- (G1) Persistent sadness
- (G2) Difficulty sleeping
- (G4) Loss of interest
- (G6) Lack of enthusiasm

These symptoms are entered into the system as initial facts. The system then matches the facts with the existing rules:

If G1 AND G2 AND G4 AND G6

Then Diagnosis = Depression

(Referring to Rule R1)

Based on the Forward Chaining inference process, the system generates an initial diagnostic result indicating Depression. This outcome serves as preliminary information that can support users in seeking further psychological consultation or professional mental health evaluation.

From the rule-based case simulation results, it was found that the Forward Chaining method can assist in identifying potential psychological disorders through combinations of selected symptoms. The system-generated diagnostic conclusions are produced through a logical and systematic reasoning process based on predefined rules. In addition to quantitative evaluation, the diagnostic results and rule consistency were reviewed by a psychology expert to ensure alignment with established psychological diagnostic principles.

Overall, this study demonstrates that the expert system design using the Forward Chaining method is capable of producing early diagnostic indications that can be used as reference material in identifying psychological disorders. However, the system is limited because the results are indicative in nature and do not replace professional psychological assessment. Future work is recommended to implement the system as a web-based or mobile application and to evaluate its performance using a broader dataset.

V. CONCLUSION

This study presented the development of a rule-based expert system for early diagnosis of psychological disorders using the Forward Chaining method. The knowledge base was constructed based on DSM-5 guidelines and relevant psychological literature and validated through expert judgment involving a

psychology expert to ensure the appropriateness of diagnostic rules.

The evaluation results obtained through rule-based case simulation indicate that the proposed system is capable of generating logically consistent early diagnostic indications based on selected symptoms. Quantitative evaluation using a confusion matrix shows that the system achieved an accuracy of 85%, demonstrating the effectiveness of the Forward Chaining inference mechanism for early mental health screening.

Nevertheless, the diagnostic results produced by the system are indicative in nature and are not intended to replace professional psychological assessment. Future research is recommended to implement the proposed system in a web-based or mobile application and to further evaluate its performance using a larger and more diverse dataset.

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Development of a Web-Based Agricultural E-Marketplace Using Laravel

Agustin Setiyorini[1], Jeffry Andhika Putra[2], Muhammad Febriyansyah[3], Venesse Kaylasha Alvino Putri[4]

[1,3.4]Department of Informatics, Universitas Janabadra, Yogyakarta, Indonesia
[2]Department of Digital Business, Universitas Janabadra, Yogyakarta, Indonesia

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***Abstract*— The agricultural sector plays a vital role in Indonesia's economic structure and food security, yet rural farmers often face significant challenges regarding market access and long, detrimental distribution chains. This study aims to design and build a web-based e-marketplace system that facilitates direct transactions between farmers and buyers to cut off conventional distribution lines. The system development method used is the Waterfall model, which includes requirements analysis, system design, implementation, and testing phases. The system was built using the PHP programming language with the Laravel framework for the back-end and MySQL for database management. The results indicate that the developed platform successfully provides features for managing products, categories, orders, and real-time sales reports. Based on Black Box testing on 10 main functional scenarios, the system proved valid and operated according to user specifications without functional errors. In conclusion, this e-marketplace is effective as a technological solution to expand the market reach of local farmers and increase the efficiency of agricultural product transactions.**

***Index Terms*— Agricultural Products; E-marketplace; Information System; Laravel; Waterfall**

I. INTRODUCTION

The agricultural sector is a fundamental pillar of Indonesia's economic structure, playing a crucial role in national food security and labor absorption. According to recent data, this sector contributes significantly to the livelihoods of the rural population [1]. However, despite its strategic importance, the agricultural distribution system in Indonesia faces systemic inefficiencies. A major bottleneck lies in the traditional supply chain, which is dominated by multiple layers of intermediaries (tengkulak). This structure creates a significant price disparity, where farmers receive low farm-gate prices while consumers pay high market prices. In rural areas such as Temanggung Regency, this issue is exacerbated by limited access to wider markets and a lack of real-time price information, leaving farmers with weak bargaining power [2], [3].

Specific observations at the "Berkah Tani" community in Temanggung reveal that the marketing process is still predominantly conventional. Farmers rely on local buyers who dictate prices, often resulting in minimal profit margins that do not cover production costs. Furthermore, the lack of digital infrastructure integration prevents these farmers from reaching potential buyers outside their region. While digital transformation concepts like e-marketplaces offer a solution to cut the distribution chain and promote price transparency [4], the adoption rate remains low due to the unavailability of platforms specifically tailored to the technical and functional needs of local farming communities [5].

To address these challenges, various technological approaches have been explored in previous studies. Susandi et al. developed an Android-based e-commerce system for agriculture [6]. However, this mobile-only approach limits accessibility for users who prefer desktop environments for managing large inventories. Another study by Sipayung et al. implemented a web-based marketplace using native PHP [7]. While functional, systems built on native PHP often suffer from security vulnerabilities, such as susceptibility to SQL Injection, and are difficult to scale compared to modern frameworks. Other research utilizing the Laravel framework focused on management but lacked comprehensive transactional features for external buyers [8].

A significant research gap exists in developing a secure, scalable, and user-friendly web platform that addresses both the security concerns of native development and the usability needs of rural farmers. This research aims to bridge this gap by developing an E-Marketplace using the Laravel Framework. Laravel was selected for its Model-View-Controller (MVC) architecture, which provides superior security features (such as CSRF protection), modularity, and ease of maintenance compared to native PHP or other legacy systems [9].

This study proposes the design and development of a robust web-based E-Marketplace specifically for the "Berkah Tani" community. The innovation of this research lies in the integration of a secure framework with a simplified user interface designed to accommodate the specific business processes of local farmers, such as harvest capability management and direct-to-consumer transactions. By digitizing the sales process, this system aims to shorten the supply chain,

increase farmer's income by eliminating unnecessary intermediaries, and provide data-driven insights for better agricultural management.

II. METHODOLOGY

This research applies the Waterfall development model. This method was selected for its systematic and sequential characteristics, ensuring each phase from analysis to testing is thoroughly completed and documented before moving to the next [10]. The development stages are detailed as follows:

A. Requirement Analysis

This phase involves a comprehensive process of identifying software and hardware requirements through direct observations of the partner's business processes. The analysis aimed to determine the functional specifications needed to solve the partner's problems. The requirements gathering process involved direct engagement with key stakeholders. Primary data was collected through semi-structured interviews and field observations at the 'Berkah Tani' community in Temanggung, specifically involving Mr. Edi as the community leader. This ensured that the system modules, such as real-time sales reporting and coupon management, were directly aligned with the actual business needs of the local farmers. Functional requirements identified include robust authentication systems for admins and buyers, a product management module (CRUD), shopping cart functionality, and real-time order status tracking. The system was developed and tested within a specific runtime environment to ensure stability and security. The software stack includes PHP version 8.1.10, Laravel Framework version 9.33.0, and MySQL as the Database Management System. This environment provides native security features such as CSRF protection and Bcrypt password hashing, which are essential for a secure e-marketplace. On the software side, Visual Studio Code version 1.83.0 was chosen as the primary text editor, while XAMPP version 3.3.0 was used to simulate the local server environment.

B. System Design

In this stage, the system architecture is visualized using Unified Modeling Language (UML) to create a blueprint of the software. The design process comprises creating Use Case diagrams to model the interactions and privileges between actors (Admin, Customer Service, and Buyers) and the system.

Furthermore, Activity diagrams are developed to illustrate the logic flow of business processes, ranging from user registration to the complexity of order completion. Simultaneously, the database structure is designed using Entity Relationship Diagrams (ERD) to define the schema and relationships between key tables such as users, products, and orders, ensuring data integrity and normalization before the coding phase begins.

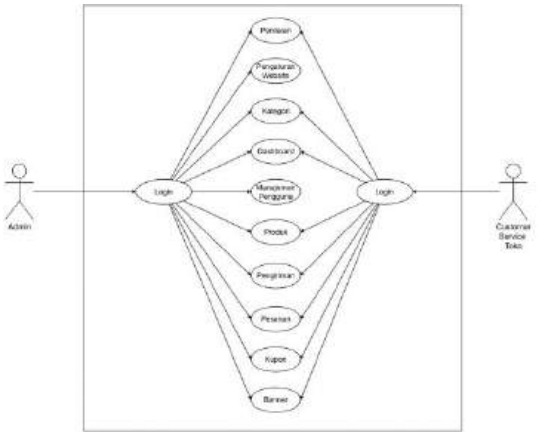

Fig. 1. Use Case Diagram Admin and Customer Service

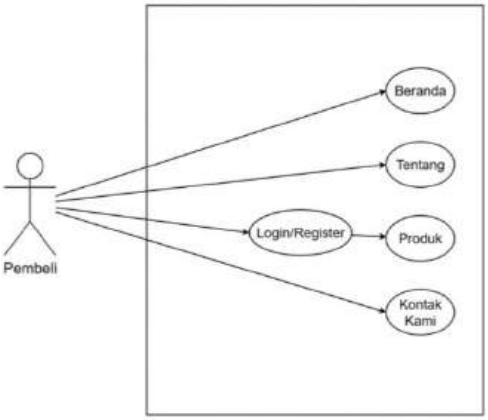

Fig. 2. Use Case Diagram Buyers

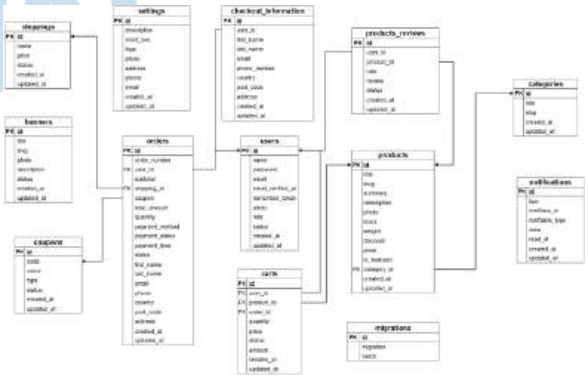

Fig. 3. Entity Relationship Diagram

C. Implementation

The implementation phase translates the design blueprints into executable program code. The back-end logic is constructed using the PHP programming language within the Laravel 9 framework environment. Laravel was specifically chosen for its Model-View-Controller (MVC) architecture, which separates business logic from the user interface, making the code

more modular and maintainable. The system utilizes Laravel's Eloquent ORM for efficient and expressive database interactions using MySQL as the Database Management System (DBMS). Additionally, the system incorporates built-in security features to protect against common vulnerabilities such as SQL Injection and Cross-Site Request Forgery (CSRF). The front-end interface is developed using Blade templating, combined with HTML and CSS to ensure a responsive and user-friendly experience.

D. Testing

The final phase is system testing, which is conducted using the Black Box Testing method. This approach focuses on validating the input-output functionality of the application without inspecting the internal code structure [11]. The testing process involves executing a series of test scenarios that cover 10 critical features of the e-marketplace, including login validation, product data management, cart updates, and the checkout process. The primary objective is to verify that the system functions 100% according to the initial requirements and is free from functional errors before deployment.

III. Result and Discussion

The implementation of the E-Marketplace system utilizing the Laravel framework has been successfully deployed to assist the "Berkah Tani" community in Temanggung. Previously, marketing and transaction processes were conducted manually, relying heavily on intermediaries (tengkulak) and limited local interactions. The proposed system digitizes these processes, offering distinct interfaces for Administrators and Buyers to facilitate seamless transactions.

A. User Interface Implementation

The system's design focuses on user-friendliness to ensure adoption by farmers and buyers. Before detailing the specific interface pages, the overall operational flow of the system is presented to illustrate the business logic.

A.1. System Workflow (Flowchart).

The fundamental logic of the application is visualized through a flowchart, as shown in Figure 1. This diagram maps the complete transaction cycle, starting from the user login validation, proceeding to the product selection by the buyer, and culminating in the secure checkout process. It also illustrates the backend decision-making process where the admin verifies the order before the transaction is finalized. This logical flow serves as the blueprint for the interface implementation described in the subsequent sections.

A.2. Admin Dashboard.

The dashboard serves as the central control unit for the administrator. As shown in Figure 5, it visualizes critical data such as total products, categories, incoming orders, and a graphical representation of monthly sales. This visualization allows the admin to monitor business performance in real-time, a capability not present in the conventional method.

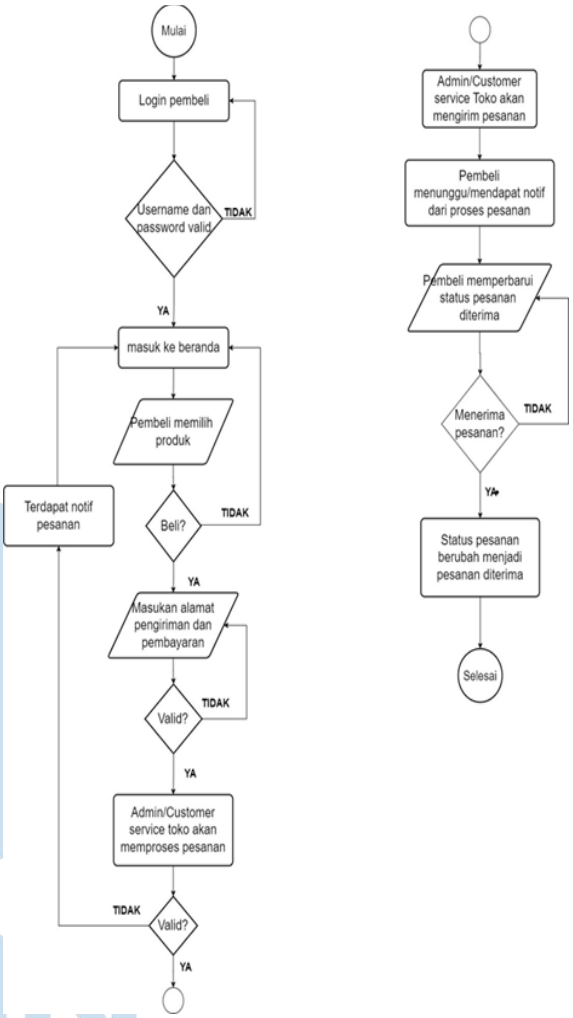

Fig. 4. System Purchasing Flowchart

Fig. 5. Admin Dashboard

A.3. Product Management Interface.

Figure 6 illustrates the product management page where farmers (via admin/CS) can upload commodities. The system allows detailed input including product names, categories, prices, stock availability, and images. This digital catalog replaces

the traditional method of physical product display, enabling 24/7 visibility to potential buyers.

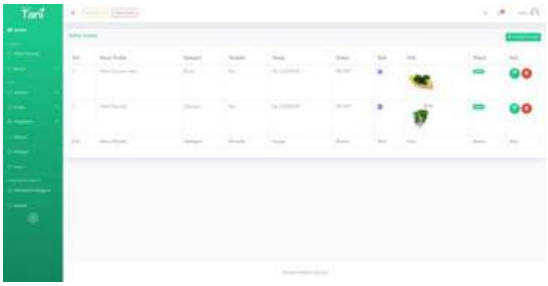

Fig. 6. Product Management Interface

A.4. Transaction and Order Processing.

The transaction interface allows admins to manage incoming orders. As depicted in Figure 7, details such as customer information, total price, and payment status are recorded systematically. This feature eliminates recording errors common in manual bookkeeping. Admins can update the status from "New Order" to "Delivered" through this interface.

Fig. 7. Order Processing Interface

A.5. Shipping Management Interface.

Shipping is a critical component of e-commerce. The shipping management interface (Figure 8) allows the admin to manage shipping rates and track delivery status. As shown in the implementation, the admin can input receipt numbers directly into the system, which will then be visible to the buyer. This transparency builds trust in the transaction process.

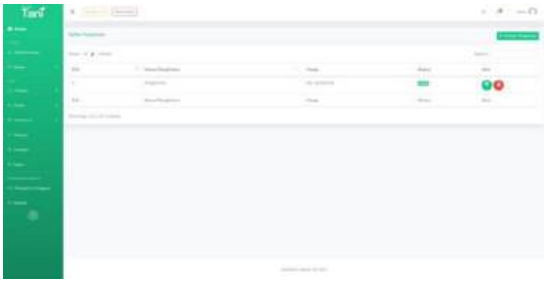

Fig. 8. Shipping Management Interface

A.6. Coupon and Discount Management.

To attract more buyers, a coupon feature was implemented. Figure 9 shows the coupon management page where admins can create discount codes (e.g., "DISKON10"), set the value (percentage or fixed amount), and determine the validity period. This feature provides flexibility for "Berkah Tani" to run promotional campaigns.

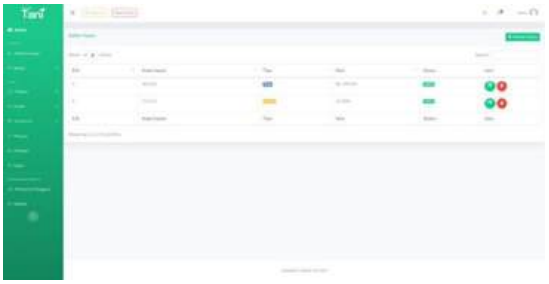

Fig. 9. Coupon Management Interface

A.7. Product Rating and Review Interface.

To maintain service quality and trust, a Rating and Review Interface was developed for the administrator. As shown in Figure 10, this dashboard page is designed to provide comprehensive access for admins to view, manage, and analyze feedback submitted by buyers regarding purchased products. The system utilizes a star-based rating scale (ranging from 1 to 5) to quantify customer satisfaction levels visually. The interface presents a structured table listing essential details such as the reviewer's identity, product title, written comments, and the submission date. Furthermore, admins are equipped with moderation tools, allowing them to view specific details or remove reviews that violate community guidelines or are deemed irrelevant, ensuring the integrity of the feedback displayed on the public storefront.

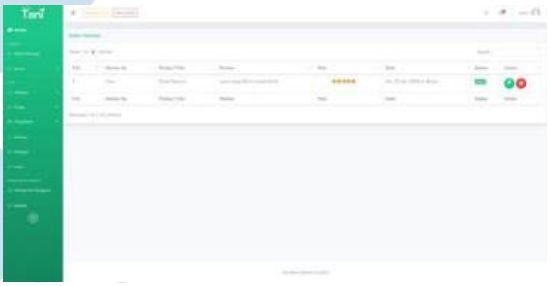

Fig. 10. Product Rating and Review Interface

A.8. User Management Interface.

Security and role management are critical components of the system's administration. The User Management Interface, as depicted in Figure 11, is designed to facilitate the administrator in overseeing all registered accounts within the e-marketplace. This module provides a comprehensive view of system users, ranging from other administrators to customers or buyers. The interface is equipped with full control capabilities, allowing the main admin to add new users (such as appointing new Customer Service staff), edit existing user profiles (including role assignment), and permanently delete accounts that are no longer active or valid. This centralization of user data ensures that system access remains secure and organized.

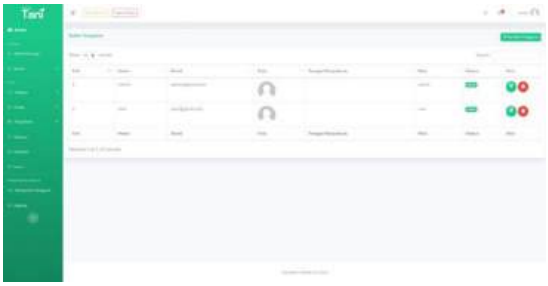

Fig. 11. User Management Interface

B. System Testing Results

System testing constitutes a critical phase in the software development lifecycle, aiming to ensure quality and identify potential functional defects before deployment. To verify that the system meets the functional requirements defined in the design phase, the Black Box Testing method was employed. This approach focuses strictly on the validity of inputs and outputs, assessing whether the application functions according to user specifications without inspecting the internal code structure or logic. The testing process involved executing a comprehensive set of test scenarios using various data inputs to validate ten critical modules of the E-marketplace, ranging from user authentication to transaction processing. The summary of these testing results is presented in Table 1.

C. Discussion

The results of this study demonstrate that the developed e-marketplace successfully digitizes the agricultural trading process in Temanggung, offering distinct advantages over previous solutions in terms of accessibility. When compared to the Android-based system developed by Susandi et al. [6], this web-based platform offers superior flexibility. While Android applications are limited to specific mobile devices and require installation, the proposed e-marketplace is platform-independent, allowing farmers and buyers to access the system via any browser on desktops, laptops, or smartphones. This cross-platform capability ensures that technological barriers regarding device specifications do not hinder market participation for the "Berkah Tani" community.

From a technical perspective, this research addresses the security vulnerabilities often found in native development, such as the system by Sipayung et al. [7]. By implementing the Laravel framework's Model-View-Controller (MVC) architecture, the system inherently benefits from built-in protection against SQL Injection and CSRF attacks, providing a significantly more secure environment for transaction data compared to native PHP solutions. The system's robustness is further confirmed by the 100% validity rate in Black Box testing, indicating that the logic is stable. Additionally, the dashboard visualization feature serves as a crucial decision support tool, effectively resolving the problem of data opacity found in the conventional manual recording method used previously.

TABLE I. BLACK BOX TESTING RESULT

No	Detail				
	Tested Module	**Test Scenario**	**Expected Result**	**Result**	**Status**
1	User Login	Input valid email & password	Redirect to Dashboard	Successful	Valid
2	User Login	(Negative) login with empty fields	System displays validation error	Successful	Valid
3	User Login	(Negative) login with wrong password	System displays "Email/Password salah"	Successful	Valid
4	Dashboard	Access dashboard page	Display stats & graphs	Successful	Valid
5	Category Mgmt	Add/Edit/Delete Category	Data updates in DB	Successful	Valid
6	Product Mgmt	Add/Edit/Delete Product	Catalog updates real-time	Successful	Valid
7	Product Mgmt	(Negative) Add product without uploading an image	System triggers validation error and prevents saving	Successful	Valid
8	Shipping	Set shipping costs	Cost added to checkout	Successful	Valid
9	Order Processing	Update order status	Status changes for buyer	Successful	Valid
10	Rating System	Input review & rating	Review appears on product	Successful	Valid
11	Coupon System	Apply valid coupon code	Total price decreases	Successful	Valid
12	User Mgmt	Admin manages users	Roles assigned correctly	Successful	Valid
13	User Mgmt	(Negative) Add a new user with an invalid email format	System displays "The email must be a valid email address"	Successful	Valid
14	Site Settings	Update site info/logo	Frontend updates	Successful	Valid

IV. CONCLUSION

This research successfully developed a web-based e-marketplace for the 'Berkah Tani' community using the Laravel framework. Functional validation through Black Box testing, including negative test scenarios,

confirmed that all core modules operate with 100% validity. The platform provides a reliable digital infrastructure for managing agricultural products and transactions, effectively replacing manual processes.

For the prospect of future development, several improvements are recommended based on the current system's limitations. First, the integration of an automated payment gateway, such as Midtrans, is highly suggested to replace the manual payment verification process, thereby providing various secure payment methods (e-wallets, virtual accounts) and increasing user trust. Second, considering the mobility of farmers in the field, developing a dedicated mobile application with offline capabilities is necessary to overcome connectivity issues in rural areas. Finally, continuous digital literacy training for the farming community is essential to ensure the sustainable adoption of this technology.

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Measurement of the Usability of the Posyandu Information System for Teenagers using the System Usability Scale (SUS) at the Seruni Posyandu in Tangerang City

Ahmad Sinnun[1], Jenie Sundari[2], Sulistiyah[3]
[1,2,3] Faculty of Informatics and Engineering, BSI University, Jakarta, Indonesia
[1]ahmad.axn@bsi.ac.id, [2]jenie.jni@bsi.ac.id, [3]sulistiyah.slt@bsi.ac.id

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***Abstract*— Usability is a critical factor in the successful implementation of information systems, particularly in community-based health services involving adolescent users. This study aims to measure the usability level of a web-based adolescent Posyandu information system using the System Usability Scale (SUS) instrument. A quantitative descriptive method was applied by involving 10 adolescent respondents selected purposively at Posyandu Seruni, Tangerang City. Respondents were asked to complete several main task scenarios on the system and then provide their assessments through the SUS questionnaire. The results show that the average SUS score was 72.75 with a standard deviation of 10.30 and a 95% confidence interval ranging from 65.38 to 80.12. This score places the system in the "Good" category, indicating that the adolescent Posyandu information system has a fairly good level of usability and is acceptable to users. However, some respondents provided lower scores due to navigation difficulties and unclear terminology within the system. These findings provide a foundation for improving the interface and enhancing user experience in the next development stage.**

***Index Terms*— Posyandu; Teeneger; usability; system; scale; web-based information system**.

I. INTRODUCTION

This research aims to measure the usability level of the Posyandu Remaja information system using the System Usability Scale method at Posyandu Seruni, Tangerang City. This study adopts a descriptive quantitative approach, utilizing the SUS questionnaire to collect user perception data regarding efficiency, ease of use, and overall satisfaction with the system [1]. The System Usability Scale method was chosen for its cost-effectiveness, minimal sample requirements, and relatively short implementation time, yet still provides adequate evaluation of the system's acceptability and usability [2]. This approach is highly relevant for public information systems like the Academic Information System, which aims to improve public services and user satisfaction [3]. Similar research has been widely conducted, such as the usability evaluation of the Simantan Web GIS using the System Usability Scale method with 15 respondents, showing a final SUS score of 70.50[4]. Another study also applied SUS to measure user satisfaction of the Jaring Bencana application, with a SUS score of 68, indicating a "marginally acceptable" category[4]. This demonstrates that SUS is a reliable method for evaluating user experience objectively[5]. The implementation of SUS involves calculating a final score based on questionnaire responses comprising ten questions, where odd-numbered questions contribute positively to the score, and even-numbered questions are calculated inversely to obtain a final value reflecting the system's overall usability[5]. The obtained SUS score is then interpreted to determine the system's acceptability level, where a score above 68 is generally considered good or above average, while a score below 68 indicates a need for improvement [5]. This research will contribute to a better understanding of how the Posyandu Remaja information system can be optimized to meet user needs and improve operational efficiency. Similar studies have proven that usability testing of information systems, including academic systems, is crucial for enhancing public services and user satisfaction[5]. Therefore, evaluating the Posyandu Remaja information system through SUS will provide critical insights into areas requiring enhancement to ensure optimal functionality and end-user acceptance [6]. The SUS method, known for its ability to provide an overview of user satisfaction levels with a system, also allows for usability comparisons between different systems [2].

In the current era of digitalization, information systems have become the operational and strategic backbone across various sectors, including government, business, education, and healthcare. The presence of effective and efficient information systems is crucial for supporting decision-making, enhancing productivity, and delivering improved services [7]. However, functionality alone is insufficient to guarantee a system's success. The aspect of usability plays an equally vital role in determining user acceptance and satisfaction with a system[8]. Systems that boast advanced functionality but are difficult to use tend to be neglected or even rejected by users, which can

ultimately lead to implementation failures and significant losses[9]. Therefore, usability evaluation is an essential step in the development and maintenance lifecycle of information systems. Usability is defined as the extent to which a product can be used by specific users to achieve particular goals with effectiveness, efficiency, and satisfaction within a given context of use[9].

To measure usability objectively and standardize its assessment, various evaluation methods have been developed. One of the most popular, simple, and cost-effective instruments is the System Usability Scale [9]. The SUS is a ten-item questionnaire utilizing a five-point Likert scale, designed to measure users' subjective perceptions of a system's or product's usability[10]. The strength of SUS lies in its ability to provide a single, representative score, its flexibility in application across various system types—including software, websites, and mobile applications—and its reliability even with relatively small sample sizes [11]. The application of SUS has proven effective in numerous studies for identifying usability strengths and weaknesses, providing valuable input for improving system design and development [12].

Despite the availability of the Posyandu Remaja information system to support adolescent health services, its effectiveness is highly dependent on how easily teenage users can understand and use the system. Adolescents often have diverse levels of digital literacy and strong expectations for simple, intuitive interfaces; poor usability may result in low system adoption, user errors, and ineffective data utilization. However, the usability of the Posyandu Remaja information system has not yet been systematically evaluated. Therefore, this study aims to assess the usability of the Posyandu information system using the System Usability Scale (SUS) method. The results are expected to provide a clear measure of the system's usability from the users' perspective and to serve as a basis for recommendations to improve user experience and system efficiency.

II. LITERATURE REVIEW

This literature review analyzes previous work related to the evaluation of information system usability, particularly focusing on studies that employ the System Usability Scale. The concept of usability is further elaborated as the capacity of specific users to effectively and efficiently achieve particular goals, leading to user satisfaction [13]. Effectiveness refers to the precision and completeness with which objectives are met, efficiency pertains to resource utilization, and satisfaction is the subjective perception of the user's interaction experience [14]. Accurate and reliable usability evaluations are crucial to ensure optimal functionality of health information systems, including those utilized in adolescent Posyandu [15]. In the development of mobile health applications, usability assessment is vital for ensuring data security and accuracy [9]. Cross-cultural adaptation of instruments such as the SUS into local languages is essential for their validity in non-English contexts, ensuring that the cultural and linguistic nuances of users are accommodated[15].

Since its introduction in the 1980s, usability has been defined as a system quality attribute measuring interface ease, encompassing learnability, efficiency, memorability, error handling, and user satisfaction[15]. High usability in information systems, including information management systems, determines their successful implementation by influencing user perceptions and decisions [8]. Applications with high usability tend to attract a larger and more loyal user base[16], whereas systems with poor usability often face rejection[17]. Prior research indicates that usability is a primary principle of user interface/user experience design, aiming to minimize confusion and input errors while accelerating interaction[12]. Usability testing has proven to be an important method for identifying design issues and enhancing the overall user experience [18]. This approach integrates attributes of satisfaction, effectiveness, efficiency, and learnability, in accordance with ISO and Nielsen standards, for comprehensive evaluation[19].

III. METHODOLOGY

In this study, the methodological workflow was systematically structured to ensure that the analytical process proceeded in a focused and objective manner. The research began with the formulation of the problem, in which the primary issues relevant to the study were identified and defined. Following this stage, a comprehensive literature review was conducted to examine theoretical foundations, prior studies, and related concepts that support the development of the research framework. Based on insights derived from the literature, the appropriate research method was determined, including the procedures for data collection, the instruments employed, and the analytical approach. The subsequent stage involved data collection, carried out according to the predetermined procedures. The collected data were then processed and interpreted during the analysis stage to generate systematic and reliable findings. These findings served as the basis for drawing conclusions that address the research problem and illustrate the study's contributions. With the formulation of these conclusions, the overall research process was completed.

The research methodology for this study was designed to assess the usability of a web-based adolescent Posyandu information system using the System Usability Scale. This methodology encompasses the identification of participants, data collection through the SUS questionnaire, and analysis of the results by calculating SUS scores.

1. Participants

The participants in this study were ten adolescent Posyandu cadres from Posyandu Seruni in Tangerang City. Participants were selected using a purposive sampling technique, ensuring that respondents were

suitable for the research objectives as potential users of the adolescent Posyandu information system.

Figure 1. Research Methodology

2. Research Instrument

The research instrument employed was the 10-item SUS questionnaire. Each statement utilized a 5-point Likert scale, ranging from "Strongly Disagree" (score 1) to "Strongly Agree" (score 5). Odd-numbered (positive) statements represented aspects of ease of use, while even-numbered (negative) statements evaluated potential problems or obstacles in system usage [13].

3. Data Collection Procedure

The data collection process began with providing instructions to respondents on how to access and use the adolescent Posyandu information system. Respondents were asked to complete several main task scenarios, such as logging in, viewing activity schedules, and accessing health information. After completing these tasks, respondents were instructed to fill out the SUS questionnaire based on their system usage experience.

4. Data Analysis Technique

Data analysis was performed through the following steps:

1. For odd-numbered statements, 1 was subtracted from each response. For even-numbered statements, the score was calculated by subtracting the response score from 5[13].
2. The values from all 10 questions were then summed for each respondent.
3. The total sum was multiplied by 2.5 to yield a SUS score ranging from 0 to 100 [13].
4. The average SUS score across all respondents was calculated to obtain a representative usability score for the system. Based on literature, a system with a score of 68 and above is considered to have good usability [1], while a score of 70 is often used as a benchmark for acceptability[20].

5. SUS Method

The System Usability Scale (SUS) is a method that is quick to administer and inexpensive to use, especially when conducted online. SUS is one of the most efficient ways to collect statistically valid data and provides a clear and reasonably accurate score. Despite its simplicity, the SUS method remains sufficiently valid for use[1] .

There are several reasons why the SUS method is suitable for measuring the usability aspects of a product or service, namely[21]:

1. SUS is easy to use because the results are presented as a score ranging from 0 to 100, and a ready-to-use template for calculation is already available.
2. SUS is very simple to implement, does not require complex calculations, and does not demand many resources to manage.
3. SUS is freely available and does not require additional costs.
4. SUS has been proven to be valid and reliable, even when used with small sample sizes.
5. SUS can help product or service providers evaluate whether a system needs to be updated.
6. SUS can help evaluate the effectiveness of system improvements over time.
7. SUS can provide confidence to business owners to invest further in the user experience of their products or services.

However, there are several important considerations when using this method [2]:

2. The scoring system can be somewhat complex.
3. Because the final score is expressed as a value on a 0–100 scale, many people incorrectly interpret it as a percentage, which is not the case.
4. The best way to interpret the score is by normalizing it to produce a desired percentile rank.
5. This method is not diagnostic; in other words, SUS is not intended to diagnose specific usability problems in a product or service.

6. SUS Questionnaire

The SUS method works based on data obtained from distributing a questionnaire to respondents, using a Likert scale consisting of 10 questions answered by users of the product or service. Respondents give a rating for each question on a scale from 1 to 5, based on how strongly they agree with each statement in the SUS questionnaire. A score of 5 indicates strong agreement, while a score of 1 indicates strong disagreement. Table

1 below lists the 10 questions included in the SUS questionnaire [16].

IV. RESULT

Usability measurement was conducted with the involvement of 10 adolescent respondents who used the Posyandu information system. After completing the task scenarios, respondents completed the SUS questionnaire. The processed data results are presented in Table 1, displaying the System Usability Scale questions used in the assessment:
Q1. I think that I would like to use this system frequently.
Q2. I found the system unnecessarily complex.
Q3. I thought the system was easy to use.
Q4. I think that I would need the support of a technical person to be able to use this system.
Q5. I found the various functions in this system were well integrated.
Q6. I thought there was too much inconsistency in this system.
Q7. I would imagine that most people would learn to use this system very quickly.
Q8. I found the system very cumbersome to use.
Q9. I felt very confident using the system.
Q10. I needed to learn a lot of things before I could get going with this system.

TABLE I.SCORE OF SUS RESPONDENT

R	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS	Interpretation
R1	3	3	3	3	3	3	3	3	2	4	75	Good
R2	4	4	4	0	4	4	4	4	4	4	80	Good
R3	3	3	3	3	3	3	3	3	3	1	70	Good
R4	1	3	3	4	2	2	3	3	3	3	68	OK/Fair
R5	3	1	3	3	4	3	4	3	1	1	65	OK/Fair
R6	4	3	4	1	3	3	3	3	3	1	70	Good
R7	4	4	4	4	4	4	4	4	4	4	100	Excellent
R8	3	3	4	1	4	3	4	3	3	1	73	Good
R9	3	3	3	1	3	3	3	3	3	1	65	OK/Fair
R10	1	3	3	1	3	1	3	3	1	1	50	Poor

Based on the results of the usability assessment of the Adolescent Posyandu Information System using the System Usability Scale (SUS), the average score obtained was 72.75. This score is above the standard SUS average of 68, indicating that the system is considered "Good" and is acceptable to users. A score in this range also suggests that users find the system relatively easy to use and satisfactory in terms of overall usability.

In interpreting the results of the SUS score calculation, five approaches can be used. One of these is:

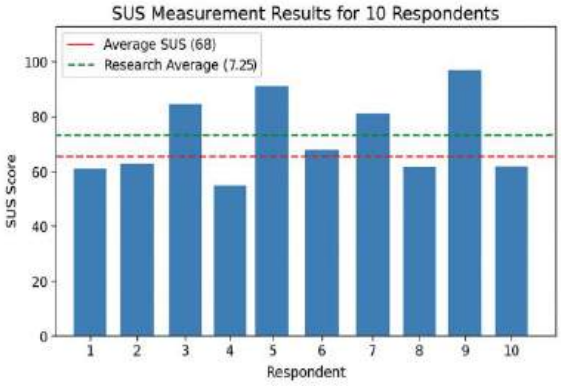

Figure 2. Graphic of SUS Respondent

1) *Percentile Rank*

The SUS score can be converted into a percentile rank. A percentile rank indicates the percentage of scores in the distribution that are equal to or lower than a given score. The figure below illustrates the percentile ranks for various SUS scores in general.

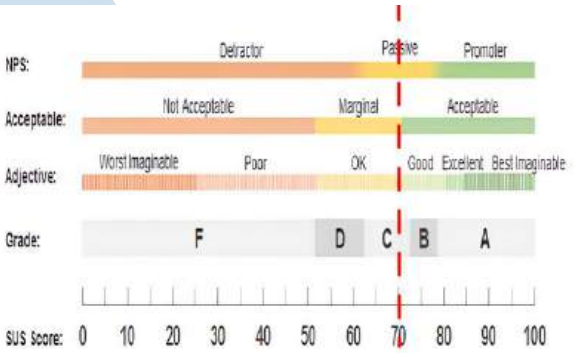

Figure 3. SUS Score Interpretation

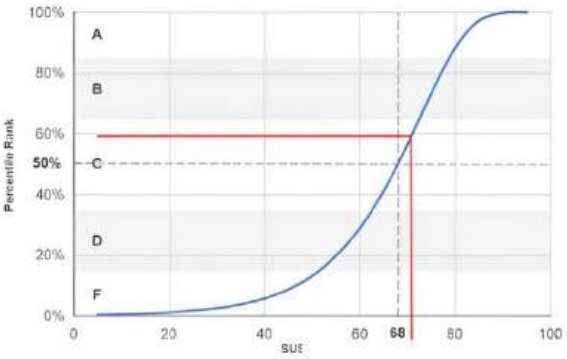

Figure 4. SUS Score Curve in Percentiles

As is widely known, the average SUS score (at the 50th percentile) is 68. This means that a score equal to is considered average, and any score above 68 is categorized as above average.

In this study, the SUS score obtained was 70.03 (as illustrated in the corresponding percentile curve). When compared with the general SUS benchmark on the

percentile curve, this score falls within the above-average category.

This indicates that the usability score for the Posyandu Information System for Teenagers, as perceived by the respondents, is categorized as good.

2. Grade

Grade is an interpretation based on percentile ranking. SUS scores are categorized into grades ranging from A to F. Grade A indicates superior performance,vGrade C represents average performance, and Grade F indicates poor performance.

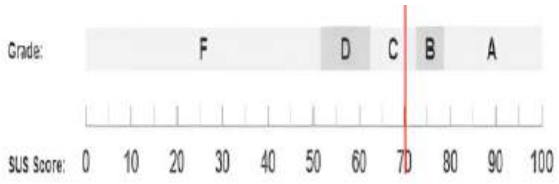

Figure 5. SUS Score in the Grade Scale

The SUS score obtained in this study was 70.03. When compared to the grade scale shown in the figure, the score falls into Grade C, which indicates an average level of usability.

3. Adjectives

The adjective rating scale for SUS scores consists of "Excellent," "Good," "OK," "Poor," and "Worst." Based on the results of this study, the score obtained was 70.03, which falls into the "OK" category.

This indicates that, according to the respondents, the usability of the Posyandu Information System for Teenagers is classified as OK.

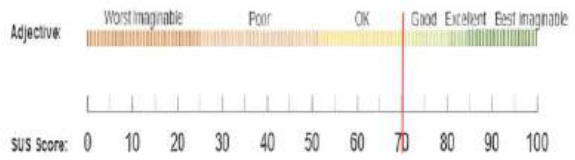

Figure 6. SUS Score in the Adjective Scale

4. Acceptability

Acceptability refers to whether a system is considered "acceptable," "marginally acceptable," or "not acceptable." A SUS score of 70 (slightly above the average SUS score of 68) is categorized as acceptable, because the threshold for unacceptable scores generally begins below 50 (which corresponds to a grade of F with a score lower than 51.6). Scores within the range of 50–70 are classified as "marginally acceptable," which corresponds to Grades C and D in the SUS evaluation scale. The score obtained in this study, 70.03, falls within the marginally acceptable category.

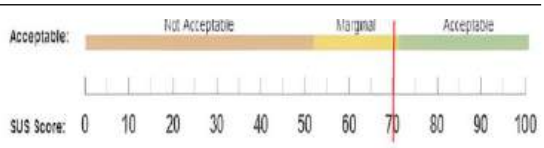

Figure 7. SUS Score in the acceptability Scale

4. Promoters daln Detractors

The SUS score of 70.03 obtained in this study, when associated with the NPS classification, falls into the **positive** category. This indicates that the respondents in this study have a positive perception of the Posyandu Information System for Teenagers. This result may reflect the respondents' knowledge and experience while using and exploring the Posyandu Information System for Teenagers.

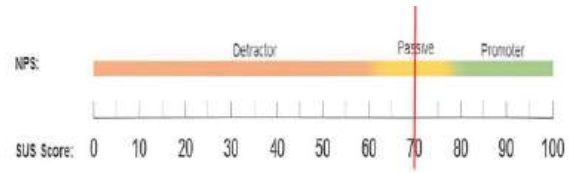

Figure 8. SUS Score NPS Classification

The average SUS score for respondents using the Posyandu Information System for Teenagers was 70.03. Based on the Adjective Ratings, this score falls into the "OK" category. According to the Grade Scales, the score corresponds to Grade C, and within the Acceptability Ranges, it is classified as "Marginal." This indicates that the Posyandu Information System for Teenagers interface is still considered acceptable by respondents, although not yet excellent.

However, based on the NPS classification, respondents tend to fall into the Passive category. Overall, respondents perceive the Posyandu Information System for Teenagers as fairly comfortable and easy to use, although there is still room for further improvement.

V. CONCLUSION

Based on the usability assessment of the Adolescent Posyandu Information System conducted using the System Usability Scale, an average score of 72.75 was obtained. This score exceeds the typical SUS average of 68, placing the system in the "Good" category. This indicates that the system possesses a satisfactory level of usability and is generally well-accepted by users. However, it was noted that some respondents provided scores below 70, highlighting areas that require improvement, particularly concerning navigation and the clarity of terminology within the system. Overall, this research confirms the adolescent Posyandu information system's suitability for use, with potential for further enhancements to optimize its support for web-based adolescent health services.

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The Impact of Super Golden Ratio Implementation on User Satisfaction: A Study of Horizontal scrolling in Bacana User Interface (UI) Design

Farizah Farha Mahdi[1], Andi Jamiati Paramita[2], Furqan Zakiyabarsi[3], Hany Alexandra Philemon[4], Rena Nainggolan[5], Fenina Adline Twince Tobing[6]
[1,2,3,4] System Informasi, Institut Teknologi dan Bisnis Kalla, Makassar, Indonesia
5 Universitas Methodist Indonesia, Medan, Indonesia
[6] Universitas Multimedia Nusantara, Tangerang, Indonesia
[1]farizahmahdi@kallabs.ac.id, [2]paramita@kallabs.ac.id, [3]furqan@kallabs.ac.id,
[4]hanyalexandra@kallainstitute.ac.id, [5]renanainggolan@methodist.ac.id, [6]fenina.tobing@umn.ac.id

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***Abstract*— Low reading interest in Indonesia (0.001%) highlights the need for innovation in digital literacy applications such as Bacana's. However, the current Bacana interface still adopts a conventional layout, which may limit user satisfaction. This study aims to evaluate the implementation of the Super Golden Ratio (ψ≈1.4656) combined with Horizontal scrolling navigation to enhance visual aesthetics and user experience. A quantitative approach was employed involving 107 respondents who evaluated the Bacana interface using a Likert-scale questionnaire. Instrument reliability testing showed excellent results (Cronbach's $\alpha > 0.94$). Data were analyzed using simple linear regression. The results indicate that all regression assumptions were met, including the absence of heteroscedasticity and autocorrelation, with a statistically significant linear relationship ($p < 0.001$). The proposed design demonstrates strong explanatory power toward user satisfaction, with a coefficient of determination of $R^2 = 0.90$ in the Post-test. These findings indicate that the implementation of the Super Golden Ratio and Horizontal scrolling significantly improves user satisfaction, reflecting better perceived readability and interaction smoothness. This study contributes to UI/UX research by providing empirical evidence on the effectiveness of mathematical proportional design in digital reading applications.**

***Index Terms*— Bacana; Horizontal scrolling; Super Golden Ratio; UI/UX; User Statisfaction.**

I. INTRODUCTION

Today, technology is experiencing rapid and massive development. Various groups, regardless of age or gender, now use technology. Both men and women, adults, and even children use it. Technological developments themselves are beneficial for users in accessing information more easily. The use of applications also demonstrates that rapid technological development marks a shift towards a new era of digitalization [1]. Therefore, the development of user interface (UI) design and user experience (UX) are crucial elements that determine the success of an application. It should be noted that UI (User Interface) is a physical or graphical interface design that allows users to interact with an application or system, while UX (User Experience) is the overall experience and satisfaction of users when using a product, including ease, comfort, and effectiveness of interaction [2]. It is stated in one research that applications that were designed through focus on UI (by methods such as HCD) tend to have higher values than the applications, which were developed without particular attention to UI. This finding is supported by an observation done by Wiradarma. " User experience (UX) value in applications that created by concerning UI has better value UX comparing to the applications that created without concerning to UI ". This confirms the importance of User interface (UI) design in increasing the satisfaction and effectiveness of application users [3].

Based on the 2025 Indonesian Digital Society Index (IMDI) score, it shows a consistent increase over the past few years, from 37.80 points in 2022, rising to 44.53 points in 2025 [4]. However, based on the results of a UNESCO study stated that the reading interest of the Indonesian people was only 0.001 percent. This figure reflects that in every 1,000 Indonesians, there is only one person who likes to read [5]. This data highlights the significant challenges in fostering a quality reading culture in Indonesia, despite the high level of basic reading skills. UNESCO emphasizes the need for collaboration between various parties to increase reading interest and strengthen literacy in the digital era to support the development of quality human resources, so that digital applications that support public reading interest can be a solution in the increasingly rapid development of the digital era as it is today [6], [7]. Bacana is a digital book reader app specifically designed to improve digital literacy among Indonesia's young generation. The app combines local reading materials with interactive elements to stimulate reading interest and community participation. With a user-centric design

approach, Bacana provides several key features, such as reading progress tracking, smart notifications, book summaries, and discussion forums for users. These features aim to create a more efficient and meaningful reading experience, encouraging users to continue reading and actively participate in local literacy communities [8].

At the current interface development, the Bacana aplication adopts a conventional vertical layout with standard scrolling behavior. The interface was developed based on general design practices without explicit proportional guidelines, resulting in a functional but visually uniform layout. This condition does not indicate a design flaw, but highlights an opportunity to explore structured proportional approaches to improve visual hierarchy and user comfort, particularly in digital reading activities that require prolonged interaction. There is no specific features that implement proportional ratios like the Golden Ratio or Super Golden Ratio in the display design, and Horizontal scrolling options are not yet enabled. Thus, all graphical components in Bacana in this early stage was developed based on general design principles and standard visual elements, without considering specific mathematical ratios or horizontal screen shifts. This situation provided an opportunity to investigate the impact of implementing these innovative concepts on improving the aesthetics and user satisfaction of the Bacana interface. The application of the Super Golden Ratio proportional principle is estimated to be able to produce a more balanced and visually attractive layout, in accordance with the results of recent research which shows a positive correlation between the use of the Golden Ratio in user interface (UI) design and increased satisfaction, with a relationship coefficient of +7.5% on satisfaction [9]. (tidak perlu dimuat) On the other hand, the implementation of Horizontal scrolling offers a more intuitive and engaging interaction pattern for users. Modern user experience studies report that the movement of swiping content sideways can increase user engagement and enjoyment compared to the conventional vertical scrolling pattern [10].

In this context, the study of the use of proportional ratios in user interface (UI) design becomes crucial. Aesthetic principles such as the Golden Ratio have been used to create visual balance in digital interfaces, as they can improve aesthetic impressions and naturally direct user attention [11]. As the concept develops, new variants such as the Super Golden Ratio have emerged that have the potential to be applied in user interface (UI) design, as stated by Herdiana. The application of these proportional principles is believed to produce a more harmonious layout arrangement, thereby influencing the perception of quality and end-user satisfaction. In addition to the importance of the functional aspects of the user interface, visual proportions in the layout also greatly determine the aesthetics and user comfort [12]. As a step to create an attractive and balanced visual appearance, mathematical ratio theories such as the Golden Ratio are used as a reference in visual design. The Golden Ratio, symbolized by φ (phi), is defined as the positive value of the solution to the equation $\varphi^2 = \varphi + 1$, so its value is approximately 1.618 [12]. Proportion is a key element that helps the audience understands various visual forms in a design. The relationship between the two dimensions which usually arranged in a certain ratio to create balance in a two-dimensional design, thus producing harmonious visual harmony [13].

In addition, mathematical research has identified an alternative ratio that has the potential to be applied in design, namely the Super Golden Ratio or φ^3. This ratio are a real positive solution of the cubic equation $\psi^3 = \psi^2 + 1$ [14]. The value of the Super Golden Ratio, denoted by ψ, is around 1.4656. Due to a similar analogy to the Golden Ratio, the Super Golden Ratio can be utilized to form geometric proportions such as the Super Golden Ratio-rectangle or the Super Golden Ratio-spiral, which have unique characteristics. Although not as popular as the Golden Ratio, some experts have begun to investigate the application of the Super Golden Ratio in the field of design [3]. For example, according to Herdiana, besides the Golden Ratio, the Super Golden Ratio are a proportional ratio option that has not been widely developed in user interface (UI) design. In their research, the design of a trouble ticket application interface using the Super Golden Ratio method resulted in a positive user experience based on UEQ measurements. This shows the potential of the Super Golden Ratio to improve the clarity, efficiency, and attractiveness of the interface. However, overall, the user interface literature is still very limited in discussing the application of the Super Golden Ratio, so that understanding of its aesthetic and functional impact on interface design is still minimal [3].

Then, when turning to the navigation aspect, implementing Horizontal scrolling in interfaces faces particular challenges. A common convention in websites and applications is vertical navigation when displaying advanced content. Nielsen Norman Group shows that when users access websites, they generally scroll down vertically, a practice that has been in place since the beginning of the web era. Therefore, the addition of a Horizontal scrolling option is often considered unconventional and can be confusing for users. The NN/g study reported that Horizontal scrolling interactions on desktops consistently elicit negative responses from users [15]. Users often fail to notice content on the right side of the screen due to their lack of familiarity with Horizontal scrolling, which can lead to missing important content hidden beyond the initial view. Similar findings were also reported by Mahardika, who showed that scrolling techniques that do not align with user expectations can reduce efficiency and cause

disorientation in navigation, especially when users are faced with tasks that require visual focus and spatial mapping of interface content [16].

According to Fessenden, in observing user behavior while browsing web pages, none of the participants performed Horizontal scrolling, and no eye focus pints was directed beyond the right edge of the screen. This indicates that the content area is outside the initial that display boundaries are not practically accessed by users [17]. Consequently, Horizontal scrolling can create a "layout trap" where side content appears to be missing, leading users to skip it or be discouraged from exploring further. Furthermore, from an interaction perspective, Horizontal scrolling requires additional effort, such as using a horizontal scrollbar with a mouse, which involves more complex adjustments than steering laws. If implemented with new buttons or gestures, it increases the user's cognitive load. In other words, users must devise a new way of navigating that differs from their usual practices, which can disrupt the smoothness of the experience.

Taking into account the literature review above, we can conclude that the study of the application of the Super Golden Ratio in user interface (UI) design is still in its infancy and has not developed significantly. Most previous studies still focus on the use of the Golden Ratio as a guideline for design aesthetics, while the Super Golden Ratio with its own mathematical character ($\psi \approx 1.4656$) has not received sufficient attention in the development of modern interface design. In fact, the potential of this ratio to create visual balance and perceptual comfort is very large to be explored further, especially in the context of digital applications that require harmony between aesthetics and functionality [3]. Furthermore, the study results show that the application of Horizontal scrolling in interface design has not been empirically evaluated much, particularly regarding user satisfaction. The literature of most user experience only provides general guidelines or practical suggestions, lacking scientific analysis that measures its impact on user experience in specific interaction contexts. Consequently, there remains a knowledge gap regarding how horizontal navigation patterns can influence users' perceptions of efficiency, comfort, and visual appeal in an application [15].

To further justify the design intervention explored in this study, a preliminary evaluation of Bacana's existing interface was conducted. This evaluation was based on an initial design audit of layout composition, typographic scale, and visual hierarchy, complemented by expert heuristic observations referring to established usability and readability principles for digital reading applications. The assessment indicated that Bacana's current vertical scrolling layout relies on general design conventions without explicit proportional guidance, resulting in a visually uniform composition with weak hierarchy, inconsistent content emphasis, and suboptimal reading comfort during prolonged interaction. In addition, the absence of horizontal affordances limits content discoverability and interaction variation, particularly for segmented reading materials. These findings, together with prior studies demonstrating that mathematically guided proportional systems can enhance visual balance and perceived comfort, provide the rationale for investigating the Super Golden Ratio as a structured proportional framework and Horizontal scrolling as an alternative navigation pattern to improve the overall user experience of the Bacana application.

II. LITERATURE REVIEW

The concept of the Golden Ratio ($\Phi \approx 1.618$) has been recognized in design as a principle of proportion that produces balanced and aesthetic visual compositions. The application of the Golden Ratio are believed to create harmony between design elements, thus making them appear more visually appealing [12]. In the context of modern user interfaces (UI), this principle has begun to be adapted to organize interface layouts in the hope of improving user visual comfort. Although the Golden Ratio has historically been widely applied in architecture, art, and logos, its application to digital User interface (UI) design was relatively rare and not yet established until 2020.

Current research attempts to bridge this gap by empirically examining the impact of the Golden Ratio on user experience. Kurniawan's quantitative study of the integration of the Golden Ratio scheme into mobile app layouts found a positive, albeit modest, relationship between Golden Ratio proportions and user satisfaction. Their simple linear regression results showed a contribution of approximately 7.5% of Golden Ratio usage to increased app user satisfaction, indicating that harmonious visual proportions can have a significant, albeit small, positive impact on user experience (UX) [9] . This finding aligns with the view that visual aesthetics contribute to perceived comfort and ease of use of an interface, which in turn increases overall satisfaction.

Along with the Golden Ratio, the concept of the Super Golden Ratio has emerged as a new mathematical proportion variant that is starting to gain attention in User interface (UI) design. The Super Golden Ratio refers to the limit ratio of the Narayana series (also known as Narayana's cows sequence) which has a value of approximately 1.4656 [18]. Different from the classic Fibonacci Golden Ratio, this ratio value of 1.4656 offers an alternative geometric comparison that is believed to have similar aesthetic potential. Until the last few years, the Super Golden Ratio has not been widely developed in the realm of user interface (UI) design. Recently, Herdiana's research study applied the Super Golden Ratio method in

designing the UI of a trouble ticket application and measured its UX using the User Experience Questionnaire (UEQ). The results show that interfaces designed with Super Golden Ratio proportions are able to provide a very positive user experience across various UX dimensions. Respondents rated prototypes with Super Golden Ratio proportions as having excellent visual appeal (attractiveness), information clarity, efficiency, accuracy, and stimulation, with the novelty aspect being rated well [3]. These empirical findings indicate that Super Golden Ratio proportions have the potential to improve the quality of user experience, reinforcing the assumption that visual harmony of layouts correlates with perceptions of satisfaction and comfort in interacting with interfaces.

The literature also highlights the general relationship between visual aesthetics and user satisfaction. The aesthetic usability effect posits that interfaces with higher visual aesthetics are more likely to be perceived by users as easier to use and more satisfying [19]. Recent research supports this effect. For example, a recent experimental study on mobile application design found that the use of "warm" aesthetic elements such as rounded button corners significantly increased perceptions of beauty and comfort, which positively influenced perceived ease of use and end-user satisfaction. Designs with rounded/oval corners give a friendly and secure impression, so that users perceive the interface as more visually appealing and intuitive, compared to sharp-cornered designs. This is in line with Liu's findings that show rounded icons or UI elements are considered more aesthetic and able to increase user satisfaction and positive emotional responses compared to rigid rectangular shapes [20]. Overall, recent UX literature emphasizes that good visual proportions and shapes are not merely decorative, but have a direct impact on the quality of the user's experience and emotions during interactions.

On the other hand, the trend of user interaction with scrolling in interfaces is also evolving. Horizontal scrolling where content is moved sideways rather than downwards was once less common in classic web design due to concerns that it would disrupt vertical navigation habits. However, with the rise of touchscreen mobile devices, horizontal swipe patterns are becoming more common, for example in photo galleries, product carousels, or story feeds in modern apps. Recent research has begun to evaluate the impact of Horizontal scrolling patterns on UX. Zhou's research provides empirical evidence that horizontal swipe interactions can have distinct advantages over vertical ones in certain scenarios. Through performance and cognitive load measurements (including eye-tracking and EEG data in elderly users), the study revealed that horizontal swipe-based navigation can increase users' sense of control and engagement without sacrificing comfort [21]. Several previous studies have also suggested the benefits of adding side-swipe navigation to mobile interfaces for more natural and faster content exploration [22].

However, these results still need to be seen in the proper context: Horizontal scrolling designs should be carefully designed so that users are aware of the presence of hidden content on the side and do not feel confused in navigation. In practice, UX guidelines emphasize the need for visual cues (e.g., arrows or partial display of the next content) to indicate the presence of horizontal scrollable content, so that the user experience remains smooth [23]. Based on the literature review above, a knowledge gap exists at the intersection of design proportion principles and Horizontal scrolling interaction patterns. The Golden Ratio and its derivative (Super Golden Ratio) have been individually studied for their impact on aesthetics and UX. Similarly, Horizontal scrolling patterns have been studied for their influence on user behavior and satisfaction in limited scenarios. However, no studies have been found that specifically integrate the Super Golden Ratio proportion into horizontally scrolling User interface (UI) designs. No scientific publications in the last five years have examined whether using the 1.4656 ratio in a sideways scrolling layout will enhance user satisfaction or significantly influence user behavior. In other words, how Super Golden Ratio-based visual composition interacts with horizontal navigation patterns remains empirically unexplained. This gap is the focus of this research. Our study aims to fill this gap by empirically testing the impact of implementing Super Golden Ratio in interfaces that utilize Horizontal scrolling on user satisfaction and experience. It is hoped that the findings of this study will provide new insights into the integration of classical aesthetic principles with modern interaction trends, while also being an original contribution to the current literature on user interface (UI) design.

III. Research Method

This study uses a quantitative experimental approach to measure the impact of implementing the Super Golden Ratio and Horizontal scrolling in the Bacana UI on user satisfaction. The experimental design used user interface testing, comparing Bacana application prototypes before and after UI improvements. The initial version (control) used a conventional layout (standard proportions, regular vertical scrolling), while the new version (experimental) implemented the Super Golden Ratio principles in its layout and Horizontal scrolling mechanism. The comparison of the two versions aimed to determine whether these design changes resulted in significant improvements in user experience and satisfaction quantitatively.

A. Procedure

The initial stage of the research was the development of a Bacana UI prototype by implementing the initial Bacana design (conventional prototype) before implementing the results of the new visual methods, namely the Super Golden Ratio and Horizontal scrolling. The old Bacana interface design will be refined: visual elements (layout, book card size, typography, etc.) are arranged according to the ratio $\varphi^3 \approx 1.4656$ for more harmonious proportions. Each key component (e.g., cover image and book title text, margins between elements) is resized to maintain the

consistency of the Super Golden Ratio based on literature guidelines [3].

In addition to proportional calculations, this study also applies the Super Golden Ratio spiral model. The Super Golden Ratio spiral is a logarithmic spiral that widens by a factor of ψ every quarter turn. This ψ factor is a real solution of the algebraic equation $\psi^3 = \psi^2 + 1$ (approximately 1.4656), which also appears as the limit of the ratios of the Narayana series [24]. This shape is analogous to the golden spiral; the golden spiral widens by a factor of φ every quarter turn, while the super golden spiral widens by a (smaller) factor of ψ [25]. Thus, both the golden and super golden spirals are logarithmic spirals with a constant growth in radius per angle, although the super golden spiral "grows" slightly slower.

In terms of visual composition, the logarithmic spiral framework can be used as a guide for arranging interface elements to direct the hierarchy of information and focus the user's attention. Generally, the center of the spiral is placed on the most important UI element (for example, the search field or the main button) so that the area becomes the main focal point, then the spiral curve naturally guides the user's eye to the surrounding secondary elements. This kind of spiral composition technique has long been known in art and photography for example, the golden spiral is often used to "flow" the audience's gaze towards the focal point organically [25].

In the context of digital interfaces, several early studies have shown similar benefits: Herdiana et al. (2022) found that a Trouble Ticket application layout designed with the Super Golden Ratio in reference to the size and position of UI components resulted in significant improvements in UX aspects [3]. In short, the use of the Super golden logarithmic spiral is expected to create a directed and harmonious visual flow, balancing the layout and facilitating user exploration of important information without feeling forced.

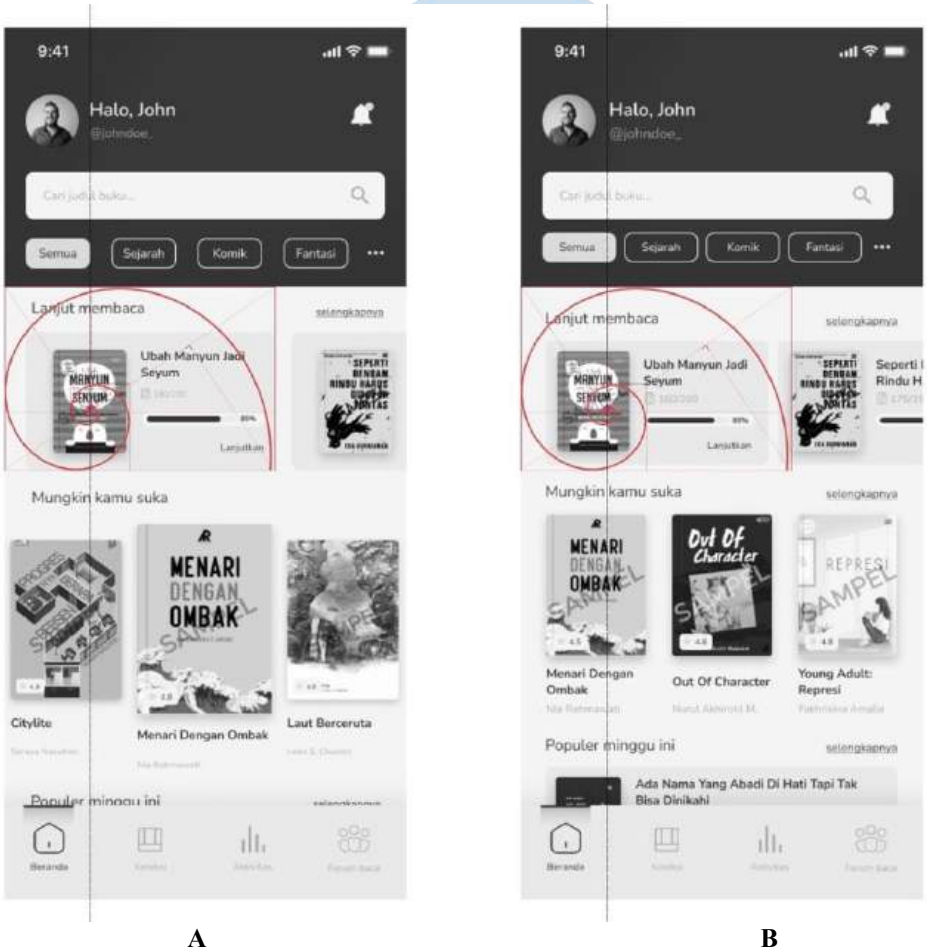

Fig. 1. User Interface design with Super Golden Ratio composition (A) and without Golden Ratio (B).

Additionally, horizontal navigation is implemented for reading content (e.g., book pages can be swiped sideways). To ensure users are aware of horizontally scrollable content (not hidden at the side of the screen), the interface includes visual cues such as arrows or the display of the next portion of content at the edge of the screen. This step was taken because eye-tracking research shows that many users will not scroll sideways if there is no clear cue [18]. Prototypes were developed in various fidelity levels: from wireframe (low-fidelity) to high-fidelity interactive prototypes using

User interface (UI) design software (e.g., Figma or Adobe XD). The final result was two versions of the Bacana prototype: (1) version B (control) with a conventional design, and (2) version A (experimental) with Super Golden Ratio + Horizontal scrolling. Both prototypes will be tested in the next stage.

B. Data Collection and Analysis Techniques

Research data will be collected using a questionnaire with a Likert scale (e.g., a scale of 1–5) to measure research variables. The Likert scale is commonly used in quantitative research because it is effective for measuring respondents' attitudes, opinions, or perceptions of a particular phenomenon [26]. Using a Likert questionnaire, each statement will have measurable answer options based on five basic User interface (UI) design principles: visual harmony, minimum content size, proportional balance, clear visibility, and cut-off session. These will be presented in the questionnaire, ensuring that the data obtained is quantitative and easy to analyze.

TABLE I. INSTRUMENTS

No.	Question(s)
1.	Visual harmony
2.	Minimum content size
3.	Proportional balance
4.	Clear visibility
5.	Cut-off section

Drawing on previous studies conducted by Kurniawan (2025), the five selected question attributes are regarded as the most relevant. This assumption is grounded in findings that visually appealing interface organization and layout can improve user statisfaction, especially when the Super Golden Ratio are implemented in combination with Horizontal scrolling [9]. This approach has also been adopted by previous studies. For example, Permana et al. (2024) explained that “a Likert scale questionnaire was used to collect data, and basic linear regression was used for analysis” [27], indicating that this method is suitable for obtaining quantifiable feedback from digital application users. Respondents will be recruited through digital reader communities and online networks, then asked to complete a prepared Likert questionnaire.

Before completing the questionnaire, respondents will complete a short demographic survey and confirm their regular use of e-book applications to ensure the relevance of the sample. The questionnaire data will be analyzed using simple linear regression analysis with the help of SPSS software. Simple linear regression is a statistical method for testing the linear relationship pattern between one independent variable and one dependent variable [28]. With this method, researchers can measure the extent of the influence of the independent variable (for example, aspects of interface design) on the dependent variable (for example, satisfaction or ease of use).

Regression analysis also allows for testing the significance of these relationships. The use of SPSS for linear regression analysis is very common in quantitative research. For example, Febrita et al. (2025) processed questionnaire data with "multiple linear regression using SPSS" in their study, confirming that SPSS is reliable for calculating regression coefficients and significance tests. This overall procedure ensures that statistical calculations can be performed accurately and efficiently, allowing for valid interpretation of research findings. The criteria set were active users of digital reading applications (e-books) aged 15–30. This criterion was chosen so that respondents were familiar with the reading application interface and could assess design differences more accurately.

A total of 107 respondents participated in this study and were included in the analysis. This sample size is considered adequate for quantitative analysis using simple linear regression, particularly in studies involving user perception data collected through Likert scale questionnaires. The number of respondents provides sufficient statistical power to identify meaningful relationships between interface design variables and user satisfaction. Simple linear regression was selected because this study focuses on examining the direct effect of a single independent variable namely the implementation of the Super Golden Ratio combined with Horizontal scrolling on the dependent variable of user satisfaction. This analytical approach is commonly applied in UI/UX research to evaluate the strength and significance of relationships between design interventions and user perception outcomes. The research instrument consisted of a questionnaire comprising 25 items measured using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Twelve items were used to measure interface design aspects related to the implementation of the Super Golden Ratio and Horizontal scrolling, while the remaining thirteen items measured overall user satisfaction.

IV. RESULT AND DISCUSSION

A. Validity check

Instrument validity testing was conducted to ensure that the questionnaire accurately measured user satisfaction. The test was conducted by using Pearson Product Moment correlation with SPSS. The test results showed that all statement items had a calculated r-value greater than the table r-value of 0.361 at a 5% significance level. Thus, all items were declared valid and suitable for use in data collection. The high item correlation value indicates respondents' consistency in assessing interface design aspects, particularly after the implementation of the Super Golden Ratio and Horizontal scrolling.

TABLE II. SUPER GOLDEN RATIO & HORIZONTAL SCROLLING (PRA-TES) – PEARSON’S VALIDITY

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
SUM	.690	.787	.721	.812	.809	.830	.760
Sig 2	.000	.000	.000	.000	.000	.000	.000

	Q8	Q9	Q10	Q11	Q12
SUM	.862	.881	.823	.800	.778
Sig 2	.000	.000	.000	.000	.000

TABLE II. SUPER GOLDEN RATIO & HORIZONTAL SCROLLING (POST-TEST) – PEARSON'S VALIDITY

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
SUM	.737	.726	.800	.713	.709	.800	.880
Sig 2	.000	.000	.000	.000	.000	.000	.000

	Q8	Q9	Q10	Q11	Q12
SUM	.812	.884	.743	.799	.806
Sig 2	.000	.000	.000	.000	.000

TABLE III. USER STATISFACTION (PRA-TES) – PEARSON'S VALIDITY

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
SUM	.835	.772	.820	.845	.790	.855	.808
Sig 2	.000	.000	.000	.000	.000	.000	.000

	Q8	Q9	Q10	Q11	Q12	Q13
SUM	.804	.830	.880	.694	.796	.726
Sig 2	.000	.000	.000	.000	.000	.000

TABLE III. USER STATISFACTION (POST-TEST) – PEARSON'S VALIDITY

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
SUM	824	.821	.843	.758	.829	.828	.801
Sig 2	.000	.000	.000	.000	.000	.000	.000

	Q8	Q9	Q10	Q11	Q12	Q13
SUM	.772	.759	.833	.741	.782	777
Sig 2	.000	.000	.000	.000	.000	.000

B. Reliability check

Based on Table 4, the pre-test and Post-test yielded Cronbach's Alpha values of 0.946 for the pre-test and 0.943 for the Post-test for the 12 items, respectively. Meanwhile, Table 5 yields Cronbach's Alpha values of 0.953 for the pre-test and 0.951 for the Post-test for the 13 items. Therefore, these values are well above the general guideline of Cronbach's Alpha ≥ 0.7 as the minimum threshold for adequate reliability, and > 0.90, which is often interpreted as very high or excellent reliability in quantitative research [29]. Even very high Cronbach's Alpha (> 0.94) remains acceptable as long as each item maintains theoretical relevance and there is no obvious redundancy in the construct being measured. In addition, quantitative research using new or modified instruments generally requires high reliability values as evidence that the scale is effective in the specific study context, including user experience (UX) and interface interaction research, where inter-item coherence is key in measuring user perceptions.

C. Heteroskedasticity check

Heteroskedasticity is a condition in which the residual variance in a regression model is not constant across observations. This violates the homoskedasticity assumption in classical regression analysis and can result in inefficient variance estimates and inaccurate statistical tests. According to research by Hanna Rajh Weber, adding a regression line to each plot can at least provide an overview of the spread of the residuals relative to the predictors [30]. If, for example, the variability of the residuals around the regression line is seen to differ for different levels of the predictor, the assumption of constant error variance may be questioned. However, using inferential tests based on this assumption can produce biased standard errors, often leading to very high Type I error rates (citations). Therefore, Table 6 shows that the Super Golden Ratio and Horizontal scrolling variables have a statistically significant effect on the dependent variable because the significance level is <0.05, so it can be concluded that the data do not exhibit potential heteroskedasticity.

D. Autocorrelation check

In this experiment, a Durbin-Watson autocorrelation analysis was conducted. Autocorrelation refers to the correlation of a variable with itself over successive time intervals [31]. Based on Table 7, the regression model at both stages shows a strong linear relationship between the predictor and dependent variables, as indicated by the multiple correlation coefficient (R) of 0.946 for both the pre-test and Post-test. The R-square values were 0.895 (pre-test) and 0.900 (Post-test), respectively, indicating that approximately 89.5% (pre-test) and 90.0% (Post-test) of the variation in the dependent variable can be explained by the independent variables in the model. The adjusted R-square was slightly lower (0.894 pre-test; 0.899 Post-test), indicating adjustment for the number of variables in the model. The standard error of the estimate decreased from 3.340 in the pre-test to 2.458 in the Post-test, indicating an increase in the model's predictive accuracy at the post-intervention measurement.

To evaluate the presence of autocorrelation in the residuals, the Durbin–Watson (DW) statistic is used, which ranges from 0 to 4, where values close to 2 indicate no autocorrelation. With a total sample size of 100 participants, the relevant critical DW limits at the 5% significance level for this model are: dL = 1.676 and dU = 1.712. In addition, the upper limit for the negative direction is calculated as 4 − dU = 2.288. According to the Durbin–Watson decision-making criterion, if dU < DW < 4 − dU then the conclusion is that there is no autocorrelation at the significance level used.

- In the pre-test, the Durbin–Watson statistic was recorded at 2.178. Since 1.712 < 2.178 < 2.288, the result is within the range dU < DW < 4 − dU, so there is no evidence of autocorrelation in the residuals of the pre-test model.

- In the Post-test, the Durbin–Watson statistic was recorded as 2.223. Since 1.712 < 2.223 < 2.288, there is again no evidence of autocorrelation in the residuals of the Post-test model.

Thus, both models (pre-test) meet the assumption of no residual autocorrelation according to the Durbin Watson test at the significance level used. DW Value slightly higher than 2 in both measurements point more towards a very weak tendency towards negative autocorrelation, but because they are still within the range without evidence of autocorrelation (between dU and 4−dU), the models can be considered free from significant autocorrelation problems. Therefore, parametric inferences (t- and F-tests) performed on the regression models can be considered undistorted by residual autocorrelation.

TABLE IV. SUPER GOLDEN RATIO & HORIZONTAL SCROLLING (PRA-TES) – RELIABILITY

Cronbach's Alpha	N of Items
.946	12

TABLE IV. SUPER GOLDEN RATIO & HORIZONTAL SCROLLING (POST-TEST) – RELIABILITY

Cronbach's Alpha	N of Items
.943	12

TABLE V. USER SATISFACTION (PRA-TES) – RELIABILITY

Cronbach's Alpha	N of Items
.953	13

TABLE V. USER SATISFACTION (POST-TEST) – RELIABILITY

Cronbach's Alpha	N of Items
.951	13

TABLE VI. HETEROSKEDASTICITY CHECK (PRA-TES)

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1 (Constant)	4.951	.975		5.077	.000
Super Golden Ratio dan Horizontal scrolling	-.052	.021	-.238	-2.512	.014

TABLE VI. HETEROSKEDASTICITY CHECK (POST-TEST)

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std.Error	Standardized Coefficients Beta	t	Sig.
1 (Constant)	8.934	1.098		8.139	.000
Super Golden Ratio dan Horizontal scrolling	-.1326	.020	-.554	-6.821	.000

TABLE VII. AUTOCORRELATION CHECK (PRA-TES)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin Waston
1	.946[a]	.895	.894	3.340	2.178

TABLE VII. AUTOCORRELATION CHECK (POST-TEST)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin Watson
1	.946[a]	.900	.899	2.458	2.223

E. Linearity check

Linearity evaluation is a crucial step in regression analysis to ensure that a linear model can adequately represent the relationship between the independent and dependent variables. The linearity test is conducted by comparing the Linearity and Deviation from Linearity components, with the primary focus of the assessment being the significance of the Deviation from Linearity. If the Deviation from Linearity significance value is greater than 0.05, the relationship between the variables can be assumed to be linear. Based on the linearity test results shown in the table, the significance value for the Linearity component is 0.000, indicating a highly significant linear relationship between the independent and dependent variables. This confirms that statistically there is a strong linear relationship in the tested model.

However, the significance value of the Deviation from Linearity component was recorded at 0.012, which is below the significance threshold of 0.05. The significance value of the Deviation from Linearity component indicates a small deviation from the linear pattern. However, the deviation value is relatively small compared to the main linearity component, so the relationship between variables is still dominated by a linear tendency. In research with user perception data and Likert scales, small deviations from linearity are often found and can still be tolerated as long as the main relationship pattern still shows a dominant linear tendency. Therefore, the linear regression model is still considered suitable for use in this study. However, the Mean Square deviation value is relatively small (16.784) compared to the Mean Square linearity (9994.413), which indicates that the contribution of the deviation is much smaller than the main linear component.

Considering the highly significant dominance of the linear component and the proportion of variation explained by the linear relationship, the relationship between the independent and dependent variables in this study can still be considered quite linear in practice and is feasible for analysis using a linear regression model. Therefore, although there are indications of deviations from linearity

statistically, their effects are relatively small and do not compromise the validity of using linear regression analysis in this study.

F. Normality check

Based on Table 9, data normality was evaluated using the Kolmogorov-Smirnov test. This test compares the empirical distribution function of the data with the theoretical normal distribution [32]. This test is commonly used in regression analysis to ensure that residuals are normally distributed, as one of the classical assumptions. In this study, the significance level was set at 0.05, so the data are considered normally distributed if the significance value (Asymp. Sig.) is greater than 0.05. The results of the Kolmogorov-Smirnov test in the pre-test stage showed an Asymp. Sig. (2-tailed) value of 0.092. This significance value is greater than 0.05, so it can be concluded that the residuals in the pre-test stage do not differ significantly from a normal distribution. Therefore, the pre-test data can be assumed to meet the assumption of normality.

In contrast, in the Post-test phase, the Kolmogorov Smirnov test yielded an Asymp. Sig. (2-tailed) value of 0.000, which is below the significance threshold of 0.05. This result indicates that there is a statistically significant difference between the residual distribution and the theoretical normal distribution, so that the residuals in the Post-test phase do not fully meet the normality assumption based on the Kolmogorov Smirnov test. However, in quantitative research using user perception data and Likert scales, deviations from normality are often found, especially in relatively large sample sizes. Furthermore, based on the Central Limit Theorem principle, the residual distribution tends to approach normality as the number of samples increases, so small violations of the normality assumption are still tolerable as long as the main analysis remains robust and other regression assumptions are met. Therefore, the results of this normality test do not substantially hinder the feasibility of using linear regression analysis in this study.

G. Linear Regression Analysis

Next, after ensuring that all data meets the required requirements, a simple linear regression statistical test can be applied. Based on Table 10, the research hypothesis is formulated as follows:

- H0: The calculated t-value ≤ the t-table value, indicating that Super Golden Ratio and Horizontal scrolling (variable X) have no effect on user satisfaction (variable Y).
- H1: The calculated t-value > the t-table value, indicating that Super Golden Ratio and Horizontal scrolling (variable X) have an effect on user satisfaction (variable Y).

TABLE VIII. LINEARITY CHECK (PRA-TES)

		Sum of Squares	df	Mean Square	F	Sig.
Between Groups	Group(Combined)	10514.730	32	328.585	37.343	.000
	Linearity	9994.413	1	9994.413	1135.835	.000
	Deviation from Linearity	520.318	31	16.784	1.908	.012
Within Groups		651.139	74	8.799		
Total		11165.896	106			

TABLE VIII. LINEARITY CHECK (POST-TEST)

		Sum of Squares	df	Mean square	F	Sig.
Between Groups	(Combined)	6007.624	22	273.074	69.937	.000
	Linearity	5701.208	1	5701.208	1406.139	.000
	Deviation from Linearity	306.416	21	14.591	3.373	.000
Within Groups		327.983	84	3.905		
Total		6335.607	106			

TABLE IX. NORMALITY KOLMOGOROV-SMIRNOV (PRA-TES)

		Standardized Residual
N		107
Normal Parameters[a,b]	Mean	46.31
	Std. Deviation	9.724
Most Extreme Differences	Absolute	.080
	Positive	.080
	Negative	-.077
Test Statistic		.080
Asymp. Sig. (2-tailed)		.092[c]

TABLE IX. NORMALITY KOLMOGOROV-SMIRNOV (POST-TEST)

		Standardized Residual
N		107
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	2.44640516
Most Extreme Differences	Absolute	.204
	Positive	.204
	Negative	-.160
Test Statistic		.204
Asymp. Sig. (2-tailed)		.000[c]

TABLE X. COEFFICIENTS (PRA-TES)

Model	Unstandardized coefficients B	Std. error	Standardized Coefficients Beta	t	Sig.
(Constant)	4.860	1.578		3.079	.003
Super Golden Ratio dan Horizontal scrolling	.999	.033	.946	29.930	.000

TABLE X. COEFFICIENTS (POST-TEST)

Model		Unstandardized coefficients B	Std. error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	8.490	1.689		5.079	.000
	Super Golden Ratio dan Horizontal scrolling	.942	.031	.949	30.718	.000

TABLE XI. MODEL SUMMARY (PRA-TES)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.946[a]	.895	.894	3.340

TABLE XI. MODEL SUMMARY (POST-TEST)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.949[a]	.900	.899	2.458

The t-table value (tα/2) is obtained from the t-distribution table with the following parameters:

α = 0.05 (two-tailed)

n = number of respondents (assuming n = 107)

k = number of independent variables = 1

The degrees of freedom (df) are calculated using the formula n − k − 1, resulting in:

df = 107 − 1 − 1 = 105

Based on the t-distribution table for

df = 105 at α/2 = 0.025, the t-table value is 1.983.

- Pre-test regression test results:

The pre-test coefficient table yields the following regression equation:

Y0 = 4.860 + 0.999XY_{0} = 4{.}860 + 0{.}999XY0 = 4.860 + 0.999X

The constant (a) = 4.860 indicates that user satisfaction is estimated at 4.860 when the Super Golden Ratio score is 0. The regression coefficient (b) = 0.999 indicates that every one-unit increase in the Super Golden Ratio score and Horizontal scrolling is associated with a 0.999-unit increase in user satisfaction. The calculated t-value for the coefficient is 29.930, significantly greater than the t-table (29.930 > 1.981), and the significance value is p = .000 (<0.05). Therefore, H0 is rejected and H1 is accepted. There is a positive and significant influence of the Super Golden Ratio and Horizontal scrolling variables on user satisfaction in the pre-test. The standardized Beta coefficient value of 0.946 confirms that the influence of variable X on Y is very strong.

- Post-test regression test results:

The Post-test coefficient table yields the following regression equation:

Y0 = 8.490 +0.942XY_{0}= 8{.}490 + 0{.} 942 XY0 = 8.490+0.942X

The constant (a) = 8.490 indicates an estimated user satisfaction of 8.490 when the Super Golden Ratio score is 0. The regression coefficient (b) = 0.942 means that every one-unit increase in the Super Golden Ratio will increase user satisfaction by 0.942 units. The calculated t-value for the coefficient is 30.718, also significantly greater than the t-table (30.718 > 1.981), with a significance of p = .000 (<0.05). Thus, H0 is rejected and H1 is accepted there is a positive and significant effect of the Super Golden Ratio and Horizontal scrolling variables on user satisfaction in the Post-test. The standardized beta of 0.949 indicates a very strong relative influence.

In conclusion, in both the pre- and Post-tests, the results of the simple linear regression analysis showed a positive and significant effect of the implementation of the Super Golden Ratio and Horizontal scrolling on user satisfaction. The coefficients approaching 1 in both measurements indicate that changes in variable X are closely related to changes in variable Y in the tested model.

H. Coefficient determination

Based on Table 11, the results of the simple linear regression analysis indicate that the implementation of the Super Golden Ratio and Horizontal scrolling have a very strong influence on user satisfaction. In the pre-test phase, the R-square value of 0.895 indicates that 89.5% of the variation in user satisfaction can be explained by the implementation of the Super Golden Ratio and Horizontal scrolling, while the remaining 10.5% is influenced by factors outside the research variables. Furthermore, in the Post-test phase, the R-square value increased to 0.900, meaning that 90.0% of user satisfaction is influenced by the implementation of the Super Golden Ratio and Horizontal scrolling, while the remaining 10.0% is influenced by other factors not examined. The correlation coefficient (R) values for the pre-test of 0.946 and the Post-test of 0.949 indicate a very strong relationship between the Super Golden Ratio and Horizontal scrolling-based interface design variables

and user satisfaction, and indicate an increase in the effectiveness of the interface design after the treatment was administered.

V. DISCUSSION

The findings in this study provide important implications for the layout design of mobile applications that use Horizontal scrolling. This context is particularly relevant to the Bacana application, which, in particular, in the context of exploring digital reading content, previously relied on conventional layouts based on vertical scrolling. In the early stages of development, the Bacana interface did not implement the principles of mathematical proportional ratios or horizontal navigation patterns, so user interaction still relied on standard visual structures without measurable aesthetic guidelines. The application of the Super Golden Ratio as an interface design technique is widely used to produce aesthetic visual proportions. Previous studies have shown that interface redesign based on UX evaluation often significantly improves design quality and user satisfaction journal.eng.unila.ac.id.

For example, another study reported a jump in usability scores from 49 to 92 after the redesign of journal.eng.unila.ac.id. Similarly, an app's System Usability Scale (SUS) can improve dramatically; one study found an initial SUS score of just 32 (far below the acceptable threshold of 68) that jumped to 75.4 after the redesign of jpti.journals.id. Such dramatic jumps often occur when the initial design is quite poor or monotonous, and is replaced by a new, much more engaging and contrasting design. Our results regression coefficients close to 1 and R values of 0.946–0.949 (R^2 ~0.90) in both the pre- and Post-tests indicate a very strong influence of the Super Golden Ratio and Horizontal scrolling on user satisfaction. An R^2 proportion of approximately 90% confirms that most of the variation in satisfaction can be explained by the tested design variables. These findings align with the literature on interface design and user experience, which emphasizes the importance of visual proportions and navigation flow in improving interaction quality in small-screen applications. Previous studies have shown that using proportional ratios, such as the Golden Ratio, can create better visual balance, naturally direct user attention, and improve the aesthetic perception and readability of digital content.

The highest Post-test scores in this study do not necessarily indicate data manipulation. In quantitative research, high or near perfect post-intervention scores are scientifically acceptable as long as the research process meets methodological standards. In this study, data were collected through systematic and consistent procedures, involving real respondents, using instruments that had been tested for validity and reliability (indicated by a Cronbach's Alpha value > 0.94), and analyzed using SPSS in accordance with applicable assumptions and stages of regression analysis. Many UX/UI studies actually record a spike in scores after the implementation of a new design, especially if the initial conditions contrast sharply with the final conditions. For example, an initial design that is less intuitive or monotonous can be refined into a new, much more visually appealing design, resulting in a dramatic increase. In the aforementioned study, SUS scores jumped from 32 to 75.4 (jpti.journals.id) and usability scores from 49 to 92 (journal.eng.unila.ac.id) after the redesign. Similar phenomena have been noted in other research reports: an old interface design deemed unsatisfactory was optimized with a new, "recently" implemented design, resulting in a dramatic increase in user response. Factors contributing to this score spike include a poor/monotonous initial design, a visually contrasting new design, and respondents who had never been exposed to a similar design before. Under these conditions, the difference in perception between designs can be so large that SPSS analysis yields a near-perfect significance value without any suspicion of data manipulation. In other words, "near perfect" results on Post-tests are more indicative of the effectiveness of the new design than of statistical irregularities, provided the research process has met strict validity and reliability standards.

In the context of Bacana, the difference between the initial, entirely vertical design and the new design based on the Super Golden Ratio and Horizontal scrolling creates substantial visual and interactional changes. These changes have the potential to strengthen the overall perception of interface quality, as reflected in the regression coefficient value approaching one and the increase in R Square in the Post-test. Considering the consistency of the results of this study with the findings of previous studies and the fulfillment of all assumptions of the statistical analysis, it can be concluded that the high Post-test results in this study reflect the effectiveness of the optimized Bacana interface design, not data anomalies or methodological deviations. Therefore, the implementation of the Super Golden Ratio and Horizontal scrolling can be recommended as a valid and potential design approach to improve user satisfaction in digital reading applications.

VI. LIMITATIONS AND FUTURE RESEAECH DIRECTION

Despite the strong findings, several limitations of this study should be acknowledged. First, the evaluation was conducted using a single application prototype (Bacana), which may limit the generalizability of the results to other types of digital reading or content-based applications. Second, the study relied primarily on self-reported user satisfaction measured through Likert-scale questionnaires, which may be influenced by subjective perceptions, novelty effects, and individual design preferences. Third, the evaluation was conducted within a short-term usage context, so long-term reading behavior, adaptation effects, and sustained usability of Horizontal scrolling were not examined. In addition, the implementation of the Super Golden Ratio and Horizontal scrolling was tested as a combined intervention, making it difficult to isolate the individual contribution of each design factor. Future studies are encouraged to conduct longitudinal evaluations, involve diverse application contexts, and experimentally separate proportional layout methods

from navigation patterns to better understand their independent and interactive effects on user experience.

VII. SUMMARY

This study addresses the issue of suboptimal layout structure and interaction flow in the Bacana application interface, which may affect user satisfaction. To address this issue, the study evaluated the implementation of the Super Golden Ratio combined with Horizontal scrolling as an interface design approach. The reliability test results indicate excellent internal consistency (Cronbach's $\alpha > 0.94$), confirming that the measurement instrument is reliable.

The results of the regression analysis show that all classical assumptions were satisfied, including the absence of heteroscedasticity and residual autocorrelation, as indicated by the Durbin–Watson statistic falling within the acceptable range ($dU < DW < 4 - dU$). The analysis also reveals a statistically significant linear relationship between the proposed interface design and user satisfaction ($p < 0.001$), with a high coefficient of determination ($R^2 \approx 0.90$), indicating that a substantial proportion of user satisfaction can be explained by the design variables examined in this study.

APPENDIX

A. Questionnaire items

The same set of questionnaire items was administered in both the pre-test and Post-test phases to ensure measurement consistency. The items were conceptually identical, with contextual adjustments to reflect the conventional interface (pre-test) and the redesigned interface based on the Super Golden Ratio and Horizontal scrolling (Post-test).

A. Visual Harmony

Q1. The interface layout appears visually harmonious and balanced.

Q2. The placement of text, icons, and images appears well integrated.

Q3. The spacing between interface elements feels apropriate.

Q4. The overall visual design is aesthetically pleasing.

Q5. The interface feels visually comfortable during use.

B. Minimum Content Size

Q6. The text size is easy to read without zooming.

Q7. The size and spacing of interface elements support reading focus.

Q8. The distance between content elements feels cofortable.

Q9. The content layout fits well with the screen size.

Q10. The interface feels comfortable for long reading sessions.

C. Proportional Balance

Q11. Interface elements appear proportionally balanced.

Q12. The layout guides visual attention naturally.

Q13. The interface layout feels neat and well organized.

Q14. Element proportions are consistent across different screens.

Q15. The overall layout proportion feels pleasant to view.

D. Clear Visibility

Q16. Main information and navigation elements are easy to find.

Q17. Icons and interface elements are easy to understand.

Q18. Information presentation is clear and well structured.

Q19. Navigation between content sections feels smooth and intuitive.

Q20. The interface is easy to use without excessive efort.

E. User Satisfaction and Horizontal scrolling Experience

Q21. The interface clearly indicates the presence of additional content horizontally.

Q22. Visual cues help users understand the Horizontal scrolling direction.

Q23. Horizontal scrolling feels comfortable to use.

Q24. Horizontal scrolling does not disrupt reading focus.

Q25. Overall, I am satisfied with the interface design..

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Implementation of Ergonomic Criteria for Evaluating the Logistic Mobile App User Interface Design

Hany Alexandra [1], Muhammad Ulil Amri [2], Fadhilah Eka Putri[3], Andi Jamiati Paramita [4], Rena Nainggolan[5], Fenina Adline Twince Tobing[6]
[1,2,3,4]Sistem Informasi, Institut Teknologi dan Bisnis Kalla, Makassar, Indonesia
[5]Universitas Methodist Indonesia, Medan, Indonesia
[6]Universitas Multimedia Nusantara, Tangerang, Indonesia
[1]hanyalexandra@kallainstitute.ac.id

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***Abstract*— The rapid growth of digital logistics has increased dependence on mobile delivery applications to manage shipments, package information, and courier operations under strict time constraints. In such environments, ergonomic and usable user interface (UI) design is essential to reduce cognitive load, minimize errors, and maintain operational efficiency. However, empirical usability research focusing specifically on delivery service applications remains limited, particularly studies conducted in realistic usage contexts. This study evaluates the ergonomic quality of a mobile delivery application using online usability testing. A quantitative evaluation framework is applied, employing three established metrics: the System Usability Scale (SUS), task completion time, and error rate. The results indicate an average SUS score of 57.7 out of 100, placing the application in the *marginal usability* category. Only 25.0% of participants rated the application as acceptable (SUS ≥ 68), while 43.8% rated it as marginal and 31.3% as poor. Task-based testing showed that although 100% of participants completed the primary navigation task, 56.3% reported experiencing difficulty, indicating issues related to navigation clarity and interaction flow. In contrast, 25.0% of users failed to correctly complete the invoice-related task, reflecting weaknesses in information hierarchy and labeling. Based on these findings, the study proposes data-driven UI design improvements aimed at enhancing navigation structure, information clarity, and cognitive ergonomics. The novelty of this research lies in integrating online usability testing with ergonomic evaluation in the delivery application domain, providing scalable quantitative benchmarks and practical design guidance for improving the usability of mobile logistics applications.**

***Index Terms*— Application; Design; Ergonomic; Mobile; UI**

I. INTRODUCTION

The growth of digital logistics services has prompted the adoption of mobile delivery apps to track shipments, handle package information, and support courier operations. These apps are critical to maintaining the speed, precision, and dependability of the delivery process, especially as e-commerce volumes grow globally. In such a high-demand setting, effective user interface (UI) design is critical for lowering cognitive load, increasing efficiency, and reducing operational error [1]. Recent research suggests that design methods should focus on improving the user interface and interactions of mobile applications to make them more suited to the community [2], which suggests that better interface and interaction might improve the purpose of the application. Therefore, design should begin with a clear understanding of the community's characteristics and usage context (e.g., digital literacy, language preferences, accessibility needs, device limitations, and time pressures), as these factors shape how users interpret interface elements and complete tasks or scenarios presented in the testing phase [3]. In practice, this typically translates into a user-centered, iterative workflow, such as contextual inquiry, task analysis, prototyping at low to high levels of detail, and iterative usability testing to identify friction points in navigation, information clarity, and user feedback [4]. When these interaction friction points are reduced, users tend to make fewer errors, complete tasks more reliably, and require less effort to achieve their goals, which can increase adoption and continued use [5]. However, improvements should be validated with measurable outcomes (e.g., task completion rates, task time, error rates, and perceived usability) to ensure that interface changes truly support the app's intended purpose, rather than simply enhancing visual appeal [6].

Although research on mobile usability and digital ergonomics has expanded significantly over the last decade, most studies concentrate on broader domains such as e-commerce platforms [7], mobile banking, or navigation-based applications [8]. Furthermore, empirical research on delivery service applications is scarce. Delivery apps have distinct and time-sensitive processes that need users, including customers and delivery service providers, to accomplish tasks promptly and properly [9]. Because of the domain-

specific complexity, traditional usability findings from other mobile applications may not be completely applicable to delivery-oriented systems, revealing a substantial research need.

Furthermore, much research is irrelevant to actual situations. These findings do not accurately reflect real-world contextual elements that influence user behavior. Recent research emphasizes the growing necessity for remote and online usability assessment methodologies that collect data in natural usage scenarios [10]. Online testing enables researchers to realistically watch user interactions and measure performance measures such as task completion time, error rates, and usability judgments without restriction [11]. However, the use of online usability testing, particularly for investigating ergonomic requirements in delivery apps, is still underexplored in the 2020-2025 research landscape.

These gaps raise several key questions:

(1) How well does the UI of a delivery application align with modern ergonomic and mobile usability principles?

(2) What usability issues? Such as prolonged task time or increased error frequency—occur during user interaction?

(3) Can quantitative metrics such as the System Usability Scale (SUS), task-time efficiency, and error rate reliably represent the ergonomic quality of the delivery interface?

(4) What UI improvements can be recommended to enhance ergonomic suitability and user performance?

Based on these questions, this study aims to evaluate the ergonomic quality of a mobile delivery application using online usability testing. Three quantitative usability metrics are used: SUS score [12], task completion time, and error rate; each of which provides valuable insights into interface performance and ergonomic suitability [13]. The study also identifies common challenges faced by users during delivery-related tasks and proposes design improvements to enhance interface clarity, efficiency, and cognitive ergonomics [14].

The novelty of this research is expected to be useful due to its ongoing and renewable contribution, building upon previous research. Online usability testing and user ergonomic heuristics are included in some of this research, a methodological combination that is uncommon in delivery-oriented UX research between 2020 and 2025. Many other studies provide performance-based evaluation models tailored to delivery processes to solve problems that remain underrepresented in current human-computer interaction (HCI) research [15]. Usability measurements are scalable and repeatable, which will make comparing and benchmarking future logistics mobile apps easier [16]. By providing practical UI design suggestions based on actual data, the result seeks to assist clients and logistics operators in developing more efficient, user-friendly, and ergonomic delivery service applications [17].

The research questions in this study were formulated based on three interrelated considerations. First, prior studies on mobile usability and digital ergonomics have predominantly focused on general application domains, leaving delivery service applications underexplored, particularly in terms of quantitative ergonomic evaluation. Second, the study adopts a performance-oriented usability perspective, requiring research questions that can be examined using measurable indicators rather than purely qualitative judgments. Third, the research questions were aligned with the selected evaluation metrics—System Usability Scale (SUS), task completion time, and error rate—to ensure a direct link between the identified research gap, data collection methods, and analytical outcomes. Consequently, the research questions were designed to (1) assess the degree of ergonomic alignment of the delivery application interface, (2) identify usability problems manifested through efficiency and error patterns during task execution, and (3) determine how effectively quantitative usability metrics represent the ergonomic quality of the interface and inform design improvement recommendations.

II. METHOD

a) Research Design

This study used a quantitative descriptive-evaluative design with a task-based usability testing approach and expert-based ergonomic evaluation. Ergonomics evaluation assesses the extent to which a predefined logistics mobile application's user interface (UI) meets ergonomic criteria, whereas online usability testing measures actual user performance and perceived usability [18], using quantitative metrics such as System Usability Scale (SUS) scores, task completion times, and error rates [19].

The overall goals of the predefined methods are to evaluate UI approaches in accordance with established ergonomic and mobile usability principles [20], identify usability issues that arise during interactions with delivery-related tasks [21], and make empirically supported interface improvement recommendations.

The research involved focuses on consumer-facing mobile logistics apps that provide essential delivery services such as shipment monitoring, package information management, order creation, and customer care. Customers often use these applications, which are installed on Android and iOS smartphones, to track and manage package deliveries in real-time.

This study focuses on the customer-side interface, which is directly involved in tasks like shipment tracking, changing delivery information, and submitting delivery requests. This research also focuses on other stakeholder interfaces (for example, couriers and administrators).

b) Participants Gathering

The study's demographics featured active users across different logistics mobile apps. The criteria specified in the study are as follows:

1. Aged 18 to 30 years old.
2. Willing to use the specified apps at least three times in the last three months for delivery-related activities (for example, shipment tracking, package delivery).
3. To access the apps, use your smartphone (Android or iOS) as the primary device.
4. Capable of following written instructions in the language used for the study.

Participants were recruited using a non-probability purposive sample strategy [22], mostly via online channels such as messaging apps, social media, and app-specific user groups.

The participant age range was limited to 18–30 years to ensure sample homogeneity and to minimize variability related to age-dependent differences in mobile technology usage. Individuals within this range represent the most active segment of mobile application users and generally demonstrate higher levels of smartphone familiarity, faster adaptation to interface changes, and more consistent interaction patterns with app-based services. Restricting the sample to this age group reduces potential confounding effects associated with age-related cognitive decline, perceptual differences, or technology anxiety that may influence task performance and usability perceptions. Consequently, this boundary improves the internal validity of the usability evaluation, while the findings are intentionally interpreted as representative of active mobile logistics application users within this age group rather than the general population.

For online usability testing, a minimum of 20–30 participants is recommended to identify common usability issues and obtain stable descriptive metrics. To increase the reliability of SUS scores and performance indicators, the study targeted approximately 20-30 participants according to related research whose data met the inclusion criteria and passed basic data quality checks (e.g., completion of all tasks and questionnaires and adherence to established criteria).

c) Variables and operational definitions

The primary constructs explored in this study are:

1. Implementation of Ergonomic Criteria (Independent Construction)

a) Refers to how well the specified logistics application's user interface corresponds to ergonomic and usability criteria. This design was operationalized using an expert-based ergonomics checklist that included various dimensions, such as:

b) Visual ergonomics (legibility, contrast, font size, and color utilization).

c) Layout and navigation: consistency, grouping, and information hierarchy

d) Interaction controls (touch target size, spacing, and reach).

e) Feedback and error management (system response, error messages, and confirmations)

f) Cognitive workload (number of steps, information density, label clarity)

3. Each checklist item is assessed using a Likert scale (1 = not fulfilled, 5 = fully satisfied). A higher overall score suggests a more advanced level of ergonomics implementation.
4. The 10-item System Usability Scale was used to evaluate tester perceptions of usability. Each question was also scored on a 5-point Likert scale, from "strongly disagree" to "strongly agree." The scores were translated to the normal SUS scale (0–100). Higher SUS ratings represent improved perceived usability.
5. Task completion time is the amount of time (in seconds) taken by a participant to complete a given task scenario, calculated from the moment the task begins until it is successful or failed. Time is collected for each task and averaged across all participants.
6. The error rate is the frequency with which participants make noticeable errors when performing a task, such as incorrectly navigating to an unexpected section of the screen, failing form submissions, or completing activities incompletely or inaccurately. The error rate can be represented as follows:
   a) Mean number of errors per participant per task, or
   b) Percentage of participants that fail to complete a task properly.

d) Instruments

Several instruments are employed in this study:

1. **Ergonomic Criteria Checklist**

The arranged checklist is based on ergonomic and application usability concepts gleaned from applicable standards and prior research. It addresses several factors (visual ergonomics, layout and navigation, interaction controls, feedback and error handling, and cognitive load). Each item is scored on a scale of 1 to 5. At least one ergonomics or user experience professional reviews the checklist to confirm that the material is valid.

2. **Task scenarios for usability testing**

A set of task scenarios is prepared to reflect core delivery-related activities. Examples of tasks include:

a) Task 1: Track the current status of a specific shipment based on a given tracking number.

b) Task 2: Update the delivery address for an ongoing shipment.

c) Task 3: Create a new delivery order from a specified pick-up address to a destination address.

d) Task 4: Access and use the customer support/contact feature regarding a delayed package.

Tasks are written in clear, concise instructions and are presented to participants in the same order.

3. **Usability Scale (SUS) questionnaire**

The SUS questionnaire consists of 10 standard items measuring perceived usability of the application as a whole. After completing all tasks, participants are asked to fill in the SUS questionnaire based on their overall experience during the session.

4. **Demographic and background questionnaire**

A brief questionnaire was utilized to collect demographic information (age, gender) as well as use information (app experience, frequency of use, user knowledge with mobile delivery applications in general).

5. **Task performance recording sheet**

A recording sheet or digital form is used to capture task completion time and error occurrences for each participant and each task. When possible, screen recording tools or analytic logs may be used to increase accuracy in measuring time and errors.

Data collection is carried out in several stages:

1. **Preparation phase**

a. Conduct a literature review on ergonomic criteria, mobile usability, and logistics-related mobile applications.

b. Create an ergonomic criterion checklist and task scenarios.

c. Create web forms for consent, task instructions, SUS, and demographic information.

d. Conduct a pilot test with 3-5 participants to ensure that task instructions are clear, the data collection platform is user-friendly, and the overall duration is reasonable.

2. **Ergonomic evaluation**

a. Selected logistics applications were systematically evaluated using an ergonomic checklist.

b. Researchers examined interface screens and interaction flows that corresponded to predetermined tasks.

c. Each checklist item was assessed, and the scores were aggregated to obtain a total ergonomic score for each dimension.

3. **Online usability testing**

a. Participants are instructed to perform the tasks on their own smartphones in their natural environment.

b. Task completion time and errors are recorded, either through:

i. self-report with clear timing guidelines, or

ii. remote observation or screen recording (if the platform allows).

c. After completing all tasks, participants fill in the SUS questionnaire and any additional questions regarding their experience.

1. **Data cleaning and validation**

a. Responses with incomplete tasks, missing SUS data, or inconsistent answers are identified.

b. Only data that meet the inclusion criteria and completeness requirements are retained for analysis.

Data analysis consists of descriptive and analytic steps:

1. **Descriptive analysis**

a. Calculate the mean and standard deviation of scores for each ergonomic dimension, as well as the total ergonomic score for the application.

b. Compute the SUS scores obtained based on the results of evaluation tests per individual and obtain the mean, standard deviation, and distribution of SUS scores. Interpret scores based on commonly used SUS acceptance ranges (Kaya et al., 2019).

c. Determine the mean, median, and standard deviation of completion times for each task.

d. Calculate the mean number of errors per task and the proportion of participants who failed or experienced difficulty in each task.

2. **Analytic interpretation of ergonomic implementation and performance metrics**

a. Compare ergonomic checklist scores based on heuristic evaluation & usability-based scenario (Andika, 2024)

b. Identify patterns linking specific ergonomic issues (e.g., small touch targets, low contrast, complex navigation, element misconceptions) with observed usability problems.

e) Research Phases

Figure 1 illustrates the overall research framework adopted in this study, which structures the research process into nine sequential phases grouped into five major clusters. The figure provides a visual overview of how the study progresses from initial problem conceptualization and research scoping, (1) Phases 1-2 focused on issue conceptualization, research scope determination, and research objective establishment. (2) Phase 3 was responsible for sampling design, including determining the target population and sampling frame, inclusion-exclusion criteria, sampling

technique, and respondent recruitment approach. (3) Phases 4-5 formed the requirements definition group, which transformed insights into organized task cases and scenarios with explicit objectives and success criteria for each case. Once the specifications were completed, (4) Phases 5-7 included data gathering and knowledge analysis, in which information was methodically gathered and analyzed to find patterns, gaps, and consequences that corresponded to the preset scenarios. The last cluster, (5) Phases 8-9, integrated the general interpretation of the preceding phases' results and generated final recommendations, including priorities and practical actions based on the examined data.

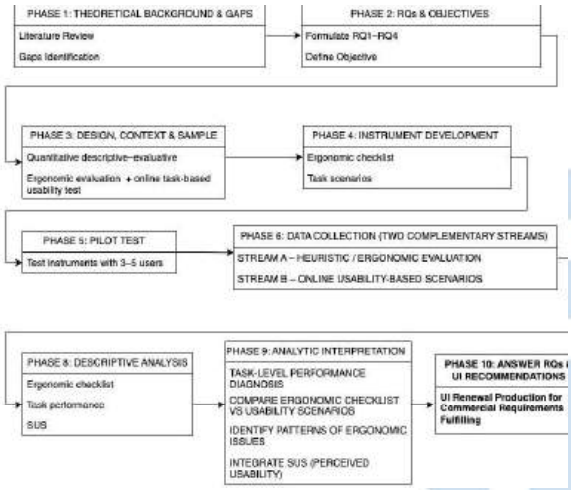

Fig 1. Research Phase

III. Result and Discussion

The research study's data were subsequently processed using batch-based interpretation in nine preset processes. This enabled the first contextual findings to be gradually transformed into practical needs, empirical evidence, and suggestions. All findings are split into several batches. Each batch is related to the other batch within the exact phase to complete the contextual purpose of the research.

A. Batch 1: Phases 1–2 (initial exploration and outlining)

This section presents preliminary contextual data and a project framework. In this section, Ulil Trans is compared to comparable apps using App Store/Google Play ratings as a high-level sentiment indicator, indicating how the app could be viewed in the larger market. However, because shop evaluations are impacted by numerous aspects other than interface design (such as stability, performance, and service quality), this comparison is viewed as supporting context rather than direct evidence of UI/UX excellence.

B. Batch 2: Phase 3 (design sampling and participant recruitment)

Phase 3 determined the sample design and defined the demographics of the usability testers, including the participant age restriction (18-30 years) as the primary demographic control, and limited participation to active Ulil Trans mobile app users. Age was purposefully chosen as the only demographic variable to preserve sample comparability and limit variability caused by age-related variations in smartphone familiarity and engagement patterns with mobile apps. In this study, active users were identified as those who had used the Ulil Trans app at least once during the previous 30 days, ensuring that task performance and SUS replies were based on recent, real use rather than first-time exploration. As a result, future interpretation of the data is confined to the experiences of active users within the designated age range, whereas onboarding and churn barriers among first-time users or users who quit usage of the app are beyond the scope of this phase.

Demographic points:

1. Primary demographic variable: Age only
2. Age range boundary: 18–30 years
3. Additional demographic segmentation: Not applied (e.g., gender, education, occupation were not used) to avoid sample fragmentation
4. User status boundary: Active users only
5. Active user definition: Used the Ulil Trans app at least once within the last 30 days
6. Interpretation boundary: Findings represent active Ulil Trans users aged 18–30; not generalizable to users outside the range or to first-time/lapsed users
7. Recruitment basis: Participants selected based on the anticipated user profile (rather than random selection), assuring relevance for task-based usability testing.

Phase 3 additionally included a brief UI picture of Ulil Trans to help with demographic borders and offer context for upcoming job situations. This temporary UI snapshot served as the study's baseline, exhibiting the interface state used and introduced to participants throughout testing and assessment, as well as defining the primary screens and navigation features essential to the task scenarios tested in the following phases.

C. Batch 3: Phase 4 to 5 (determination of requirements based on task cases and scenarios)

In this phase, all requirements have been integrated into selected questions with suitable requirements that have been concluded based on the previous phase or stages.

1. **Demographic Data & Experience**

a) Age

b) Frequency of Ulil Trans Use

(a) 1–2 times

(b) 3–5 times

(c) 6–10 times

(d) More than 10 times

(e) Never used

c) Frequency of Other Logistics Apps

(a) Rarely / almost never

(b) Sometimes (1–2 times per month)

(c) Fairly often (3–5 times per month)

(d) Very often (>5 times per month)

2. **Task 1: Navigating the Menu Options on the Home Page**

a) Did you complete all the steps in Task 1 (opening the Ticket Booking menu, returning to the homepage, then opening the Notifications menu)?

(a) Yes, I managed to complete all the steps without any difficulty.

(b) Yes, I managed to complete them, but with some difficulty.

(c) No, I did not manage to complete all the steps.

b) Estimated time required to complete this task

(a) < 1 minute

(b) 1 minute

(c) 1 minute 30 seconds

(d) 2 minutes

(e) > 2 minutes

c) While performing Task 1 (opening the Ticket Booking menu, returning to the homepage, then opening the Notifications menu), what difficulties did you encounter? (You may select more than one)

(a) I'm having trouble finding the Ticket Booking menu on the homepage.

(b) I'm confused by the menu icons or labels (I don't immediately understand what the icons/text mean).

(c) I'm having trouble finding how to return to the homepage after opening a menu.

(d) I'm having trouble finding the Notifications menu or I'm not sure where the information is located.

(e) I find the navigation between menus unclear, making it take a long time to navigate from one section to another.

(f) Other

3. **Task 2: Order History**

a) Were you successful in finding and understanding the order status you were looking for on the History page?

(a) Yes, I managed to complete all the steps without any difficulty.

(b) Yes, I managed to complete them, but with some difficulty.

(c) No, I was unable to find or understand the order status I was looking for.

(d) Other

b) Estimated time required to complete this task

(a) < 1 minute

(b) 1 minute

(c) 1 minute 30 seconds

(d) 2 minutes

(e) > 2 minutes

c) While viewing the History page and trying to understand the information on the order list, what difficulties did you encounter? (You may select more than one)

(a) I had difficulty finding a specific order.

(b) The information in each history (name, origin-destination, service type, status) felt too dense and difficult to read quickly.

(c) I didn't understand the meaning of the colors used to indicate trip status.

(d) I had difficulty distinguishing the type of service (freight vs. passenger ticket) from the display.

(e) I had difficulty scrolling or navigating through the History page to view older or newer orders.

(f) No difficulty.

(g) Other

d) What was the most confusing or hindering aspect of this task?

4. **Task 3: Booking Passenger Tickets**

a) Were you able to easily fill out the passenger ticket booking form?

(a) Yes, it worked.

(b) No, it didn't work.

b) Estimated time required to complete this task

(a) < 1 minute

(b) 1 minute

(c) 1 minute 30 seconds

(d) 2 minutes

(e) > 2 minutes

c) What problems did you encounter while performing this task? (You can select more than one)

(a) I was able to fill in all the data easily without any issues.

(b) I was confused about the order or location of the required fields.

(c) The text/labels in the fields were unclear or too small, making them difficult to read.

(d) I entered data incorrectly and didn't receive a clear error message.

(e) Buttons or elements that needed to be touched (e.g., the continue/submit button) were difficult to find or difficult to touch.

(f) Other

d) What was the most confusing or hindering aspect of this task? (You can leave blank if none occurred)

5. **Task 4: Checking Invoices**

a) Do you understand the details of the invoice listed on the page?

(a) Yes, it worked.

(b) No, it didn't work.

b) Estimated time required to complete this task

(a) < 1 minute

(b) 1 minute

(c) 1 minute 30 seconds

(d) 2 minutes

(e) > 2 minutes

c) While viewing the invoice page, what were your experiences? (You can choose more than one)

(a) I had difficulty understanding some of the information on the invoice (e.g., terms, labels, or transaction descriptions).

(b) The information felt too dense, making it take me a long time to find the details I was looking for.

(c) The text or number display (date, amount, transaction code) was too small/difficult to read.

(d) I had difficulty finding the buttons or menus to download the invoice (download/print/save).

(e) I was confused by the layout of the information (the order details, total payment, and shipping status were unclear).

(f) Other

d) What was the most confusing or hindering thing about completing this task?

6. **Usability Questionnaire (SUS)**

a) I think I'll use Ulil Trans frequently.

b) I find Ulil Trans too complicated to use.

c) I find Ulil Trans easy to use.

d) I feel like I need help from others to use Ulil Trans.

e) I find Ulil Trans' features well-organized.

f) I feel like there are too many inconsistencies in Ulil Trans.

g) I imagine most people will quickly become proficient with Ulil Trans.

h) I find Ulil Trans complicated and confusing.

i) I feel confident using Ulil Trans.

j) I need to learn a lot before I can use Ulil Trans well.

7. **Additional Open-Ended Questions**

What part of the Ulil Trans interface or flow do you find most helpful and user- friendly? Please describe it briefly.

D. Batch 4: Phase 5 to 7 Results (Pilot Test, Data Collection, Descriptive Analysis)

Based on the data provided, the usability testing of the Ulil Trans application generated moderate but inconsistent results, with an average SUS score of 57.7/100 (marginal category). Only 25.0% of respondents rated the usability as "good/acceptable" (SUS ≥ 68), while 43.8% rated it as "marginal" (SUS 50-<68) and 31.3% rated it as "poor" (SUS < 50). At the task level (n = 32), users were generally able to complete the task. In Task 1 (homepage navigation: Ticket Booking → Home → Notifications), 100% of the testers were successful, but the majority did not succeed (56.3%) stating that they succeeded with some difficulties, which indicates problems with the clarity of the navigation structures, navigation flows, and visual clues while navigating menus; in Task 2 (finding and understanding booking status in History), most of the testers completed the scenario without difficulty. In Task 4 (understanding invoice details and downloading invoices), 75.0% stated that the majority of testers understood the flow and procedures for downloading invoices, while 25.0% did not. This was indicated by indicators that showed weaknesses in information

design, such as display hierarchy, cost or status terms/labels, information grouping, and marking of important elements. Overall, these results indicate that Ulil Trans has not been consistently considered user-friendly by the majority of testers or users. As a result, the key ergonomic and usability improvements that must be addressed center on (1) enhancing the navigation and wayfinding design; (2) strengthening menu/icon marking as well as affordance and consistency of interaction; and (3) increasing the hierarchy and clarity of information on the History and Invoice screens, rather than focusing primarily on the data/form input flow.

E. Batch 5: Phase 8 to 9 (final phases)

Following Phases 6-7, which established fundamental usability results through SUS and task-based testing, Phase 8 broadened the analysis by converting those findings into data visualizations that made patterns of obstacles simpler to understand at a glance.
Phase 8 clarified where barriers were most frequently encountered (particularly in homepage navigation and discoverability for low-experience users) and which areas indicated remaining interaction understandability or reliability issues.

The data reveals that Ulil Trans's overall usability remains mediocre, with an average SUS score of 57.73 and a score dispersion indicating an uneven user experience. The sample findings demonstrate that testers had never used Ulil Trans, and the majority have only used it once or twice, emphasizing the importance of first-time discovery and navigation. Across the scenario results, Task 1 (Home Navigation and Accessing Notifications) presented the greatest challenge, with more than half of respondents completing the task or scenario but finding it difficult, and the distribution of times hovered around 2 minutes, indicating inefficient exploration rather than complete failure.

The History and Invoice scenarios demonstrated better overall completion and comprehension, but still left a significant portion of users struggling, consistent with visuals indicating information density, unclear status cues, and weak design hierarchy; furthermore, at least one instance of an impressable icon presented an interaction reliability issue that could disproportionately lower perceived usability of the app. The order form performed relatively better in terms of completion, but the observed failure rate remained significant for the core conversion flow. Overall, these figures support prioritizing improvements that reduce navigational ambiguity (clear global navigation and consistent back/home behavior), address interaction reliability (tap targets and responsive UI elements), and improve the information design on the History and Invoice pages through clearer labeling, a scannable layout, and prominent primary actions.

IV. Conclusion

By visualizing and calculating data, this research indicates that the Ulil Trans mobile app's performance is greatly determined by how well its interface and interaction design match the characteristics of its target users and the environment in which it is used. Differences in digital literacy, linguistic expectations, accessibility requirements, device limits, and time constraints affect how users understand interface signals, traverse displays, and perform activities in user-tested scenarios. When these contextual elements are not clearly handled, problems arise as recurrent impediments in the app's usage flow, such as discovering functionalities, comprehending labels and status information, properly inputting data, and identifying system feedback.

These findings also reinforce that iterative, user-centered design cycles are not a silver bullet, but rather a necessary tool for reducing barriers. Contextual inquiry and task analysis help clarify the intended use of an app and its specific constraints, while interactive prototyping and iterative usability testing reveal where interactions are struggling in practice. As interface clarity improves and interaction effort decreases, users are more likely to consistently complete tasks with fewer errors, contributing to higher acceptance, continued use, and more reliable achievement of app goals.

To address the identified limitations, this study presents a new interface approach that focuses on enhancing important user processes while also boosting clarity and feedback. Recommended interface improvements include: (1) restructuring the navigation hierarchy so that core features are more accessible; (2) improving information clarity through more explicit labels, consistent iconography, and easily understandable history summaries; (3) improvements to feedback and error prevention mechanisms (confirmation for risky message actions, clear progress indicators); and (4) adapting the interface to device accessibility and context. In this approach, the suggested interface is not only more visually appealing, but it is also intended to reduce cognitive burden, minimize user mistakes, and speed up job completion.

Acknowledgement

Finally, this study has practical implications for design and evaluation: interface modifications should be prioritized based on friction points that have the largest influence on crucial usage and confirmed with performance-based usability indicators. Future study might enhance these findings by testing a larger range of user segments, assessing use in more natural circumstances, and tracking long-term usage to see if usability benefits transfer into maintained engagement over time.

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Android Shortcut Application Development as A Medium for Religious Information Using The AppsGeyser Platform

Imam Mualim [1], Nuari Anisa Sivi [2], Nurkaif [3], Rena Nainggolan[4], Fenina Adline Twince Tobing [5]
[1,2,3] Universitas Nahdlatul Ulama Lampung
[4] Universitas Methodist Indonesia
[5] Universitas Multimedia Nusantara
[2] Program Studi Sistem Informasi, Fakultas Teknologi Industri, Universitas Trisakti
[1]imammualim200281@gmail.com, [2]nuarisivi@gmail.com, [3]nurkaif33@gmail.com,
[4]renanaing99olan@gmail.com, [5]fenina.tobing@umn.ac.id

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***Abstract*— The development of information and communication technology has encouraged the use of mobile devices as a medium for disseminating information, including in the religious field [10]. Today's society requires fast, practical, and easy-to-use access to religious information through Android-based smartphones [6]. This study aims to develop a shortcut-based Android application as a medium for religious information by utilizing the AppsGeyser platform [7]. The development method used includes needs analysis, application design, implementation, and functional testing of the application using a Research and Development (R&D) approach [3]. The results of the study indicate that the Android shortcut application is able to present religious information effectively, is easily accessible, and is lightweight to use without requiring high device specifications.**

***Index Terms*— Android Application, Religious Information Media, AppsGeyser**.

I. INTRODUCTION

The development of information technology in the current digital era has had a significant impact on various aspects of life, including education and the dissemination of religious information [10], [15]. The advancement of Android devices, particularly Android-based smartphones, has driven changes in the way people access information.

The use of Android applications as an information medium has several advantages, including ease of access, interactive displays, and the ability to integrate various types of content such as text, images, audio, and video [11]. However, the application development process often requires technical programming skills that not everyone possesses [1].

Furthermore, the existence of Android shortcut applications can also increase the visibility of religious institutions because the applications can be displayed directly on the smartphone screen. This will strengthen the institution's digital identity, increase congregational engagement, and open up wider space for the spread of Islamic preaching [9]. In the context of digital technology development, the ability of religious institutions to utilize digital media is one indicator of their readiness to face the era of digital transformation.

Based on the background explained above, the research problem is formulated as follows: How is the process of developing an Android shortcut application as a medium for religious information using the AppsGeyser platform?

Developing an Android shortcut application that can facilitate user access to religious information by utilizing the AppsGeyser platform as a coding-free application development tool.

II. EASE OF USE

A. Android Application

Android applications are a rapidly growing technological innovation with the increasing use of mobile devices such as smartphones and tablets [6]. In general, an Android application can be defined as software designed and developed to run on Android devices with the aim of providing certain services, functions, or conveniences to users [6], [13], [14]. These applications work by utilizing the device's built-in features such as the touchscreen, camera, GPS, motion sensors, and internet connection to provide an optimal interactive experience [11].

Android applications are a rapidly growing technological innovation with the increasing use of mobile devices such as smartphones and tablets. In general, an Android application can be defined as software.

Fig 1. Android icons by version

B. *Shortcut Applications*

Shortcut apps are a form of innovation in Android app development that focuses on ease and speed of information access [12]. Generally, shortcut apps are simple applications that function as shortcuts to connect users directly to specific content, such as websites, digital services, or specific features, without the need for lengthy navigation. This type of app is widely used on Android-based devices because it is easy to create, lightweight, and practical for a wide range of users.

Technically, shortcut apps are generally developed using web-based app creation platforms or generator apps, such as AppsGeyser, WebView, or Progressive Web App (PWA) [7], [16]. These platforms allow developers to create apps without having to write complex programming code. This makes shortcut apps an effective solution for individuals, educational institutions, religious organizations, and small agencies with limited development resources.

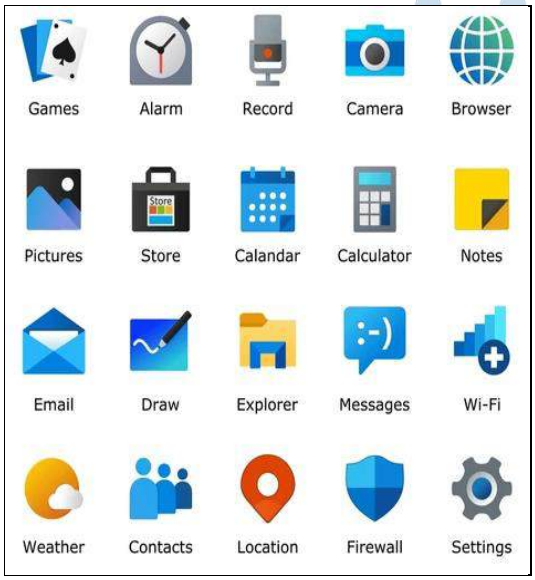

Fig 2. Shortcut applications

C. *Functions and Benefitsof Shortcuts*

A shortcut is a feature or mechanism designed to provide quick access to a specific function, application, or information without going through lengthy processing steps. In the context of information technology, shortcuts act as digital shortcuts that simplify user tasks on computers and Android devices [12]. Shortcuts are an essential part of modern interface systems because they support efficiency, speed, and convenience in technology use.

The primary benefit of using shortcuts is time and energy efficiency. Shortcuts enable users to complete tasks more quickly by eliminating unnecessary steps. This efficiency is crucial in modern life, which demands speed and practicality in accessing information and digital services.

Shortcuts also provide benefits in optimizing device resources. Applications or systems that utilize shortcuts are generally lightweight and do not require large storage or memory capacities. This is particularly advantageous for devices with low specifications or limited storage capacity, allowing them to still perform their primary functions optimally.

D. *Religious Information Media*

Religious information media is a means of communication used to convey religious teachings, values, and messages to the public in a systematic and sustainable manner [8]. This media plays a crucial role in the process of preaching, education, and moral and spiritual development of the community, both in print and digital formats. With the development of information technology, religious information media has undergone a transformation from conventional methods to more interactive and accessible digital-based media. Religious information media serves as a bridge between sources of religious teachings and the wider community [9]. Through this media, various religious materials such as studies of the Quran and Hadith, guidance on worship, morals, Islamic history, and information on religious activities can be effectively conveyed. The existence of this media helps the community understand religious teachings more deeply and apply them in their daily lives.

E. *The Role of Religious Information Media*

Religious information media plays a crucial role in society, particularly in conveying religious values widely, quickly, and easily accessible [9].

1. Religious information media serves as a means of preaching and disseminating religious teachings.
2. Religious information media serves as a medium for education and learning.
3. Religious information media plays a role in shaping attitudes, morals, and character in society.
4. Religious information media serves as a means of uniting the community. This media can serve as a forum for communication and fostering friendship

between religious communities and among adherents of other religions.

F. *AppsGeyser*

AppsGeyser is a web-based platform for creating Android applications (APKs) without writing any programming code. This platform allows users to convert various types of content—such as websites—into Android apps. In general, AppsGeyser can be defined as an effective, efficient, and economical no-code Android app creation solution for educational, informational, and digital promotional purposes [7], [17].

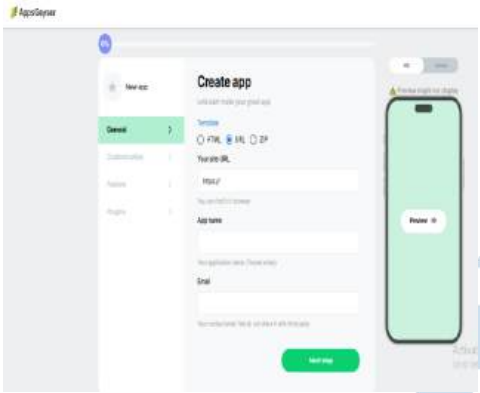

Fig 3. Form AppsGeyser

The following are the main features offered by AppsGeyser, a no-coding Android app creation platform:

a) No-Code App Builder

b) Ready-to-Use App Templates

c) Web Content to App Conversion

d) Fast App Creation

e) Design and Content Personalization

f) App Monetization

g) Push Notifications

h) Integration with Third-Party Services

i) Export & Publishing

III. RESEARCH METHOD

A. *Research Design*

This research uses the research and development (R&D) method, research method used to produce a specific product and test its effectiveness [3].

This development model has advantages and disadvantages. The advantages of this model are its ability to produce a product with a high validation value and encourage continuous product innovation. However, the disadvantages of this model are its relatively long time-consuming nature, as the procedures are relatively complex and require significant funding.

The first stage is Define, often referred to as the needs analysis stage. The second stage is Design, which prepares the conceptual framework for the model and learning tools. The third stage is Develop, which involves validation testing or assessing the feasibility of the media. Finally, the Disseminate stage is implementation on the actual target audience, the research subjects [3].

Fig 4. Development Steps

B. *Data Types and Data Collection Techniques*

The types of data used in this study consist of primary and secondary data. Primary data is data obtained directly from primary sources through direct interaction with the research subjects. This data is collected to obtain information relevant to the research objectives, such as respondents' opinions, responses, and behaviors toward the research subjects [10].

C. *Data Analysis Techniques*

The collected data is then processed. The data management steps in this research include:

1. Editing, which involves reviewing and re-examining the data collected from respondents. Through editing, researchers can improve the quality of the data to be processed and analyzed.
2. Design, which involves assigning symbols to respondents' answers to facilitate data analysis.
3. Tabulation, which involves processing data by arranging or entering data into tables, then analyzing them based on the research objectives.

In development research, the results of data analysis are also used to evaluate and refine the product being developed. Data from expert validation and user trials are analyzed to determine the product's feasibility and effectiveness, allowing for improvements based on the feedback and findings obtained [3].

IV. RESEARCH RESULTS AND DISCUSSION

A. Research Results

The result of this research is an Android Shortcut application developed using the AppsGeyser platform and functioning as a religious information medium. This application is designed to facilitate users' quick, practical, and integrated access to religious information via Android-based smartphones [7].

This Android Shortcut application utilizes the web-based shortcut concept, where the application's main content comes from websites or online sources and is packaged as an Android application without requiring complex programming.

B. Application Development Process

1. Need Analysis

   This stage aims to identify user needs for religious information media. Based on observations and literature review, it was found that users require media that is easy to access, easy to use, and contains up-to-date and relevant religious information.

2. Application Design

   The application design was carried out by selecting the AppsGeyser platform with its Website to App feature. At this stage, the application name, application icon, content source website address, and initial application display (a simple splash screen) were determined.

3. Implementation

   Implementation was carried out by utilizing AppsGeyser features, converting the website to an Android Shortcut application, as well as setting up navigation and creating an APK file.

4. Application Testing

   Tests were conducted by installing the application on several Android devices to ensure the application runs properly and displays religious information as intended.

C. Application Display

1. Main Application Display

   The Android Shortcut application, a religious information medium developed using the AppsGeyser platform, is displayed as an application icon on the user's smartphone home screen. The application icon is designed to be simple and represents religious identity for easy user recognition.

Fig 5. Main applications on the smartphone screen

2. Application Icon

   On the smartphone screen. The application icon is the main visual element displayed on the smartphone screen after the Android Shortcut application installation process is complete. In this study, the application icon was designed using symbols and colors that reflect religious identity so that it is easily recognized by users

Fig 6. Application icons on the smartphone screen

3. Navigation Menu (if available on the source website)

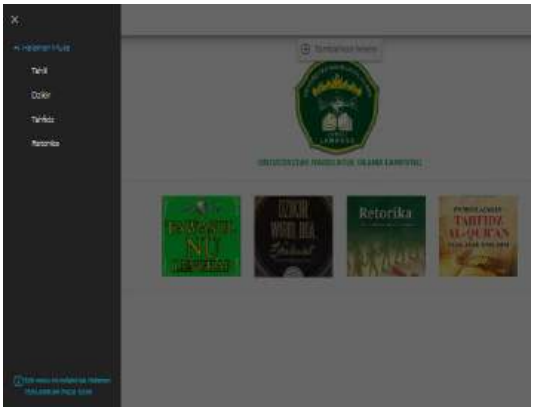

Fig 6. Navigation Menu

D. Application Testing Results

Application testing was conducted using the black box testing method to ensure the application functions as expected.

TABLE I. APPLICATION TESTING RESULT

No	Skenario Pengujian	Hasil yang Diharapkan	Hasil Pengujian	Keterangan
1	Application installation	Application can be installed	Successful	Valid
2	Application run	Application opens normally	Successful	Valid
3	Content access	Religious content appears	Successful	Valid
4	Page navigation	Navigation works well	Successful	Valid

Based on the test results, it can be concluded that the Android Shortcut application runs well and meets its development objectives.

V. CONCLUSIONS AND SUGGESTIONS

A. Conclusions

Based on the research results and discussion regarding the development of the Android Shortcut application as a medium for religious information using the AppsGeyser platform, the following conclusions can be drawn:

1. This research has successfully developed an Android Shortcut application utilizing the AppsGeyser platform as a medium for delivering religious information that is easily accessible via Android-based smartphones.
2. The developed application is capable of displaying religious information quickly and practically without requiring complex Android programming processes, thus providing an alternative solution for religious institutions or communities in disseminating information.
3. Application testing results indicate that the Android Shortcut application runs well on Android devices, and all main functions, such as installation, opening the application, and accessing religious information content, function as expected.

The use of the AppsGeyser platform has proven effective in the development process of simple applications, particularly for website-based applications packaged as Android Shortcuts.

B. Suggestions

Based on the research results, the author offers the following suggestions:

1. The application can be further developed by adding a notification feature to provide users with the latest religious information.
2. Further development could consider using a more complex Android platform or framework to allow the application to run offline and include interactive features.
3. The application interface design could be improved to be more attractive and tailored to user needs.

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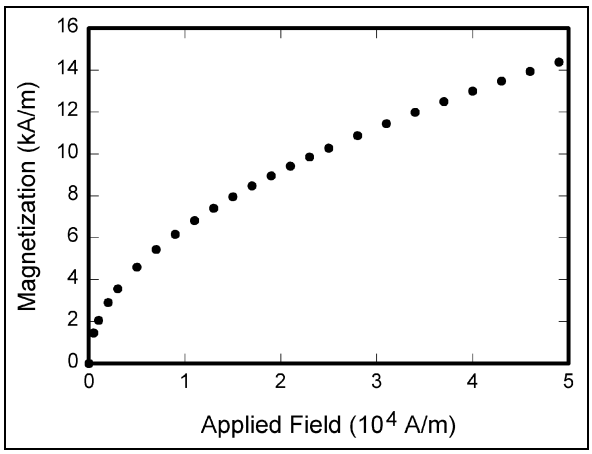

Fig. 1. Example of a figure caption

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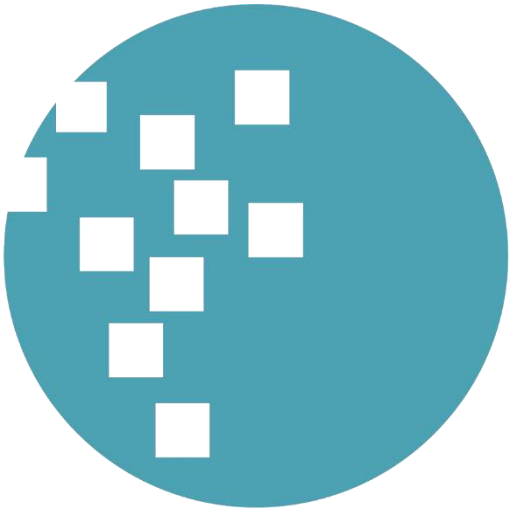

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