Trends and Future Outlook for Mobile Application Development Using Design Thinking Approach: A Systematic Literature Review

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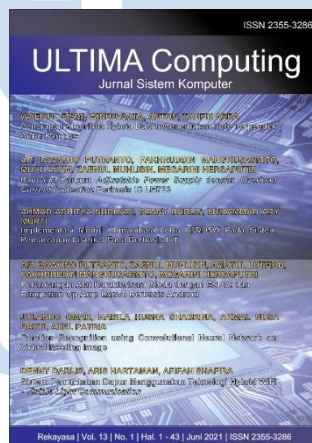
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FOREWORD

Greetings!

Ultima InfoSys : Jurnal Ilmu Sistem Informasi is a Journal of Information Systems which presents scientific research articles in the field of Information Systems, as well as the latest theoretical and practical issues, including database systems, management information systems, system analysis and development, system project management information, programming, mobile information system, and other topics related to Information Systems. ULTIMA InfoSys Journal is published regularly twice a year (June and December) by Faculty of Engineering and Informatics in cooperation with UMN Press.

In this December 2024 edition, ULTIMA InfoSys enters the 2nd Edition of Volume 15. In this edition there are ten scientific papers from researchers, academics and practitioners in the fields covered by Ultima Infosys. Some of the topics raised in this journal are: Trends and Future Outlook for Mobile Application Development Using Design Thinking Approach: A Systematic Literature Review; Exploring Masterweb's Effectiveness in Optimizing Digital Based Learning and Education Management; Development of an Expert System for Diagnosis of Pests and Diseases in Soybean Plants Using the Forward Chaining Method Case Study: Badan Standarisasi Instrumen Pertanian (BSIP) Aneka Kacang Kendalpayak Malang; Development E-Catalogue Portfolio Design Architecture with Android Mobile Apps using Kodular Framework; Sentiment Analysis of Indonesian Presidential Candidate Before and After the Election; CodeGuardians: A Gamified Learning for Enhancing Secure Coding Practices with AI-Driven Feedback; Goal Directed Design Method on UI/UX Design Mobile-Based Application for Preventing Waste Dumping ; Quality Analysis of Scheduling System Using COBIT 2019 at Ministry of Religious Affairs Pasuruan; Systematic Literature Review of Knowledge Management in Students Based on Education Level in Indonesia; and Web-Based ERP System Prototype for Enhanced Inventory and Supply Chain Management in the Logistics Industry..

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 ultimainfosys@umn.ac.id and the web page of our Journal here.

Finally, we would like to thank all contributors to this December 2024 Edition of Ultima Infosys. 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 2024,

Wella, S.Kom., M.MSI.
Editor-in-Chief

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Trends and Future Outlook for Mobile Application Development Using Design Thinking Approach: A Systematic Literature Review

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Abstract—In today's technological world, mobile-based application development has become a crucial and integral element for achieving competitive advantage. Various fields have tried to create mobile applications. One widely used method is Design Thinking, which focuses on creating more innovative, user-focused, and contextual solutions. This writing reviews mobile application development using the Design Thinking approach as the main method. In this research, the author explores the basic principles of Design Thinking, its processes, and how they can be applied effectively in the stages of mobile application development. The authors also analyze the benefits derived from this approach, including improved product quality, positive user response, and the potential to meet changing market needs. The results illustrate that the Design Thinking approach is not just an application development tool, but also a philosophy that drives better innovation and more relevant solutions. This SLR will display research results to what extent the Design Thinking approach in mobile application development has been used.

Keywords— Mobile Application Development, Design Thinking, Systematic Literature Review, innovative, User-Focused, Contextual Solution

I. INTRODUCTION

The rapid development of mobile applications has changed the digital landscape, influencing the way we live, work, and interact [1]. In this dynamic world, the adoption of innovative development methodologies has become essential to remain competitive and meet evolving user needs [2]. Among these methodologies, Design Thinking has emerged as an interesting approach that places human-centered design at its core, fostering creativity, empathy, and problem solving [3].

This systematic literature review investigates the evolving landscape of mobile application development through the lens of Design Thinking. Our investigation aims to provide a comprehensive overview of the trends, insights and best practices that have shaped this field [4]. By synthesizing existing research and examining the key principles and processes of Design Thinking, author seek to offer a deeper understanding of how this approach is systematically applied in the context of mobile application development [5].

Throughout this review, author will explore various dimensions of the interaction between Design Thinking and mobile application development, including its impact on user experience, market competitiveness, and the ability to effectively address complex challenges. By highlighting recent trends and emerging patterns, this research aims to contribute to the ongoing discourse on how Design Thinking can be utilized as a valuable tool in the growing field of mobile application development.

II. LITERATURE REVIEW

A. Design Thinking

Design thinking is a series of problem-solving processes that emphasize human-centric approach [6], this means that design thinking prioritizes the needs and comfort of design users. Thus, in carrying out design thinking, it is necessary to have a deep understanding of human needs and ensure that these needs are met [7].

The elements of design thinking are:

- Empathize: The first step in the design-thinking process is to empathize. To understand the demands of their users personally, design teams do research. They let go of preconceived notions to observe and speak with users to gain insights into their environment. They are more able to comprehend the challenges, motives, and experiences of users.

- Define: At this stage, the information and observation results that have been collected in the previous step will be analyzed to determine the core of the

problem. Identification of this problem must be human-centered.

- o Ideate: The next stage in the design thinking process is ideate. After knowing and understanding the problems that occur, now is the time to translate these needs into the form of innovative ideas and solutions. This process is usually carried out by brainstorming. The more people discuss, the more diverse the ideas that are produced. Make sure all ideas about the problem have been identified, even the ones that don't make sense.

- o Prototype: At the prototype stage, the designer will produce a prototype according to the ideas that have been developed. Not all ideas will be prototyped. This is because not all ideas really make sense and can be turned into products. Sometimes, there are some ideas that cannot be realized due to technological limitations, costs, etc. For this reason, screening needs to be done before it can enter the prototype stage.

- o Test: After the prototype, the next stage is the test or testing stage. The prototype that has been developed will be tested directly with the user to ensure everything is running well. Any input from the user will be accommodated. If necessary, a prototype can be made again and tested again afterwards.
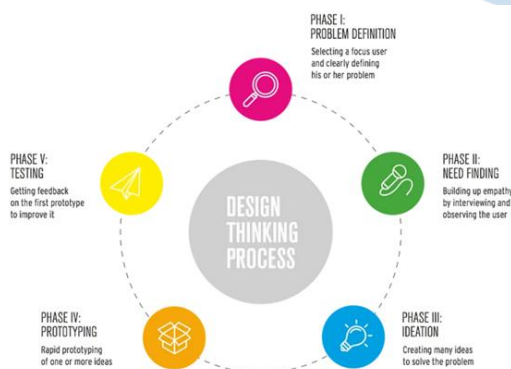

Figure 1 Phases of Design Thinking [8]

B. Design Thinking in Mobile Application Development

Design Thinking, as a human-centered approach, has gained significant traction in mobile app development over the last decade. Researchers and practitioners have recognized its potential to improve user experience and drive innovation. Studies such as the seminal work [9] on design thinking have laid the foundation for its application in the context of mobile applications. Several studies have explored the principles of empathy, ideation, and prototyping in the field of mobile application design [10]. These early works provide a basis for understanding how Design Thinking principles can be systematically integrated into the mobile application development process.

C. User-Centered Design and Mobile Apps

The main principle of Design Thinking, user-centered design, aligns with the mobile application development philosophy. As mobile applications continue to develop across industries, there is an increasing emphasis on understanding user needs and preferences. As a result, much research has explored the integration of Design Thinking to improve the usability and user experience of mobile applications [11].

D. Innovation and Creativity in Mobile Application Development

Innovation is the driving force in the mobile app industry, where staying ahead of the competition requires creative problem solving. Design Thinking's emphasis on brainstorming, prototyping, and iteration has attracted attention as a way to foster creativity in mobile app development. Several studies have highlighted the role of Design Thinking in fostering innovative ideas and translating them into successful mobile applications [12].

E. Design Thinking Process and Framework for Mobile Apps

The systematic application of Design Thinking principles to mobile application development often involves the use of specific processes and frameworks. Researchers have proposed and refined frameworks tailored to the unique challenges of mobile app design. This framework offers a structured guide for integrating Design Thinking into the mobile application development lifecycle [13].

F. Challenges and Limitations

Although Design Thinking offers promising benefits, it is not without challenges and limitations in the context of mobile application development. Managing time constraints, balancing user preferences with technical feasibility, and ensuring scalability are some of the challenges faced by developers and researchers. Acknowledging these challenges is critical to a holistic understanding of the practical implications of applying Design Thinking in this domain [14].

G. Future Directions

The literature reviewed here underscores the growing importance of Design Thinking in mobile application development. As the field continues to develop, future research avenues may include exploring the integration of emerging technologies (e.g., Artificial Intelligence, Augmented Reality, Virtual Reality) with Design Thinking, examining the impact of cultural factors on user-centered design, and investigating the long-term sustainability of mobile apps developed through this approach.

III. RESEARCH METHODOLOGY

The methodology used in this research uses a method developed by Barbara Kichenham [15]. This methodology is popular and widely used by researchers in Systematic Literature Review-based research because the stages are systematic and clear. Using the SCOPUS research database, the steps to be carried out can be seen in the figure below:
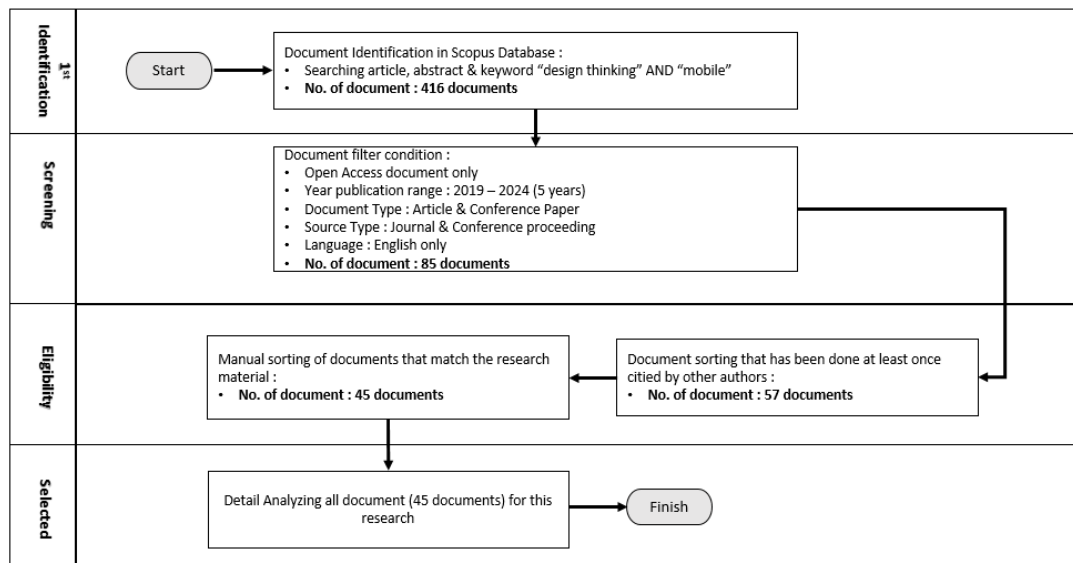
Figure 2 Systematic Literature Review

The initial stage is to identify and determine the keywords that will be used. This stage determined that the keyword used was "design thinking" and would only search for articles in English. From a search using the search engine on SCOPUS, 416 articles were found that met these criteria.

The next stage is to expand the criteria in order to narrow down the number of articles obtained. The criteria included are that only articles of the "open access" type are selected with the aim that the articles obtained can later be downloaded in full, and the publication time range is only up to 5 years ago (2019 to 2024), source type from journal and conference proceeding, language : English only and document type are article and conference paper only. From these criteria the number of articles obtained was 85 articles. After this stage, it was continued with the "Eligibility" stage by adding criteria, namely the articles searched were only documents that have been cited at least once by other authors. From this stage author obtained 57 journals and proceedings. The 57 documents were then manually selected based on the material that was suitable for this research and obtained 45 documents that were applied for more detailed analysis for the Systematic Literature Review (SLR) research to be carried out..

IV. RESEARCH FINDINGS AND DISCUSSION

Design thinking as an approach in mobile application development has been widely adopted by various countries. This can be seen from the distribution of writers who come from various countries and are not dominated by a particular country. Figure 3 shows the top 10 countries that have published writing on the design thinking approach for developing mobile-based applications. This illustrates that the mobile-based application development approach using the Design Thinking concept is still relatively popular. And, referring to the positive trend of writing on this theme in the last 5 years (2020-2024), it is estimated that this theme will continue to be researched and developed. This can be seen in the figure below:
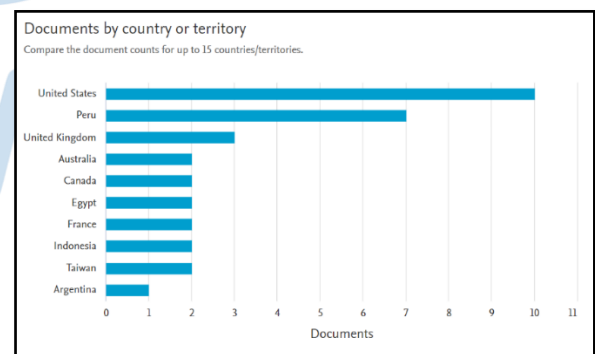
Figure 3 Origin of Documents by Country
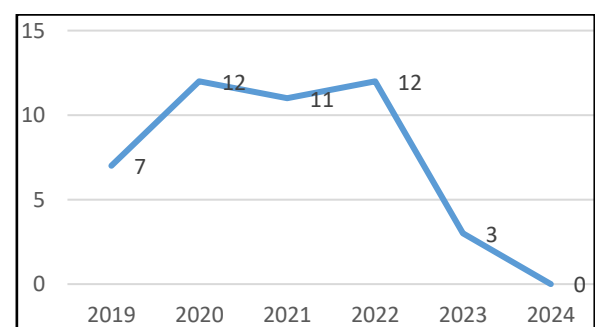
Figure 4 Origin of Documents by Year

Turns out, design thinking method is used in various disciplines. Computer science is the field with the highest percentage (25%), followed by health (12.9%) and engineering (10.9%). This indicates that the application of design thinking for mobile-based application development can be applied in many fields. This is because the design thinking framework is designed to be universal and can be applied anywhere. To see which fields use the design thinking approach the most, see the figure below.
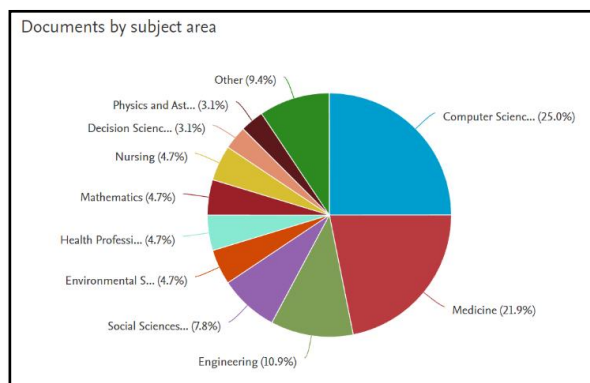
Figure 5 Fields of Research

The comparison of the number of documents in this Systematic Literature Review (SLR) research is : 38 documents come from articles/journals with a percentage of 84% and 7 documents are conference papers with a percentage of 16%. This comparison graph can be seen in the figure 7.
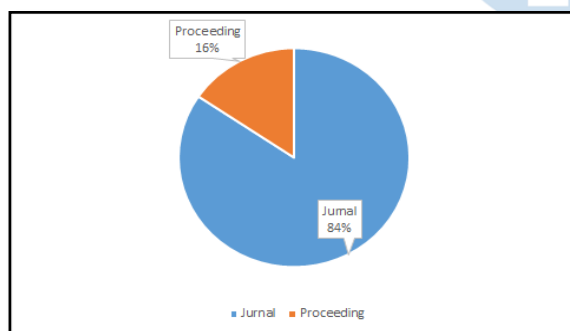
Figure 7 Proceeding & Journal Comparison

To see the themes of each 45 document in detail, see table 1. The contents of this table provide an overview of the current trends in the development of mobile-based applications, especially those using the Design Thinking approach. As an approach that is not very old compared to other approaches in developing mobile-based applications, the Design Thinking approach is mostly used in the health sector, the second ranking use of design thinking in mobile-based applications is used for education and next is games.

TABLE I.   LIST OF PAPERS

No.	Research Area	Article/Journal
1	Health and Medicine	1. [16],

No.	Research Area	Article/Journal
		2. (Marko-Holguin et al., 2019),
		3. [18]
		4. (Farao et al., 2020),
		5. (Hou et al., 2020),
		6. (Schoenthaler et al., 2020),
		7. (Kamran & Dal Cin, 2020),
		8. (Korpershoek et al., 2020),
		9. (Cunyarachi et al., 2020),
		10. [25],
		11. [26],
		12. (Fontenot et al., 2020),
		13. [28],
		14. (Polhemus et al., 2020),
		15. [30],
		16. (Nimmolrat et al., 2021),
		17. (Pinnarong et al., 2021),
		18. [33],
		19. [34],
		20. (Jarman et al., 2022),
		21. (Thomas et al., 2022),
		22. [37]
2	Education	1. [38],
		2. [39],
		3. [40],
		4. [41],
		5. [42],
		6. (Darmawan et al., 2022),
		7. [44],
		8. (Puebla et al., 2022),
		9. (Zapata-Paulini et al., 2023),
		10. (Lazo-Amado & Andrade-Arenas, 2023),
		11. (Purbasari et al., 2021),
		12. [49]
3	Games	(Olivares-Rodríguez et al., 2022), (Koutsabasis et al., 2022), [52], (Challiol et al., 2019), [54], [55]
4	Farming/Agriculture	1. (Kenny et al., 2021), 2. [57]
5	Ecology	1. [58]
6	Marketing	1. [59]
7	Transportation	1. [60]

Based on the keywords used in searches in the SCOPUS database, when using the VOSViewer keyword analysis software, it gives a picture as seen in Figure 8. Design Thinking is the center of keywords which then have many branches for various types of research.
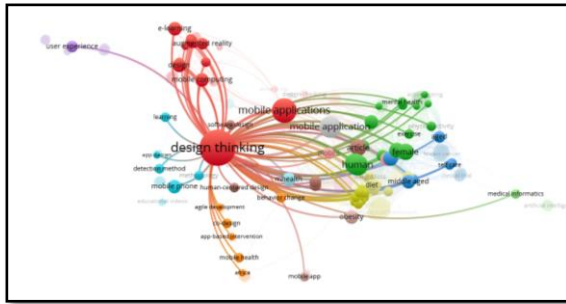
Figure 8 VOSViewer Analysis

V. CONCLUSION

In order to achieve sustainable success in mobile application development with a Design Thinking approach, developers need to consider existing challenges, but must also remain focused on the main goal: creating solutions that are better, more innovative, and more suited to user needs. This conclusion underscores the importance of a user-centered approach in the ever-evolving world of mobile application technology. As a final insight, this research also confirms that the role of Design Thinking in mobile application development will continue to grow and become more important along with ongoing changes in the mobile technology ecosystem.

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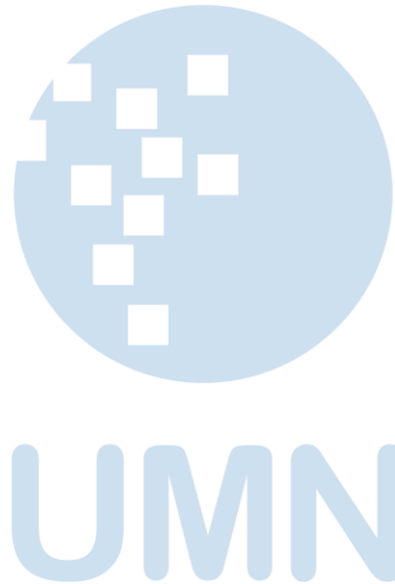
Exploring Masterweb's Effectiveness in Optimizing Digital Based Learning and Education Management

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Abstract— **Masterweb is a concept where multiple web services are integrated into a centralized platform, offering seamless access and management of various online tools and resources. Research discusses the effectiveness of masterweb in optimizing digital-based learning and education management. Research method uses a mix method approach with an exploratory design. Paper also highlights the importance of transforming learning media in the digital era and how digitalization can improve the quality of vocational education. Research results show that the application of Masterweb allows the adoption of blended learning methods that combine conventional approaches with digital elements. Collaboration with expert companies in developing e-learning and multimedia systems also ensures the availability of ICT infrastructure that supports the smooth learning process. With Masterweb, teachers and school management can be more effective in recording teaching and learning activities, monitoring student attendance, and increasing the effectiveness of monitoring and developing student skills. This research provides important insights into the importance of technology integration in education to increase efficiency, effectiveness, management and the attractiveness of learning in the digital era**

Keywords: Masterweb; Effectiveness; Digital learning

I. Introduction

Learning media in the digital era continues to undergo transformation, this is marked by the increasingly easy access of media to all groups [1]. Most users of digital learning media in vocational education see the digitalization process as an opportunity to increase accessibility and quality management of education [2]. Effectiveness of education and learning in a class will be problematic when learning management is not optimal [3]. Digitalization process in vocational education is a step to develop technological skills and improve the quality

of educational management needed in an increasingly digitalized world.

State that educational transformation continues to develop through diverse learning media which involves integrating advanced technology to increase accessibility, interactivity and learning effectiveness [4]. Most users of digital learning media see the digitalization process as an opportunity to improve accessibility and education management. Masterweb is a concept where multiple web services are integrated into a centralized platform, offering seamless access and management of various online tools and resources, it aims to streamline user experience by providing a single interface for interacting with diverse online. Integration enhances efficiency and convenience, allowing users to navigate and utilize multiple online functionalities effortlessly [5]. Digitalization process in education is a step to develop technological skills and improve the quality of educational management needed in an increasingly digitalized world. For developed countries, educational management in technology-based learning activities has a positive impact in achieving various educational goals and maximally exploiting the potential of technology [6]. The research results showed that there was an increase in teacher creativity by 72% after implementing technology-based learning management. Apart from that, teachers can also present learning material in a more interesting and interactive way [7]. Rich and varied digital content can also enrich students' learning experiences and support better understanding of concepts [8].

Learning by utilizing information and communication technology can also stimulate student activity, increase student interest in the learning process so that it can increase student motivation and attention [9]. Seeing the many benefits obtained from technology, the use of technology in education needs attention [10]. One use of technology in the education sector is the use of learning media. Learning media in

the digital era continues to undergo transformation, this is marked by the increasingly easy access of media to all groups [11]

Stated that most users of digital learning media in vocational education see the digitalization process as an opportunity to improve accessibility and quality management of education [12][13]. Digitalization process in vocational education is a step to develop technological skills and improve the quality of educational management needed in an increasingly digitalized world [14].

The reality of vocational learning, especially in vocational schools today, is that there are still various dynamics of problems that have not been resolved [15]. One of them is that the implementation of digital learning and management in monitoring this learning has not been optimal [16]. Therefore, it is important to optimize technology integration to increase efficiency, effectiveness, management and attractiveness of learning [17]. Teachers and teaching staff need to understand and implement strategies for optimizing digital learning and appropriate management [18], so it is not only focused on aspects of technology-based learning media, but also on data security, managing student information, and monitoring learning [19]. The solution to existing problems is through optimizing learning with Masterweb.

MasterWeb is an application used by vocational high schools in facilitating learning management. Masterweb is an application developed to help vocational education institutions, especially vocational schools, in creating interactive digital learning systems and improving effective learning management [20]. Masterweb is currently being developed and applied to monitor the planning, implementation and evaluation of learning in vocational schools. The existence of this masterweb can be used as an effective tool in supporting learning, helping focus on monitoring learning, highlighting the need to increase the effectiveness of monitoring, and developing students' skills so that they can increase capabilities in the digital era. However, in the process of using it, further exploration is needed regarding the effectiveness of masterweb in optimizing digital-based learning and education management.

II. RESEACH METHODS

This research uses a mix method with an Exploratory Design approach. This research activity was carried out in 2 stages, to obtain instruments that were developed from findings obtained from natural settings. The first stage uses principles that apply to qualitative research, including: (1) the presence of the researcher is very important and (2) data is obtained through in-depth interviews, in addition to using documents and observations. Researchers are as instruments. The second stage is quantitative research. Second stage of research uses quantitative research, so

research activities use quantitative research principles. Data collection uses a questionnaire [21].

The research location is at SMK Negeri 6 Malang which is located on JL. Ki Ageng Gribig No.28, Kedungkandang, Malang City, East Java. Research informants include the Deputy Principal for Curriculum, Head of the Head of the Machining Engineering Department, and teachers. At the end of the data, the results of the research are presented which will then be discussed further using a review of relevant literature. The researcher was guided by the grid of questions explained in Table 1.

TABLE I. GUIDELINES OR GRID (MASTERWEB ON LEARNING IN VOCATIONAL SCHOOLS)

No	Grille	Question	Data retrieval		
			Interview	Observation	Doocumentation
1	Understand the use and function of Masterweb	How masterweb functions in learning	✓		
		How to operate masterweb in learning	✓	✓	
		Do you have a guidebook for using Masterweb in learning?	✓		✓
		Is there a workshop on using masterweb?	✓		✓
2	Satisfaction with using Masterweb in learning planning	How to use masterweb in learning planning	✓		
		What documents need to be prepared in learning planning			✓
		What documents need to be uploaded to masterweb in learning planning	✓		✓
		What are the steps in making a learning plan on masterweb	✓	✓	
3	Satisfaction with using Masterweb in implementing learning	How to use masterweb in implementing learning	✓		
		What documents need to be prepared for implementing learning			✓
		What documents need to be uploaded to masterweb for the implementation of learning	✓		✓

No	Grille	Question	Data retrieval		
			Inter view	Obse rvati on	Dooc ume ntati on
		What are the steps for implementing learning on Masterweb	✓	✓	

In strengthening the research results, researchers used satisfaction survey data in using the Masterweb application, by taking 30% of sources from many teachers at SMKN 6 Malang, which was carried out with interviews related to opinions regarding the use of Masterweb in learning. The survey data was calculated using a Likert scale, which is explained in Table 2.

TABLE II.   LIKERT SCALE

No	Score	Category
1	4	Very satisfactory
2	3	Satisfying
3	2	Less satisfactory
4	1	Not satisfactory

The next step is quantitative research, through a Google form questionnaire to evaluate the effectiveness of Masterweb. The aim is to test the level of effectiveness of masterweb in optimizing learning. This quantitative research used a sample of 30 students.

III. RESULT AND DISCUSSION

Digital-based school management has been implemented by SMKN 6 Malang for the last 3 years from 2020 until now. The ICT-based management implemented by Vocational Schools has a very positive impact on the management system for all aspects of the school, one of which is learning. The use of information and communication technology (ICT) in the provision of institutional services has great potential to increase the effectiveness of information systems. This implementation allows the parallel adoption of blended learning methods, which combine conventional learning approaches with digital elements. Collaboration with companies that are experts in developing e-learning and multimedia systems ensures the availability of ICT infrastructure that has been prepared in advance, thereby supporting the smooth learning process [22]. Masterweb is an application developed by educational service providers to assist school institutions in creating effective, ICT-based management systems.

Currently, Masterweb continues to be used by vocational schools to monitor planning, implementation and evaluation of learning. The results of the exploratory analysis of masterweb's effectiveness at SMKN 6 Malang can be explained in Figure 1.

A. Masterweb Based Digital Learning Planning

Learning media in the digital era continues to undergo transformation, this is marked by the increasingly easy access of media to all groups. Most users of digital learning media in vocational education see the digitalization process as an opportunity to increase accessibility and quality management of education [23].

Learning planning is a systematic process carried out by teachers in designing and organizing learning activities to achieve predetermined learning objectives. This involves various steps, including identifying learning objectives, selecting appropriate teaching methods, preparing learning materials, and assessing and evaluating learning outcomes. Learning planning also includes setting a supportive learning environment, adjusting the curriculum, and using relevant and effective resources [24]. The main goal is to ensure that the learning process is efficient, effective, and in accordance with the needs and characteristics of students.

In the masterweb system, learning planning begins with inputting data on lesson hours for each teacher and inputting study groups as shown in Figure 2, which is carried out by school administration staff. This aims to provide masterweb access rights to teachers who teach subjects.

Fig. 1. Inputting Teacher Service Hours

Then the next stage is inputting core competencies and basic competencies for the K13 curriculum and inputting learning achievement elements in the independent curriculum. This input includes: attitude competency, knowledge competency and skills competency. The competency input display model contained in the curriculum is explained in Figure 3.

Fig. 2. Input to Core and Basic Competencies in Subjects

In learning planning, the next step is to upload teaching documents for each teacher. SMKN 6 Malang still uses 2 curricula, namely the K13 curriculum for grades 11 and 12, and the Merdeka curriculum for grade

10. In the K13 curriculum the documents uploaded to masterweb for learning planning are: semester program, annual program, and learning implementation plan. Meanwhile, in the independent curriculum, the documents uploaded to masterweb are: learning outcomes, flow of learning objectives, and teaching materials.

Fig. 3. Teaching Device Document Upload Process

Found that learning planning using (ICT) is very effective because it allows wider access to and is better archived in learning documents. With improved administrative efficiency, the use of ICT in learning planning also helps improve the overall effectiveness of learning by utilizing the potential of technology to support various aspects of learning [25].

B. Implementation of Masterweb-Based Digital Learning

Optimizing the integration of technology implementation is very necessary to increase efficiency, effectiveness, management and attractiveness of learning. Teachers and teaching staff need to understand and implement strategies for optimizing digital learning and appropriate management. So it is not only focused on aspects of technology-based learning media, but also on data security, managing student information, and monitoring learning [26]. The solution to existing problems is through optimizing the implementation of Masterweb in implementing learning.

Teaching and learning activity management systems such as Masterweb play an important role in facilitating teachers and school management in recapping teaching and learning activities. Masterweb or similar learning management systems have the ability to record and recapitulate student attendance during learning sessions. This feature allows teachers to monitor students' activeness in attending class and participating in learning activities. Meanwhile, at the beginning of learning, a teacher takes attendance of students, which is explained in Figure 5. Figure 5 explains the page on Masterweb which functions to take attendance of students by a teacher.
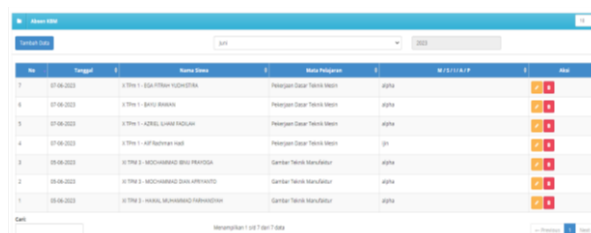
Fig. 4. Input of Student Attendance for Each Lesson

Then the teacher continues to fill in the teaching journal which is explained in Figure 6. The menu for uploading the teaching journal on Masterweb consists of filling in subjects, core competencies and basic competencies that are being implemented, learning implementation journals and documentation.
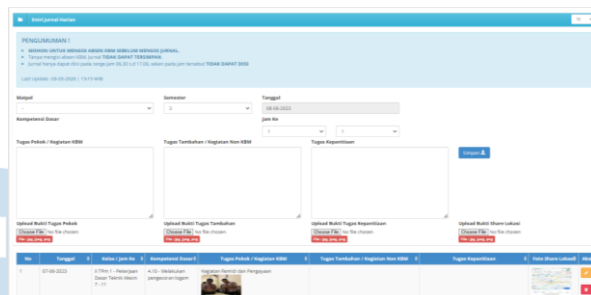
Fig. 5. Journal of Learning Implementation

Masterweb filling in the implementation of learning carried out by teachers is integrated into the analysis report of the curriculum staff section which is used to monitor learning, so that the curriculum staff section can record student attendance and summarize the results of the learning implementation journal that has been carried out by the teacher.

C. Exploring the Effectiveness of Masterweb in Optimizing Digital-Based Learning and Education Management

Masterweb is an application developed to help vocational education institutions create interactive digital learning systems and improve effective learning management. Masterweb is currently being developed and applied to monitor planning, implementation and evaluation of learning. The existence of masterweb can be used as an effective tool in supporting learning, helping to focus on monitoring learning, highlighting the need to increase the effectiveness of monitoring, and developing students' skills so that they can increase capabilities in the digital era. The satisfaction of a teacher in using a webmaster in learning is explained in Figure 7.

Fig. 6. Recapitulation of Teacher Satisfaction in Implementing the Use of Masterweb in Learning

learning includes: student attendance activities and uploading journals of learning activities carried out by teachers, then the curriculum staff recapitulates student absences and monitors learning activity journals. The level of satisfaction with the implementation of information and communication technology -based management using the results of a survey conducted by teachers at vocational schools showed that the frequency of 22 people chose very satisfactory in the use and use of Masterweb in implementing learning.

Based on the results of a survey conducted by researchers on 30% of the total number of 100 teachers, both productive and normative teachers, it was found that 30 teachers were used to conduct a satisfaction survey for using the Masterweb application. The survey results showed that 22 teachers chose very satisfactory, 5 teachers chose satisfactory, and 3 teachers chose unsatisfactory. In this regard, it can be formulated that the Masterweb application has a positive impact on vocational school learning and management, as well as making it easy for teachers to review learning stages. Meanwhile, for those who choose less satisfaction, this may be due to the age of the teacher who has passed the productive limit and has not yet mastered the Masterweb application in learning.

Quantitative research shows that there are 66.7% effective responses, 30% moderately effective responses, and 3.3% ineffective responses. These results show that masterweb is effective and really helps students in learning. The following is data from the results of a questionnaire to 30 students regarding the effectiveness of Masterweb.

TABLE III. EFFECTIVENESS OF MASTERWEB IN LEARNING

	N	Mean	Stdv	Min	Max
Effectiveness of use	208	3.64	0.563	3	5
Ease of Use	208	3.92	0.568	2	5
Learning Management System	208	5.00	2.585	1	9

IV. CONCLUSION

The implementation of information and communication technology-based management using Masterweb implemented in vocational schools has had a very positive impact on the learning management system. Starting from the implementation of Masterweb in learning planning which includes: uploading KIKD and teaching tools for teachers, while for school administration officers uploading personnel biodata and service hours of teachers who teach. The implementation of Masterweb in implementing

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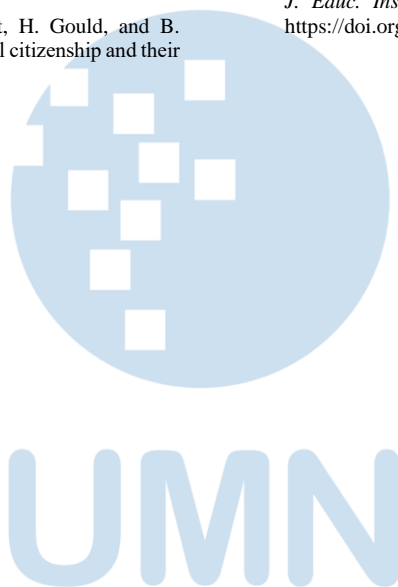
Development of an Expert System for Diagnosis of Pests and Diseases in Soybean Plants Using the Forward Chaining Method

Case Study: Badan Standarisasi Instrumen Pertanian (BSIP) Aneka Kacang Kendalpayak Malang

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Abstract— **This research focuses on developing an expert system to detect pests and diseases affecting soybean plants (Glycine max), which often reduce yield. The system employs forward chaining with the best-first search decision-making algorithm, which was developed using the waterfall methodology. Data utilized includes comprehensive information on symptoms, types of pests, diseases, and their respective management solutions gathered through case studies and expert interviews. Users of the system can input observed symptoms in soybean plants, and the system provides diagnoses and treatment recommendations based on established knowledge rules. Feasibility testing of the system was conducted using the TAM approach to assess technology acceptance among users and BlackBox Testing to ensure system reliability from a technical perspective. Test results indicate that the expert system is viable, achieving a feasibility rate of 83.7% based on TAM criteria and 100% across eight modules using BlackBox Testing, demonstrating significant potential in effectively supporting the diagnosis and management of pests and diseases in soybean plants.**

Index Terms— Expert System, Forward Chaining, Soybean, Pests, Diseases, Diagnosis

I. INTRODUCTION

The lack of knowledge among farmers about pests and diseases is one of the factors affecting crop yield quality [1]. To improve crop quality, farmers need to obtain information from sources knowledgeable in this field. Farmers should be aware of the pests and diseases that can damage crops and be able to promptly address them.

Badan Standarisasi Instrumen Pertanian (BSIP) Aneka Kacang is an organization under the auspices of the Ministry of Agriculture. BSIP Aneka Kacang is tasked with coordinating, formulating, implementing, maintaining, and harmonizing agricultural instrument standards. The secretariat of BSIP Aneka Kacang is located at Jl. Raya Kendalpayak no. 66, Segaran, Kendalpayak, Pakisaji, Malang, Jawa Timur.

BSIP Aneka Kacang Kendalpayak Malang has somewhat kept pace with technological advancements by implementing digital guest registration, digital employee attendance records, and other administrative processes. However, the organization still lacks a specialized detection tool for soybean plant pests and diseases, which would greatly aid soybean farmers in their cultivation practices. As an agricultural institution involved in standardizing agricultural instruments, acquiring such a tool is crucial to enhance farmers' knowledge about soybean pests and diseases.

One tool related to detecting pests and diseases in soybean plants is an Expert System. This aligns with rapid technological advancements where computer developments have also surged, benefiting users of all ages, from children to adults [2]. The use of computers and the internet enables more effective and efficient information delivery systems. The success of such information systems, however, relies heavily on skilled human resources to ensure they meet expectations and operate optimally [3].

An expert system is a computer system capable of imitating or simulating the intelligence of an expert. It is a form of artificial intelligence that combines knowledge and data analysis to solve problems typically requiring human expertise [3]. This view aligns with Pati's statement [4] that expert systems optimize specialized knowledge similar to how an expert addresses issues.

The application of Forward Chaining in expert systems has been widely utilized, particularly in agriculture. Previous research, as documented in a journal by Sholikhah et al. [5], applied Forward Chaining in an expert system for diagnosing pests and diseases in rice plants. The system development followed the Waterfall method. The study concluded that implementing Forward Chaining in diagnosing pests and diseases not only facilitated the process but also enhanced farmers' knowledge. While the research tested the Forward Chaining algorithm, details about the system's testing were not provided, leaving uncertainties regarding the overall system validation beyond the algorithm's accuracy rate of 75%.

Based on these considerations, this research proposes an expert system aimed at providing information on diagnosing pests and diseases in soybean plants, along with recommended solutions. The study aims to enhance farmers' knowledge, enabling better soybean plant care through the proposed system. The expert system in this research utilizes forward chaining with the waterfall model for software development. Programming languages include PHP version 8 for system development and MySQL for database storage. System testing involves user evaluation using the Technology Acceptance Model (TAM) and Black Box Testing by programmers.

Additionally, the use of TAM by users aims to ensure that the developed system is more readily accepted. TAM generally explains how internet technology can be accepted by society in specific contexts. TAM is a theory that reveals how individuals' perceptions of something can influence their behavior, ultimately shaping their attitudes toward information technology [6].

Forward Chaining is a method applied in designing expert system applications to progressively perform forward tracing or reasoning [1]. Waterfall is one of the concepts within the System Development Life Cycle (SDLC) commonly used for developing software systems [7]. Expert systems are expected to assist farmers in soybean plant care, including the prevention and management of pests and diseases affecting soybean plants.

II. LITERATUR REVIEW

A. Pests and Diseases

The term "pests" is used to describe any form of disturbance to humans, livestock, and crops. In the context of agriculture, the term "pest" is used to describe any animal that can damage crops or agricultural products, resulting in economic losses. A narrower definition of pests can be defined as any harmful animal activity in crop cultivation. Plant diseases are conditions where physiological disturbances appear in plants due to major factors, both biotic and abiotic, that occur at the level of plant cells or tissues. This disturbance can result in abnormal plants and can continue to cause losses because it can damage plant health and growth [8].

B. Soybean Plants

The soybean (Glycine max L.) has its origins in mainland China and has been cultivated since 2500 BC. In Indonesia, the soybean is a highly significant crop, ranking as the third most important food crop after rice and corn. Additionally, it serves as a vital source of vegetable protein in the Indonesian food industry [9].

The morphology of the soybean plant encompasses roots, leaves, stems, pods, and seeds. This plant exhibits an upright growth pattern, reaching a height of 30-100 cm, and is capable of producing 100-200 pods per tree in fertile soil (Erlanda et al., 2021). However, soybeans are susceptible to pests and diseases, including armyworm and root rot, which necessitate proper identification for effective control [11].

C. Expert System

An expert system is a system that utilizes human knowledge akin to that of an expert to solve problems requiring human expertise [5]. As part of artificial intelligence (AI), this system employs a knowledge base to tackle specific problems in various fields, including complex medical diagnostics [12]. The main components of an expert system include a knowledge base for storing information, an observation base for gathering data, and an inference engine for extracting knowledge and making decisions similar to those made by an expert [13].

An expert system is structured into two main environments: the development environment and the consultation environment [14]. The development environment is used to build the expert system in terms of developing components and the knowledge base. On the other hand, the consultation environment facilitates interaction with users who do not possess specialized expertise with the expert system to obtain solutions or information they require.

D. Waterfall Method

The waterfall method is a sequential software development process model, which is one of the earliest approaches in project management and product development. This method involves a series of linear and sequential stages, starting with requirements analysis, system design, implementation, testing, and maintenance [2].

E. Forward Chaining Method

Forward chaining is a method in the design of expert systems applications that involves a progressive process of tracing or reasoning forward [1]. The

process begins with facts provided by the user, and then rules are applied to reach conclusions. This process follows a bottom-up model by checking each rule to see if the observed data meets its premises. If the premises are satisfied, the rule is executed to generate new facts that may be used by other rules. This process is also known as rule interpretation, conducted by the inference engine in knowledge-based systems [15].

III. RESEARCH METHODS

To develop an Expert System aligned with research goals, several stages are employed: utilizing the Forward Chaining algorithm, designing a database with a table structure, and creating a user interface to depict system objects. This development adheres to the waterfall model, a sequential software development process encompassing stages such as requirements gathering, system design, implementation—integrating the Forward Chaining algorithm—and subsequent testing and maintenance phases to ensure functionality and longevity.
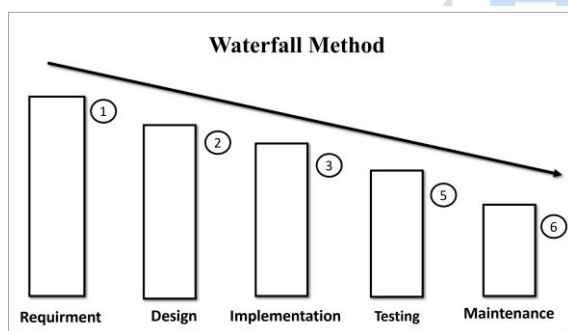

Fig. 1. Stages of the Waterfall Method

A. Requirement

To obtain valid and accurate data, researchers need to collect sources through two main methods. First, conduct a literature review to gather relevant references from books, websites, and journals, summarize them into a literature review, and formulate the research methodology. Secondly, conducting direct interviews with Mrs. Kurnia Paramita Sari, S.P., M.P., a Junior Expert Plant Pest Controller at BSIP Aneka Kacang, who provided insights into data input processes and relevant theories related to the research object, as well as with farmers to gather practical information regarding soybean farming processes. This approach ensures comprehensive data acquisition as follows:

TABLE I.   PEST AND DISEASE DATA

Code	Pests and Diseases
P1	Bean Seed Fly Pests (*Ophiomyia Phaseoli*)
P2	Stem Fly Pests (*Melanagromyza Sojae*)

Code	Pests and Diseases
P3	Armyworm Pest
P4	Pest Caterpillars (*Chrysodeixis chalcites*)
P5	Soybean pod borer pest (*Etiella Zinckanella treit*)
P6	Anthracnose disease (*Collectrium demotion var truncatum dan C. Destrucvitum*)
P7	Falling of Sprouts, Leaf, and Pod Rot (*Rhizoctonia solan*)
P8	Stem blight (*Sclerotium roofs*)
P9	Blight, Leaf spot, and Purple seed spot (*Cercospora Kikuchi*)
P10	Mosaic Virus Disease

TABLE II.   SYMPTOM DATA

Kode	Symptom
G1	Withered stems
G2	White spots on the first or second leaf
G3	Spots on young leaves
G4	There are larvae holes on the stem
G5	The leaves are gone and only the bones remain
G6	Young pods are damaged
G7	Leaves appear whitish
G8	The pod walls look damaged and irregular
G9	The stem is rotting
G10	Stems wilt and curl
G11	The number of seeds decreases
G12	Brown or black spots on the stem
G13	Brown spots on leaves
G14	Brown or black spots on pods
G15	Rot near the roots
G16	Stems rot
G17	Pods rot
G18	Leaves rot
G19	Red spots on the stem
G20	Stems become brittle
G21	The stem experiences shrinkage
G22	Seeds are purple
G23	Seeds Rough and Stiff
G24	The pattern of yellow spots on the leaves
G25	The pattern of yellow spots on the pods
G26	Redness on seeds

Based on the data on pests, diseases, and their symptoms, rules or production guidelines can be formulated to diagnose pests and diseases in soybean plants.

TABLE III.   RULES

Code	Rule
R1	if G1 and G2 then P1
R2	if G3 and G4 then P2
R3	if G5 and G6 and G7 then P3
R4	if G8 and G9 then P4
R5	if G10 and G11 then P5
R6	if G12 and G13 and G14 then P6
R7	if G15 and G16 and G17 and G18 then P7
R8	if G19 and G20 and G21 then P8
R9	if G22 and G23 then P9
R10	if G24 and G25 and G26 then P10

In making decisions, expert systems use a decision tree with the Best-First Search method. The Best-First Search algorithm is a heuristic search method that combines the advantages of Breadth-First Search and Depth-First Search, prioritizing search efficiency at the expense of completeness [16].
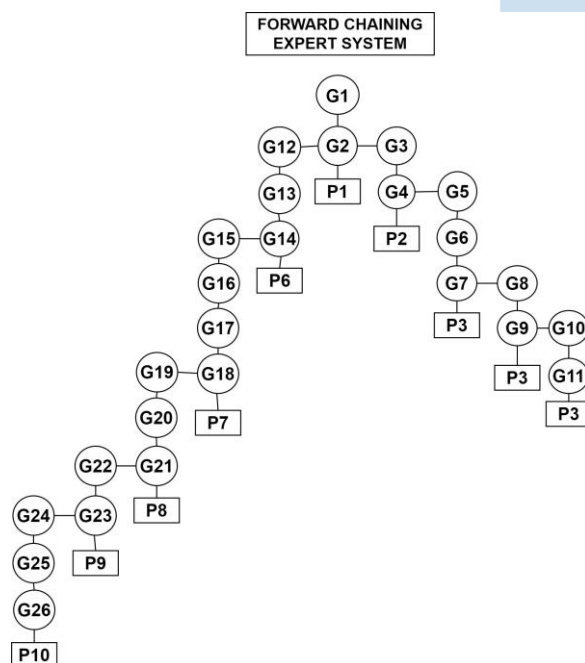
Fig. 2.   Decision Tree

To determine the accuracy of the forward chaining method, weights are assigned to each symptom about the disease. The assignment of symptom weights utilizes the formula based on the probability of an event occurring [5].

$$P(A) \frac{Selected\ Symptoms}{Number\ of\ Symptoms\ of\ Disease} \times 100\% \quad (1)$$

B.   Design

This stage involves analyzing the collected data and applying diagrams such as ERD (Entity-Relationship Diagram) for database design, as well as UML (Use Case Diagram, Activity Diagram, and Class Diagram) to visualize the system, and DFD (Data Flow Diagram) to illustrate its operational processes.

- Flowchart system
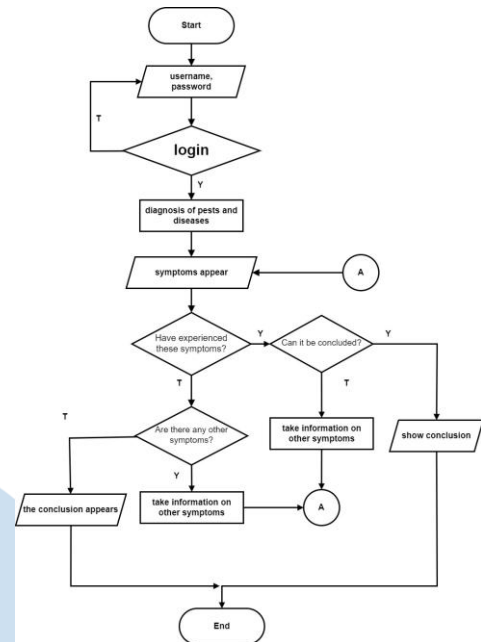
Fig. 3.   Flowchart System

- Use Case Diagram
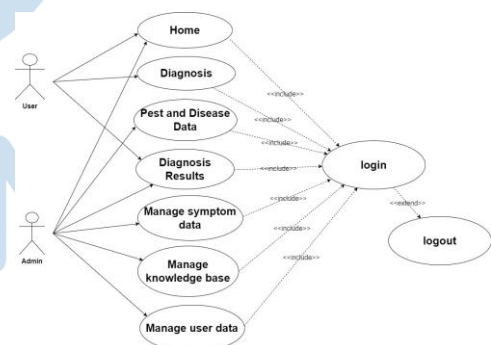
Fig. 4.   Use Case Diagram

- Activity Diagram
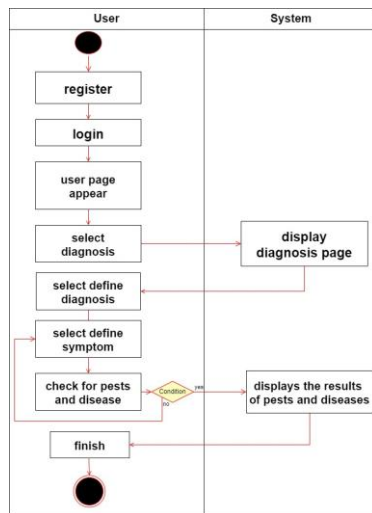
Fig. 5. Activity Diagram

Users log in as members, access the diagnosis menu to diagnose pests and diseases in soybean plants, and answer a series of questions about plant symptoms.

- Entity Relationship Diagram

Fig. 6. Entity Relationship Diagram

The Entity-Relationship Diagram (ERD) of the system includes entities such as user, disease, symptom, knowledge base, knowledge detail, diagnosis, diagnosis detail, and disease detail.

- Data Flow Diagram
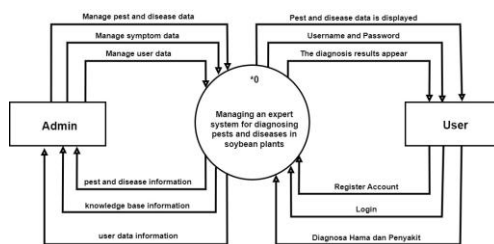
Fig. 7. Data Flow Diagram Level 0
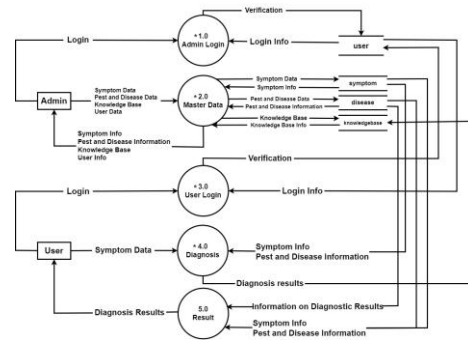
Fig. 8. Data Flow Diagram Level 1
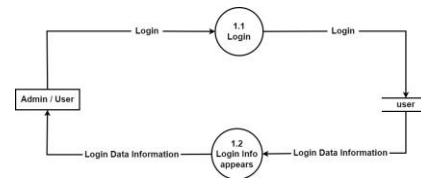
Fig. 9. Data Flow Diagram Level 2 Process 1
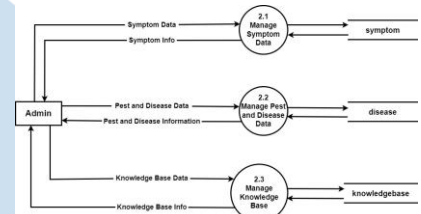
Fig. 10. Data Flow Diagram Level 2 Process 2
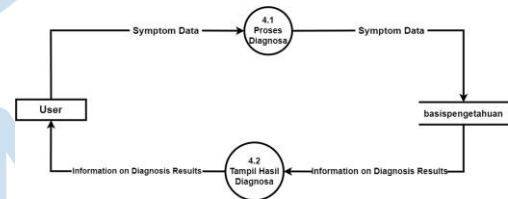
Fig. 11. Data Flow Diagram Level 2 Process 3

In the Expert System, the Level 0 Data Flow Diagram (DFD) illustrates that the Admin manages data on pests, diseases, symptoms, and users, with the system displaying relevant information. Farmers can register, log in, and perform diagnoses using symptom data, with the system showing diagnosis results and information on pests and diseases. In Level 1 DFD, the Admin manages symptom, pest, disease, and knowledge base data. Users input symptoms for diagnosis, and the system provides results based on predefined rules. In Level 2 DFD, the Admin logs in, the system validates identity and manages related data. Users input symptoms, the system processes the diagnosis, and displays the results.

- Class Diagram
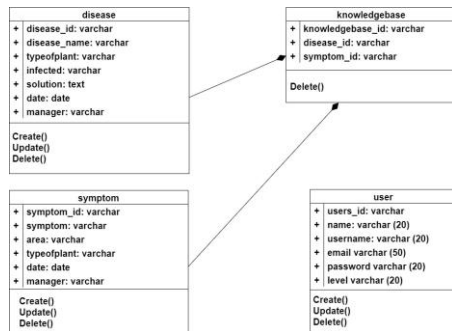
Fig. 12. Class Diagram

A class diagram is a diagram in software modeling that illustrates the static structure of an object-oriented programming system. It includes classes, attributes, methods, and relationships between these classes.

C. Implementation

During the implementation phase, the conceptual analysis and design concepts are executed to produce a functional system. Following implementation, thorough testing of the system is conducted to ensure its performance aligns with the planned specifications before it is put into operation.

D. Testing

Testing is conducted to identify errors in the system, aiming to minimize deficiencies so that the system functions as expected upon implementation. Testing occurs from two perspectives: first, system feasibility testing by users using the Technology Acceptance Model (TAM) method, focusing on perceived ease of use, usefulness, user attitudes towards use, behavioral intention to use, and actual system usage [17]. Second, system feasibility testing by programmers is done using the Black Box Testing method, which tests input values and disregards the internal mechanisms of the system [18].

E. Maintenance

System maintenance is performed periodically to ensure effective bug handling, while also updating the knowledge base data to remain relevant with developments in symptoms, pests, and diseases affecting soybean plants. This is crucial for maintaining the accuracy and quality of the expert system in diagnosing pests and diseases in soybean plants.

IV. RESULTS AND DISCUSSION

Development of an Expert System for Pest and Disease Diagnosis in Soybean Plants using Forward Chaining Method with PHP 8 and MySQL as the Database, and CSS with Bootstrap 4 Framework for Website Interface.

A. Main Menu Screen Display
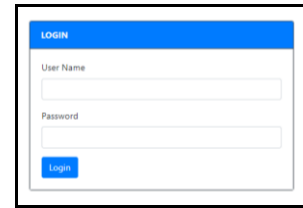
Fig. 13. Login Page

The main page of the expert system for diagnosing pests and diseases in soybean plants serves as the initial point for users accessing the system, featuring a login menu that grants access to diagnostic features upon successful login.
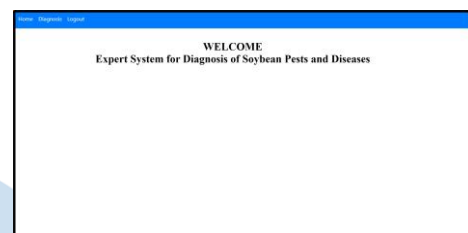
Fig. 14. Welcome Page
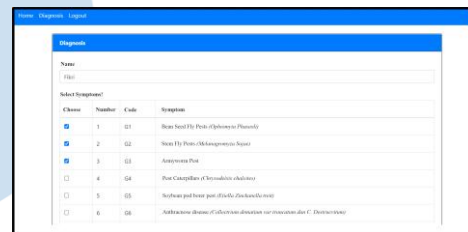
Fig. 15. Select Symptoms page
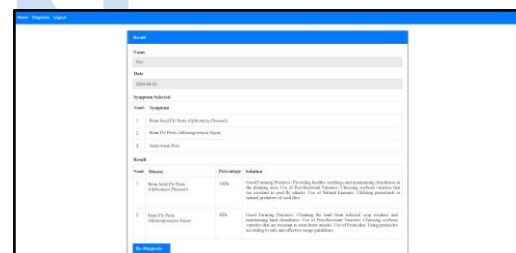
Fig. 16. Diagnosis Results Page

Figure 14 displays the welcome page. Figure 15 shows the symptom page, where users are instructed to select symptoms exhibited by the plant for pest or disease diagnosis. Figure 16 presents the diagnosis result page, where the expert system displays the diagnosis outcome based on the previously selected symptoms.

B. Forward Chaining Trial Results

The success of the expert system for diagnosing pests and diseases in soybean plants using the forward chaining method is determined through joint testing with experts. The system processes symptom inputs to

obtain diagnostic information for pests and diseases affecting soybean plants.

- Selected symptoms

Selected and detected symptoms in the knowledge base: G2 G6 G15 G16 G17

- Rules that have symptoms are detected.

R1: if G1 and G2 then P1

$$P(A) = \frac{1}{2} \times 100\% = 50\%$$

R3: if G5 and G6 and G7 then P3

$$P(A) = \frac{1}{3} \times 100\% = 33\%$$

R7: if G15 and G16 and G17 and G18 then P7

$$P(A) = \frac{3}{4} \times 100\% = 75\%$$

The possible diagnostic outcomes that can be obtained are as follows: Bean Seed Fly Pest with a probability of 50%, Armyworm Pest with 33%, and Falling-off, Leaf, and Pod Rot with 75%. Therefore, it is highly likely that the soybean plants are affected by Falling-off, Leaf, and Pod Rot, with a probability weight of 75%.

TABLE IV. COMPARISON OF SYSTEM AND EXPERT DIAGNOSIS RESULTS

System Diagnostics		Manual Diagnostics		Info
Indication	*Grade*	*Indication*	*Grade*	
Bean Seed Fly Pests	50%	Bean Seed Fly Pests	50%	Suitable
Armyworm Pest	33%	Armyworm Pest	33%	Suitable
Falling of Sprouts, Leaf, and Pod Rot	75%	Falling of Sprouts, Leaf, and Pod Rot	75%	Suitable

C. Testing by User

The population studied comprises prospective users of the expert system for pest and disease diagnosis in soybean plants at the Seed Management Unit of the BSIP Aneka Kacang, with a total of 153 employees as of June 27, 2024. The sampling method employed was Simple Random Sampling, where sample members were randomly selected from the population without consideration of strata.

The questionnaire was distributed to 30 respondents. The demographic characteristics of the sample can be outlined as follows:

- Gender: 43.8% of respondents were male and 56.2% were female.

- Age range: 67.4% of respondents were aged 25-35 years, 28.8% were aged 35-45 years,

and 3.6% were aged 45-50 years, with no respondents above 50 years old.

The testing of the Expert System for Pest and Disease Diagnosis in Soybean Plants by users was conducted using a Likert Scale-based questionnaire. Each question had five answer choices with predefined scores: Excellent (E) 5, Good (G) 4, Fair (F) 3, Poor (P) 2, and Very Poor (VP) 1.

TABLE V. ASSESSMENT INTERVAL

Number	Information	Initials
0-19%	Very Poor	VP
20-39%	Poor	P
40-59%	Fair	F
60-79%	Good	G
80-100%	Excellent	E

TABLE VI. STATEMENTS ON THE QUESTIONNAIRE

Numb	Indicator	Statement
1	Perceived Ease of Use	The expert system operates effectively
2		The expert system is easy to use
3		The expert system can process data quickly
4	Perceived Usefulness	The expert system can assist in identifying pests and diseases in soybean plants
5		The expert system can provide useful information regarding the management of soybean plants affected by pests or diseases
6		The expert system has comprehensive data that aligns with an expert's knowledge
7	Attitude Towards Using	The expert system has a well-designed interface
8	Behavioral Intention to Use	Motivations for continuing to use the system
9		Desire to use the system frequently
10	Actual System Usage	User satisfaction in using the expert system
11		The expert system is worth using

TABLE VII. TAM ASSESSMENT RESULTS

Numb	Evaluation					Total Score	%
	E	G	F	P	VP		
1	12	17	1	0	0	131	87.3%
2	2	26	2	0	0	120	80.0%
3	7	16	7	0	0	120	80.0%
4	10	17	3	0	0	127	84.7%

Numb	Evaluation					Total Score	%
	E	G	F	P	VP		
5	8	16	6	0	0	122	81.3%
6	9	14	7	0	0	122	81.3%
7	7	21	2	0	0	125	83.3%
8	8	19	3	0	0	125	83.3%
9	8	21	1	0	0	127	84.7%
10	9	19	2	0	0	127	84.7%
11	16	13	1	0	0	135	90.0%
Average							83,7%

Based on the testing results using the Likert Scale method, the system achieved an average percentage of 83.7%. This result indicates that the questionnaire-based evaluation meets the criteria for "Excellent," as per the assessment interval where 83.7% falls within the range of excellent (80% - 100%).

The testing results calculate the total score based on the cumulative value of each assessment. The percentage is derived using the formula where the total score is multiplied by 100% and divided by 150, which represents the maximum total score if all respondents choose "Excellent." For example, if 30 respondents choose "Excellent," the total score obtained is 30 x 5 = 150, equivalent to 100%.

D. Testing by Programmer

Testing the Expert System for Pest and Disease Diagnosis in Soybean Plants using the Black Box testing method involves testers evaluating the program based on its functional specifications without considering the internal code structure. The objective of using this method is to quickly detect errors or deficiencies within the system.

TABLE VIII. BLACK BOX TESTING RESULTS

Module	Expected output	Results	Info
Login	Users can access the system according to their respective levels using usernames and passwords	Users can access the system according to their respective levels using usernames and passwords	Succeed
Disease Page	Displaying disease data, adding disease data, editing disease data, Deleting disease data	Displaying disease data, adding disease data, editing disease data, Deleting disease data	Succeed
Symptoms Page	Displaying symptom data, adding symptom data, editing	Displaying symptom data, adding symptom data, editing	

Module	Expected output	Results	Info
	symptom data, Deleting symptom data	symptom data, Deleting symptom data	
Knowledge Base Page	Displaying knowledge base data, adding knowledge base data, displaying knowledge base details, editing knowledge base data, deleting knowledge base details, Deleting knowledge base data	Displaying knowledge base data, adding knowledge base data, displaying knowledge base details, editing knowledge base data, deleting knowledge base details, Deleting knowledge base data	Succeed
Diagnosis	Displaying symptom data, displaying diagnosis results, Displaying diagnosis history	Displaying symptom data, displaying diagnosis results, Displaying diagnosis history	Succeed
User	Displaying user data, adding user data, editing user data, Deleting user data	Displaying user data, adding user data, editing user data, Deleting user data	Succeed
Logout	Revoking user access rights from the system	Revoking user access rights from the system	Succeed

Based on the testing results, the developed expert system successfully diagnosed pests and diseases in soybean plants with a 100% success rate across eight testing modules, without encountering any errors.

V. CONCLUSION

Based on the research findings from the project "Development of Expert System for Pest and Disease Diagnosis in Soybean Plants Using Forward Chaining Method with Best-First Search Decision-Making Method and Waterfall Software Development Model," it can be concluded that the expert system can provide accurate pest and disease diagnosis results for soybean plants. The conclusions are based on the alignment of diagnosis outcomes with data obtained from plant pest and disease experts.

Based on the comprehensive evaluation, the expert system developed for diagnosing pests and diseases in soybean plants has proven highly feasible and effective. Evaluation using the Technology Acceptance Model (TAM) showed a system feasibility score of 87.3%, indicating excellent acceptance among users. Additionally, rigorous testing through BlackBox testing by programmers resulted in a flawless performance, achieving a 100% success rate across all eight testing modules. These results affirm the system's readiness and suitability for accurate pest and disease diagnosis in soybean plants, highlighting its reliability and usability in agricultural applications.

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Development E-Catalogue Portfolio Design Architecture with Android Mobile Apps using Kodular Framework

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Abstract— **The Bisma Kasada (Commanditaire Vennootschap/CV) is a company that provides technical consulting services to communities and governments. The Bisma Kasada covers various aspects of the field of work with minimal qualifications, including the process of promoting consultant services aspecially in the field of architecture. The Bisma Kasada continues to operate conventionally, with architects creating design portfolios of 2-dimensional and 3-dimensional architectural drawings of buildings or spatial layouts. Then, architects promote or market the portfolio to the public through printed brochures and social media. Using this method still presents several challenges, including the time, costs, and energy required for promotional activities, the challenge of updating product data, and the limited scope of promotion and marketing in the surrounding environment. The goal of this research is to develop an Android mobile-based E-Catalogue application, which can serve as a promotional and marketing tool for architectural design of the portfolios. The application, designed by the Bisma Kasada, incorporates a feature for cost estimation and calculation. In building the application, the author used the waterfall method, which consists of analysis stages, design stages, coding stages, and testing stages. We build the application based on android platform using the Kodular framework and Airtable database to strongly interfaced but simplify in the system.**

Index Terms—E-Catalogue, Portfolio, Kodular, Android Platform, Airtable Database

I. INTRODUCTION

To encourage company progress, competitors must make strategic decisions and implement new innovations. The application of information technology will significantly contribute to the company's progress. Information technology serves as a platform for companies to foster innovation by transforming activity processes that were previously exclusive to local operations [1].The company's goal in utilizing technology, information, and promotional media is to facilitate the introduction of its products and services more efficiently. The businesses are facing fiercer competition in marketing their products, offering a range of product qualities from low prices to large promotional budgets. In competition to victory, every organization must innovate by looking for new techniques, especially in the field of promotion, in order to successfully achieve predetermined goals. To make this happen, various strategies need to be implemented, one of which is utilizing promotional media.

Current technology can use software implemented through computer hardware as a means to achieve desired results. Android-based applications on smartphones are a growing trend [2]. Android-based phones are now beginning to incorporate the latest improvements to the transaction data architecture. Android is a Linux-derived platform designed for use on mobile phones and tablet PCs. The use of Android-based regulatory data frameworks offers many advantages for Android-based applications. This framework allows application customers to access data conveniently and at any time [3]. Individuals from various age groups, including children, teenagers, and adults, use mobile devices, especially smartphones. The reason is that mobile devices can help complete important or challenging work. The advent of smartphones has revolutionized information accessibility, facilitating rapid and convenient communication and information retrieval.

The Bisma Kasada is a company that provides technical consulting services to communities and governments. Founded in 1998, the Bisma Kasada occupies a location on Jl. Alfalah/Suka Bhakti 20 in Medan 20146, North Sumatra, Indonesia. The Bisma Kasada covers various aspects of the field of work with small qualifications, including environmental management, architecture, and civil works. In carrying out company management, the Bisma Kasada is run by

professionals who are experts in their respective fields. As a consulting services company, the Bisma Kasada has been registered as a member of the National Association of Indonesian Consultants (INKINDO), as have staff and experts who are members of various professional associations in accordance with their field of expertise.

The marketing process for consulting services on the Bisma Kasada, especially in the field of architecture, is still done conventionally. Architects create design portfolios of architectural drawings of buildings or spatial layouts in the form of 2-dimensional and 3-dimensional drawings. Then, the portfolio will be promoted or marketed to the public through printed brochures and social media. By using this method, there are still several problems faced, especially with the time, costs, and energy used in carrying out promotions, the difficulty of updating data on products offered, and the limited scope of promotion and marketing in the surrounding environment. The online company promotion and marketing based on mobile phone have increased dramatically during now and the future trend.

II. LITERATURE REVIEW

Similar research previously discussed Sahabatkoe Ponsel's use of printed catalogs as a means of providing product information to consumers during the sales process. The print catalogs available are very limited, and the products listed in them are not always accurate, so the information presented is often out of date. The lack of staff and catalogs prevents consumers from receiving optimal service, as promotions are constantly changing and products are always the newest. This research aims to develop a website-based computer system that functions as a comprehensive online information platform, a powerful promotional tool, and a product ordering mechanism that utilizes barcodes as proof of purchase. The system has the ability to present comprehensive information efficiently and quickly to users, making it simple to access and ensuring consumers can easily find the information they are looking for apart from that, Sahabatkoe Ponsel can speed up the transaction process, communicate promotions effectively, and provide optimal customer service [5].

Other similar research discusses the challenges faced by the Media Kreasindo Karya is the dissemination of product information that is inadequate and unfocused. An effective way to distribute information efficiently and accurately is through the use of e-catalogs that utilize information technology. This research aims to describe the development of a web-based e-catalog system for the Media Kreasindo Karya Media, with the aim of distributing product information efficiently and accurately. The system development method uses rapid application development by involving system users throughout the process, resulting in faster development

time. The system development stages include business-oriented modeling illustrations, data illustration modeling, as well as process modeling, application construction, testing and replacement. The system was built using the Unified Modeling Language and supported by the use of the PHP programming language and database [5].

Other research has also discussed that Choco Cake Shop is a micro, small and medium-scale business (MSME) that focuses on retailing culinary products, including birthday cakes. The current sales system relies on a manual approach, particularly through telephone communications or direct customer visits to physical stores for product selection and purchase. This causes a decrease in service efficiency for consumers and has a small impact on company revenue growth. Apart from that, progress in the development of the business world seems relatively slow. The e-catalog system was developed to facilitate product introductions to consumers by Chocho Cake Shop. The application developed was built using the PHP programming language and MySQL database, as well as the JavaScript and jQuery frameworks. This research uses the System Development Life Cycle (SDLC) methodology, which includes many stages including planning, analysis, design, development, testing, implementation, and operation and maintenance [6].

The research carried out is different or updated (novelty) with similar research that has been carried out, namely the E-Catalog application, which was built on a mobile basis so that it can be accessed online via an Android mobile device. The system development method oriented towards application development goals is the waterfall method, consisting of the stages of requirements analysis, design, coding and testing. Apart from that, the Android mobile-based E-Catalog application that was built is equipped with a feature for calculating estimated costs for architectural design services, making it easier for the public to obtain information regarding the estimated costs that must be incurred.

III. METHODOLOGY

A. System Development Method

The research that will be applied implements the Waterfall method, an organized approach to software development. In the waterfall method, the steps must be performed sequentially, without the possibility of skipping to the next level [7].
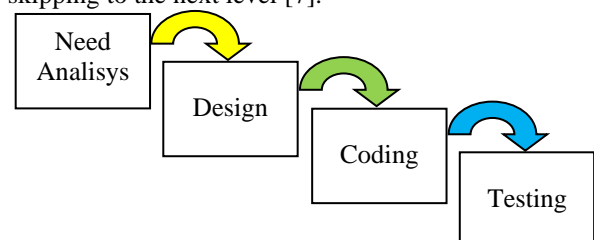

Fig.1. Waterfall Method Stage

The stages contained in Waterfall can be explained as follows [8]:

1. Analysis Stage

In the initial stage of the research, the author carried out analysis activities to extract information related to user interests. The analysis findings will then be used as a basis for building a computerized system with operational functions to carry out the intended tasks. This stage consists of three different stages: problem analysis, analysis required to create the system, and analysis of user needs.

2. Design Stage

After implementing the analysis stage, the author formulates a system design that will be built before the coding process. This approach centers on user interface design that utilizes UML diagrams, which include use case diagrams, sequence diagrams, activity diagrams, and class diagrams.

3. Coding Stage

Coding describes the process of transforming a design into computer-readable language. This step is a crucial phase in building a system. The author uses the Kodular platform and Airtable database to build the application.

4. Testing Stage

After the coding process is complete, the author continues to evaluate the functionality of the system being built. The purpose of testing is intended to identify deficiencies and errors that may occur in the system to facilitate improvements. The author uses black box testing to carry out testing.

B. Method of Collecting Data

The method used by the author to collect the data needed for this research activity is as follows:

1. Observation

Data collection through direct observation and recording of research objects. At this stage the researcher recorded matters relating to the promotion and marketing process of architectural design portfolios on the Bisma Kasada.

2. Interview

Gather information through direct conversations with the Bisma Kasada and customers. Here the researcher asks questions related to the promotion and marketing of architectural design portfolios.

3. Literature Review

Conducting a literature review is the initial stage in the process of gathering data. A literature study is a research technique that gathers facts and information from various sources, including written papers, photographs, drawings, and electronic documents, to support the writing process. Therefore, we can assert that the study of literature has the potential to influence the credibility of the research findings [9].

IV. RESULTS AND DISCUSSION

A. Problem Analysis

At this stage, the author carries out a running system analysis regarding the marketing process of consultant services at the Bisma Kasada, especially in the field of architecture, is still done conventionally, architects create design portfolios of architectural drawings of buildings or spatial layouts in the form of 2-dimensional and 3-dimensional drawings. Then, the portfolio will be promoted or marketed to the public through printed brochures and social media. By doing this, there are still several problems faced, namely:

1. Customers find it difficult to obtain information about the portfolio being offered.
2. Customers find it difficult to obtain information regarding the estimated costs that must be incurred.
3. Time, costs and energy used in carrying out promotions.
4. Difficulty in updating product data offered.
5. The scope of promotion and marketing is limited to the surrounding environment.

B. System Requirements Analysis

The author identifies a solution to address the challenges that arise from the problem analysis. By using the development of Android mobile information technology as a medium for promoting or marketing a product. Therefore, the author conducted research aimed at creating an Android mobile-based E-Catalog application that can be used as a promotional and marketing medium for architectural design portfolios on the Bisma Kasada. With this application, it is hoped that it will make easier the Bisma Kasada in promoting and marketing the architectural design portfolio to the public and expanding the scope of marketing and promoting the architectural design portfolio.

C. Design System

The application design process that will be built uses the Unified Modeling Language (UML) model. Unified Modeling Language (UML) is a graphical language used to visualize, design, construct, and document software development systems that are based on object-oriented principles [10]. The use of UML is not limited to certain methodologies, although in fact it is most widely used in object-oriented methodologies [11].

1. Use Case Diagram

Use case diagrams are used to simulate the behavior of the information system that will be developed. Use case diagrams are employed to determine the system's functionalities and the individuals or entities authorized to access and utilize these functionalities [12].

Use case diagrams depict the possible interactions that a user can engage in with the system. The E-Catalog program was developed with a multiuser architecture, allowing it to be accessed by many types

of users, specifically customers and administrators. Figure 2 displays the use case diagram.
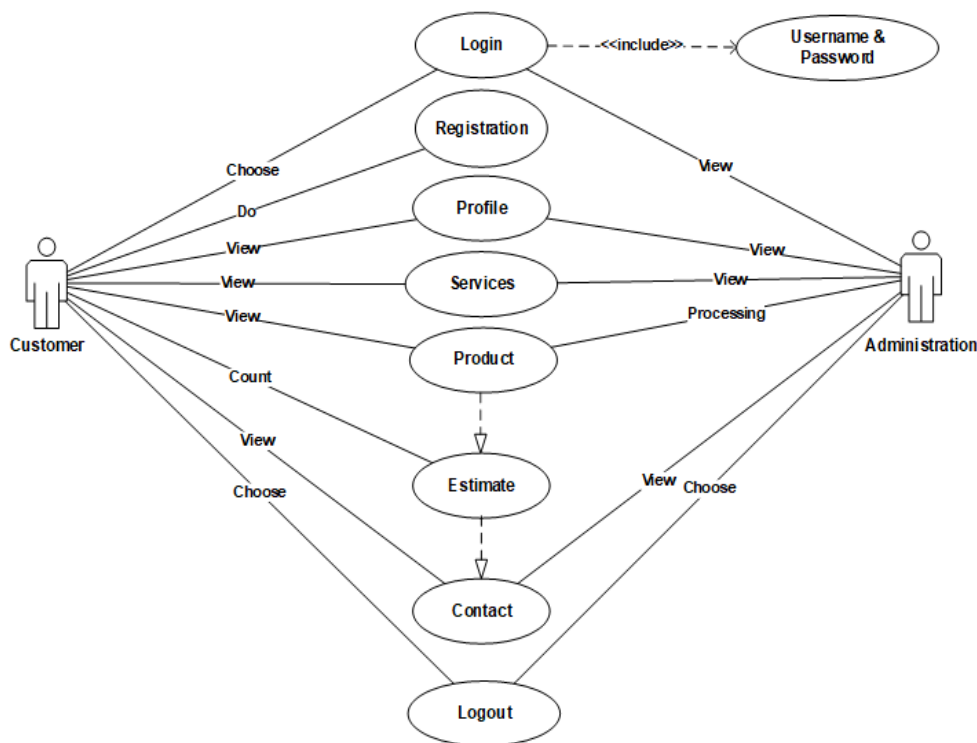
Fig.2. Use Case Diagram

Figure 2 displays a use case diagram of the application that will be built. Use case diagrams describe the actions that actors can perform in the application being developed. The mobile-based E-Catalog application can be accessed by customers and the admins company (Bisma Kasada). Before accessing the application, each user is required to log in by entering the username and password that have been previously set. Customers can get a login account by registering an account first and entering the required data. After logging in, customers can see information related to the company profile, scope of company services and company contacts. Customers can also view information about the available portfolio and calculate estimated costs incurred. Admin has the authority to manage portfolio data including additions, changes and deletions.

2. Sequence Diagram

Sequence diagrams are utilized to portray the interactions that occur between items within and surrounding the system, represented as messages that occur over a specific period of time. Sequence diagrams comprise a temporal dimension (vertical) and an object-oriented dimension (horizontal) [13].

The Sequence Diagram illustrates how customers interact with the E-Catalog application to get the information they need. The customer sequence diagram can be seen in Figure 3.
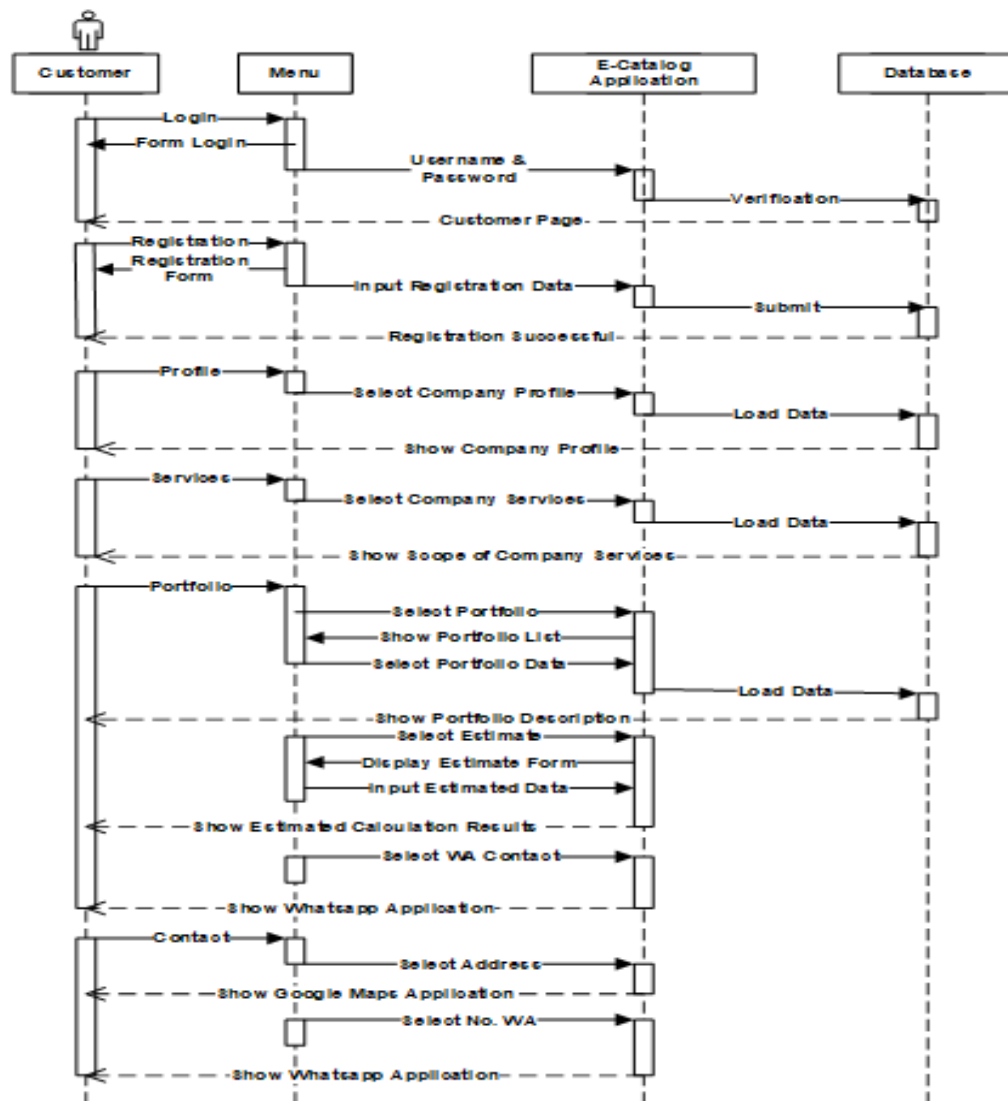
Fig.3. Sequence Diagram

Figure 3 depicts the sequence diagram of the application being built. The sequence diagram for the upcoming mobile-based E-Catalog application begins with the customer authentication process into the application. When the username and password are entered during login, the system verifies the credentials against the database. If the customer does not have a login account, then the customer can register an account and the account will be saved to the database. Next, customers will navigate to the specified page. When a customer selects the company profile menu, the application will display the company profile to the customer. When a customer selects the service menu, the application will display the scope of the company's services. The application can display portfolio data that

has been processed by the admin to customers. Customers can view available portfolio information and calculate cost estimates on the form provided by the application.

3. Activity Diagram

Activity diagrams depict the sequential flow of actions or tasks performed by a software system. The distinction between use case diagrams and activity diagrams is in the fact that use cases delineate the level of involvement and actions of active actors or entities when utilizing the system to execute activities. Activity diagrams delineate system activities rather than the actions performed by actors [14]. The customer activity diagram can be seen in Figure 4.
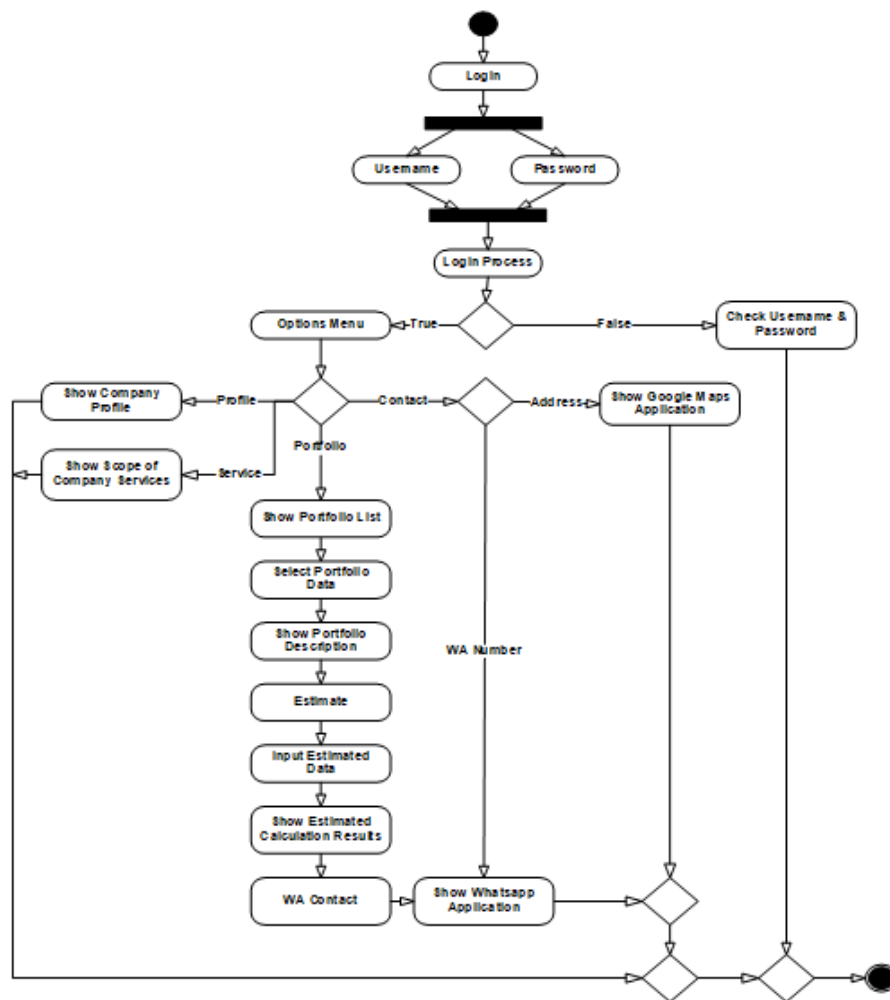
Fig.4. Activity Diagram

Figure 4 illustrates the activity diagram. The activity diagram in the upcoming mobile-based E-Catalog Application begins with the customer logging into the application, which is equipped with a predetermined username and password input. Next, the application authenticates the username and password provided by the customer. If the username and password are correct, customers can access the options menu page and select available menu items. If the login and password provided are incorrect, customers cannot access the application and need to verify the authenticity of the username and password submitted. In this application, customers can see the company profile, scope of company services, company contacts. Apart from that, customers can also view portfolio data that has been processed by the admin and can calculate estimated costs incurred.

4. Class Diagram

Class diagrams are used to illustrate and define classes, properties, and objects, as well as their interconnections. Class diagrams offer a comprehensive overview of a system. This is evident in the current classes and their relationships. A typical system often comprises multiple class diagrams. Class diagrams are quite beneficial for illustrating the class hierarchy of a system. This diagram is frequently utilized in the modeling of object-oriented systems. Class diagrams serve the purpose of elucidating the many categories of system entities and their relationships with other entities [15].

Classes or tables contained in the E-Catalog application database. The E-Catalog application class or database consists of customer tables, admin tables, portfolio tables, category tables and calculation tables.
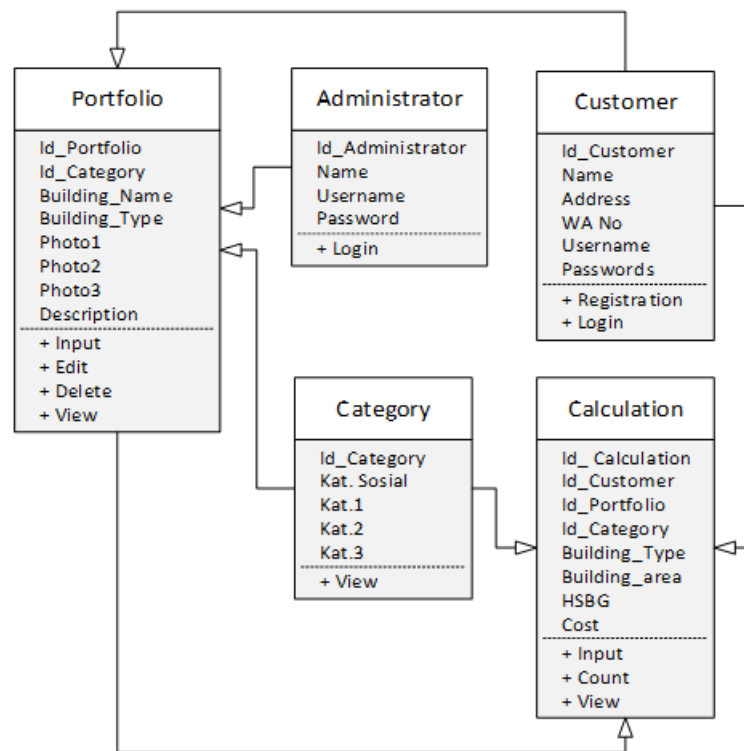
Fig.5. Class Diagram

Figure 5 illustrates the correlation of each table in the mobile-based E-Catalog Application. The customer table structure consists of id_customer, name, address, No. Wa, username and password. The administrator table consists of id_administrator, name, username and password. The portfolio table structure includes id_portfolio, id_category, building_name, building_type, photo1, photo2, photo3 and description. the category tab consists of id_category, kat. social, kat.1, kat.2, kat.3 and the calculation table consists of id_calculation, id_customer, id_portfolio, id_category, building_type, building_area, HSBG and cost. Administrators have the authority to process portfolio data, such as adding, changing and deleting.

D. System Implementation

The application page displays that are built consist of a login page display, registration page display, portfolio page display and estimation page display.

1. Login Page Display

On this page display, customers must log in first by entering the specified username and password. The page display can be seen in Figure 6.

Fig.6. Login Page Display

2. Registration Page Display

On this page, customers can register for an account by entering the data needed to get the account used in the login process. The page display can be seen in Figure 7.
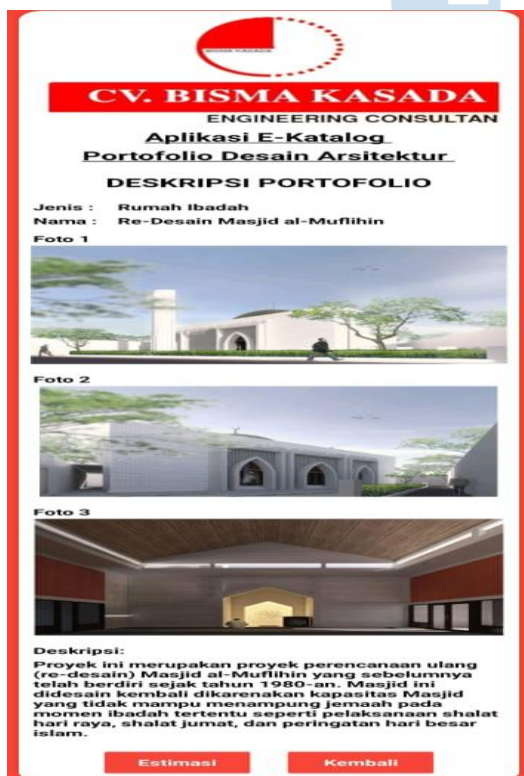
Fig.7. Registration Page Display

3. Portfolio Page Display
On this page, customers can see a description of the portfolio that has been selected in the list provided. The page display can be seen in Figure 8

Fig.8. Portfolio Page Display

4. Estimation Page Display
On this page, customers can calculate the estimated costs incurred by filling in some of the data needed in the calculation. The page display can be seen in Figure 9.

Fig.9. Estimation Page Display

E. *Application Testing*

Black Box testing is used to detect defects and deficiencies such as incorrect or missing functionality, interface errors, errors in data structures or access to databases and others [16]. Black Box testing focuses on specifications from the functional side of a software. In Black Box testing using limit value analysis techniques, each function to be tested is given an upper limit value and a lower limit value to see whether the input and output are appropriate or not [17]. The frequent occurrence of errors in input is one of the principles of software testing using boundary value analysis techniques, where using this technique the input will be tested for its functional requirements [18].

TABLE I. BLACK BOX TESTING

Testing Module	Testing Procedures	Input	Output	Conclusion
Customer Login Page	- Open the application - Select the login menu - Input username "arya" and password "123456" - Click Login	Username "arya" and password "123456"	Customers have successfully logged in and can see a list of available portfolios	Valid
Account Registration Page	- Open the application - Input complete registration data - Registration	Complete registration data	Customer has successfully registered an account	Valid
Admin Login Page	- Open the application - Select the login menu - Input username "imam" and password "admin" - Click Login	Username "imam" and password "admin"	Admin has successfully logged in and can process portfolio data	Valid
Portfolio Data Page	- Open the applicatio - Input complete portfolio data - Add	Complete portfolio data	Portfolio data added successfully	Valid

V. CONCLUSION

After conducting this research, conclusions can be drawn regarding the design and development of the E-Catalog application on the Bisma Kasada is mobile-based, namely the E-Catalog application which was built to help customers obtain information regarding the architectural design portfolio available at the Bisma Kasada online via Android smartphone, the E-Catalog application that was built can help customers in calculating architectural service cost estimates in making building portfolios, the E-Catalog application that was built can help the Bisma Kasada in promoting and marketing architectural design portfolios to the public or potential customers, the E-Catalog application built can expand the scope of promotion and marketing of architectural design portfolios. Bisma Kasada, the E-Catalog application that has been built can replace the architectural design portfolio promotion and marketing system. The Bisma Kasada manually becomes an information technology-based marketing system via Android smartphones, The E-Catalog application has been customized to meet the criteria of Android devices commonly used by the majority of users in order to ensure a smooth installation and usage experience without any hindrances.

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Sentiment Analysis of Indonesian Presidential Candidate Before and After the Election

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Abstract— **As one of the world's democratic countries, Indonesia has just held a general election to choose its next president. The development of the times encourages presidential candidates to make a new breakthrough, such as the use of social media as campaign media. Currently, X is a popular social media used as a campaign medium. On X, users are given the freedom to share their opinions. Various opinions related to one of the presidential candidates were used by the researchers to collect data using the data crawling method. The results of the data crawling are first processed with different methods in the pre-process to make the data ready for use. Some of the steps that need to be taken in the pre-process are such as cleaning, normalisation, stopword, tokenisation, stemming and translation processes. All the processes carried out in the pre-process stage will produce mature or usable data. The mature data is then classified into positive, negative and neutral using the Naïve Bayes classification method. Once the classification is complete, the results are evaluated in terms of sentiment towards one of the presidential candidates. The results of a total of 2117 data collected from 01 February 2024 to 20 May 2024, there are 390 data used for the pre-presidential election sentiment analysis and 1618 data used for the post-presidential election sentiment analysis. Both before and after the presidential election was held, this presidential candidate had more positive sentiments than the negative and neutral sentiments he received from the public.**

Index Terms—**Data Crawling; Data Preprocessing; Naïve Bayes Classification Method; Sentiment Analysis.**

I. INTRODUCTION

Indonesia is one of the countries that implement a democratic political system. In a democratic system, citizens are given the freedom to participate in national development both in political development and other fields [1]. According to Alhamid & Hanim and also Kelibay [2] one form of citizen participation in a democratic country is by participating in general elections, where in general elections citizens are given the freedom to choose prospective leaders who deserve to take office next. Then on February 14, 2024, Indonesia held a general election to choose the next presidential candidate.

In this election, there were three people running as Indonesian presidential candidates, namely Anies Baswedan, Prabowo Subianto, and Ganjar Pranowo. The rapid development of technology has led these three presidential candidates to campaign on social media during the campaign period. As a result of the social media campaigns, the public became more free to express their opinions, which made this election quite interesting [3]. One of the social media that is often used to convey good ideas and opinions by the public is X [4].

The popularity of X to be used as a place to convey opinions cannot be separated from its social media model in the form of microblogging which allows users to send text messages of up to 280 characters so that they can convey their intentions and objectives briefly, concisely, and clearly [5]. The popularity of X is supported by data in 2023 which shows the number of X users in Indonesia is around 25.25 million users, making Indonesia the 4th country with the most X users. With so many X users in Indonesia, it will certainly make a lot of tweets circulating discussing various things related to presidential candidates in the current election.

The number of tweets circulating on X, especially those discussing presidential candidates in this election, makes researchers interested in looking at sentiment analysis of tweets on X. According to Septiani et al [6] the purpose of sentiment analysis is to classify the text in a sentence so that it can be determined whether the opinion contained in a sentence contains positive, negative, or neutral sentiment. There are various methods for performing sentiment analysis such as Naive Bayes Classifier, Decision Tree, and Support Vector Machine [7].

There are many studies on sentiment analysis that have been done before. First, research conducted by Septiani [8] made a sentiment analysis system with the Naive Bayes Classifier method to see how public

sentiment towards moving the National Capital. The results obtained are that the system does not work optimally because there is a mismatch of the dataset used, which affects the data classification process and there are obstacles in understanding sentiment classification such as in the system a sentence is considered positive, but when manually classified the sentence should be negative. Second, research conducted by Gunawan [9] made a sentiment analysis system with the Naive Bayes Classifier method to analyze public sentiment on product reviews, from this study getting accuracy results above 50% of two types of tests with different numbers of classes. Where in testing 5 classes show a lower level of accuracy with a value of 52.66% - 59.33% compared to testing 3 classes which have a value of 73.89% - 77.78%. Third, research conducted by Mahfud [10] used the Naive Bayes Classifier method to determine the trend of Indonesian presidential candidates in 2024. The results obtained from this study are the high accuracy value of the Naive Bayes method used which strengthens the studies stating that Naive Bayes is a fairly reliable classification method.

II. METHODS

In this research, there are several steps taken to complete this research and get good results. These steps are data crawling, data preprocessing, Naive Bayes classification, and result evaluation. Figure 1 is the stages of the research conducted:
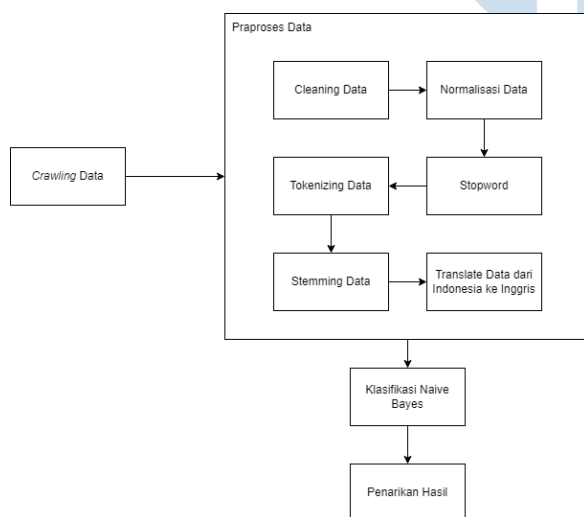
Fig. 1. Research Stages

A. Data Crawling

Data crawling is the process of collecting data from a database. In this study, data was retrieved from X using tweet-harvest. Tweet-harvest is a tool for crawling data from X by utilizing the API from X itself. The keywords used for data retrieval are "pilpres", "pemilu", and the name of one of the presidential candidates in Indonesian with a period of time from February 1, 2024 to May 20, 2024.

B. Data Preprocessing

Data preprocessing is the process of preparing raw data into data that is ready for use by eliminating and converting data into a form that can be processed by the system [11]. In pre-processing, there are several stages that need to be passed, namely:

1. Data cleaning: this stage is used to clean data from unused characters or symbols [12]. Cleaning is needed because the data provided by X contains a lot of dirty data such as URLs, retweet text, hashtags, and other things that are not used in research. In addition, a process is carried out to change the text to lowercase to make the data the same.
2. Data normalization: this stage is used to correct incorrect spelling so that it can be converted into standard words.
3. Stopword: the stage used to eliminate conjunctions.
4. Data tokenizing: this stage is used to break sentences into words.
5. Data stemming: this stage is used to eliminate connecting words, so that words become basic words only.
6. Data translation: at this stage all words will be translated into English to make the data can be processed in the next stage.

C. Naïve Bayes Classification

After preprocessing the data, the data is classified using Naïve Bayes method. Naïve Bayes method is used because it has fast modeling capabilities, has the ability to predict, and also provides new methods in exploring and understanding data [13]. At this stage we use a library in Python called TextBlob, the reason why the data needs to be translated into English is because this library can only be used for English, German, and French. In this classification, the data will be classified by the NaiveBayesClassifier function from TextBlob into three types of sentiment, namely positive, negative, or neutral sentiment [14].

D. Result Recall

After classifying with Naïve Bayes, results will be drawn to see the distribution of sentiment on the presidential candidate who is the target of the research. After the distribution of sentiment is obtained, a comparison will be made between the results of the presidential candidate sentiment before the presidential election and after the presidential election is carried out.

III. RESULT

The results of this research are carried out in accordance with the research flow arrangement. The structure of this research flow starts from crawling

data, data preprocessing, naïve bayes classification, and results recall.

A. Data Crawling

At this stage, researchers retrieved data from the X server using the available API. This stage resulted in a total of 2117 tweet data, each tweet from February 2024 to May 2024 and derived from the keywords "pemilu", "pilpres", and the name of one of the presidential candidates selected for this study. Table I is an example of tweet data obtained from crawling data.

TABLE I. DATA CRAWLING RESULTS

Conversation_id_str	Created_at	Full_text	Username
175991180299193974 8	Tue Feb 20 12:04:06 +0000 2024	Pemilu dah selesai tapi test print standee baru dateng But its okay! CAKEP BANGET GW TADI YG LEMES PULANG KERJA JADI SEMANGAT LAGI https://t.co/ygbsaYfLgf	jejenjreng
179053703888390579 1	Wed May 15 00:17:51 +0000 2024	Negeri ini memang Terlalu kejam bagi manusia2 Kelas Bawah Padahal di setiap PEMILU Lima Tahunan Derajat orang Kaya orang Miskin bahkan ORANG GILA Sekalipun itu sama2 Sama2 Punya Satu hak Suara Alehhh22 https://t.co/ZyMRdFTsxG	Heraloebss
175778601511542008 6	Wed Feb 14 15:16:58 +0000 2024	Minta tolong drop bukti-bukti kecurangan pemilu di kolom reply dong. Thx ya. #KawalSampaiFinal https://t.co/UADUN0rVRT	timpenguinnas

The crawling data results have 15 columns columns that are relevant and will be used for this research are conversation_id_str, created_at, full_text, and username. Those columns are required for the next stage of the research. On a later stage, data will be preprocessed to be a fully prepared data.

B. Data Preprocessing

Before classifying data, the dataset obtained from data crawling needs to be preprocessed first until the dataset is clean and ready to be used in the next stage. At this stage the data must go through a cleaning process, normalization, stopwords, tokenizing, stemming, and translating data from Indonesian to English.

In the cleaning stage, each tweet is cleaned from URLs, punctuation marks, emoticons, hashtags, retweet text, and others. It also creates a dataframe that uses only three columns, namely 'full_text', 'username', and 'created_at'. In addition, cleaning up duplicate data, changing strings to lower case and changing the date format in the 'created_at' column to year-month-date

hour:minute:second. Table II is one of the results of the cleaning stage.

TABLE II. DATA CLEANING RESULTS

Created_at	Full_text (after cleaning)	Username
2024-02-20 12:04:06	pemilu dah selesai tapi test print standee baru dateng but its okay! cakep banget gw tadi yg lemes pulang kerja jadi semangat lagi	jejenjreng

In the normalization stage, some words will be changed to become standard words. Table III shows the word forms before and after being changed with a total of 14 normalized words.

TABLE III. NORMALIZATION WORDS LIST

Before	After
Gt	Gitu
Cth	Contoh
Tp	Tapi
Tpi	Tapi
Yg	Yang
Bgt	Banget
Srkg	Sekarang
Prabowo	"null"
Prabowogibran	"null"
Gibran	"null"
Ganjar	"null"
Ganjarmahfud	"null"
Mahfud	"null"
Jgn	Jangan

From the table, there are some words that changed to null, because the other presidential candidates name are not relevant for this research, as we only focused to one of them. Also, not every slangs are covered in this normalization list because Indonesian have so many slangs to begin with.

After normalization, stopwords are performed to remove tokens or unimportant words such as conjunctions. To do stopwords using the Sastrawi library in Python. Sastrawi is used because it can identify stopwords in Indonesian.

At the tokenizing stage, existing sentences are converted into a collection of tokens or made into words. After the sentences converted into tokens, then the next stage data will be stemmed which means the affix words are removed to become basic words. Sastrawi is also used for stemming the data, because Sastrawi allows the user to do language processing for

words or text in Indonesian and finally, the data is translated from Indonesian into English. The translation process is carried out with the help of the unlimited machine translator library which is a free translator library without word limits for translation in Python. This translation process is done to facilitate the data classification process. Table IV shows the data that has been preprocessed.

TABLE IV.   PREPROCESSED DATA RESULTS

Full_text	Full_text_en
milu dah selesai test print standee baru dateng but its okay cakep banget gw tadi lemes pulang kerja jadi semangat	milu dah selesai test print standee baru dateng but its okay cakep banget gw tadi lemes pulang kerja jadi semangat
negeri memang terlalu kejam manusia2 kelas bawah padahal tiap milu lima tahun derajat orang kaya orang miskin bahkan orang gila sekalipun sama2 sama2 punya satu hak suara alehhh22	The country is indeed too cruel to lower class people, even though every five years the rich, poor and even crazy people all have the same right to vote alehhh22
kabar baik pasang calon bukti laku curang milu diskualifikasi posisi dua naik menang banyak doa zikir seluruh dukung amin kun faya kun	good news put up candidates proof of fraudulent behavior milu disqualification second place up win lots of prayers of remembrance all support amen kun faya kun

From the preprocessing results, the data shown is not perfectly processed. There is some words that not covered in normalization stage that will affect the translation and error in removing affix for some words. Word like pemilu has an affix removal error, the function identifies "pe" in "pemilu" as a prefix and removed it when it shouldn't get removed.

C. Naïve Bayes Classification and Result

Before classifying the data that has gone through the preprocessing, 50% of them will be used as train data. Both for pre-election and post-election datasets will use the same treatment. Figure 2 shows the code for making training data.

```
import random

set_positif = []
set_negatif = []
set_netral = []

for n in datasetpasca:
  if (n[1] == 'Positif'):
    set_positif.append(n)
  elif (n[1] == 'Negatif'):
    set_negatif.append(n)
  else:
    set_netral.append(n)

set_positif = random.sample(set_positif, k=int(len(set_positif)/2))
set_negatif = random.sample(set_negatif, k=int(len(set_negatif)/2))
set_netral = random.sample(set_netral, k=int(len(set_netral)/2))

train = set_positif + set_negatif + set_netral

train_set = []

for n in train:
  train_set.append(n)
```

Fig. 2.   Code for Splitting Training Data

After dividing the training data, data classification began using the taining data with NaiveBayesClassifier function that provided by Textblob library. Besides classification, labelling is also done to see which data is belong to which sentiment category. Figure 3 shows the code for classifying and labeling sentiment data.

```
from textblob.classifiers import NaiveBayesClassifier

cl = NaiveBayesClassifier(train_set)
print("Akurasi Test : ", cl.accuracy(datasetpasca))

Akurasi Test :   0.7719406674907293

#labeling

data_tweetpasca = list(datapasca['full_text_en'])
polaritas = 0

status = []
total_positif = total_negatif = total_netral = total = 0

for i, tweet in enumerate(data_tweetpasca):
  analysis = TextBlob(tweet, classifier = cl)

  if analysis.classify() == 'Positif':
    total_positif += 1
  elif analysis.classify() == 'Netral':
    total_netral += 1
  else:
    total_negatif += 1

  status.append(analysis.classify())
  total+=1
```

Fig. 3.   Code for NaiveBayesClassifier & labelling

After classifying and labeling the data using naïve bayes classification, the accuracy rate for pre-election is 72,8% and 77,2% for post-election. The results of the pre-presidential election data classification have a total of 390 data and post-presidential election data have a total of 1618 data. Then Table V shows the results of data classification.

TABLE V.   DATA CLASSIFICATION RESULTS

Data Classification Results			
	Positive	Negative	Neutral
Pre-election	191	51	148
Post-election	963	523	132

From Table V, the amount of positive, negative, and neutral data can be converted into sentiment distribution results. Sentiment distribution results are shown in Figure 4 & 5.

Fig. 4.   Sentiment Distribution Pre-Presidential Election

Fig. 5.   Sentiment Distribution Post-Presidential Election

From the results obtained both before and after the election was held, positive sentiment is still owned by one of the presidential candidates, and with quite high results when compared to the negative sentiment he got. Looking at the results before the election was held, from a total of 390 data, there were 49% positive sentiments, 38% neutral sentiments, and 13% negative sentiments. And after the election, starting from before the announcement of the election results until after they were announced, there was a total of 1618 data, consisting of 59% positive sentiment, 32% negative sentiment, and 8% neutral sentiment. From these results there is an increase in the number of positive sentiments when the election has been held, but with a note that there is a considerable difference in the amount of data and can make this increase only influenced by the amount of data and not because of the quality of the existing data. In addition to sentiment distribution, word cloud results are also obtained as shown in Figure 6.

Fig. 6.   Word Cloud from The Data Used

When viewed from the word cloud obtained, the keyword that appears most often is one of the names of the presidential election candidate which is the focus of the discussion. Followed by several keywords that lead to the context of the general election, such as the keywords "presiden", "politik", and "rakyat". In addition, some words also indicate that many tweets discuss hopes and expectations related to candidates or elections in general, shown by words such as "mau", "buat", and "bisa". Then, when looking at the sentiment dimension, there are more potentially positive and neutral words than negative ones. These results can strengthen the results of sentiment analysis, which shows a positive trend both before and after the election, and the consistency between the results of the sentiment distribution and the word cloud shows the reliability of the method used.

IV.   CONCLUSION AND RECOMMENDATION

From this research, it can be concluded that one of the presidential candidates used as the object of research has more positive sentiments both before and after the presidential election. From a total of 390 data for before the presidential election, 191 data were obtained with positive sentiments, then from a total of 1618 data for after the presidential election, 963 data were obtained with positive sentiments. This shows that people on X still have sentiments that tend to be positive towards this one of the presidential candidates.

Future research that wants to conduct research on the comparison of sentiment analysis before and after the implementation of the 2024 or subsequent elections, it can be done by examining sentiment analysis of all existing candidates and comparing between each candidate, then it can also use other methods in classifying sentiment to see the difference in results from different methods. Also, could add more words into normalization list to normalize slangs and acronym that Indonesian mainly used on X to achieve more accurate result in this type of research.

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CodeGuardians: A Gamified Learning for Enhancing Secure Coding Practices with AI-Driven Feedback

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Abstract—**This paper introduces CodeGuardians, a gamified platform designed to improve secure coding practices using AI-driven, real-time feedback. The platform focuses on key secure coding concepts, such as input validation, authentication, session management, and cryptography. Developed using the ADDIE (Analyze, Design, Develop, Implement, and Evaluate) instructional model, CodeGuardians enhances engagement and knowledge retention by incorporating interactive challenges. The AI component, powered by OpenAI, provides adaptive feedback on user-submitted code, helping users to learn secure coding practices more effectively. To assess its impact, a one-group pretest-posttest design was conducted. The results of a paired sample t-test showed a significant improvement in secure coding knowledge (t = 19.50, p = 0.048), confirming the platform's effectiveness. In addition, the system's usability was rated highly, with a score of 0.93 on the Computer System Usability Questionnaire (CSUQ), classifying it as "Very Good." The practical implications of this research suggest that CodeGuardians could be implemented in both educational and professional settings to enhance secure coding skills and reduce software vulnerabilities. From a theoretical standpoint, this study advances cybersecurity education by integrating AI-driven feedback into gamified learning environments. The research supports the theory that gamification improves engagement and learning retention, while also highlighting the value of adaptive technologies in addressing real-world security challenges. Future work will examine the long-term retention of knowledge and scalability across diverse learning environments.**

Index Terms— *AI-Driven Learning; Cybersecurity Education; Gamification learning; Interactive Learning; Secure Coding*

I. Introduction

The widespread dissemination of code snippets through platforms like StackOverflow has significantly contributed to the spread of insecure coding practices. This is particularly concerning given that empirical studies reveal 58.4% of answers on StackOverflow are outdated, with only a small fraction receiving necessary updates. Outdated answers on StackOverflow can propagate insecure coding practices by encouraging the use of deprecated libraries or unsafe methods, which can introduce vulnerabilities. Bei et al. [1] highlighted prevalent code license violations, identifying numerous instances of Creative Commons violations stemming from code copied from StackOverflow. Furthermore, Mareek et al. [2] found that 15.4% of security-related code in the applications they reviewed contained at least one insecure snippet, underscoring the urgency for more robust and secure coding practices. These issues emphasize the increasing need for solutions that can actively address and reduce the proliferation of insecure code in real-world applications.

As cybersecurity threats continue to grow in complexity and frequency, innovative educational approaches have emerged as a key strategy to combat these vulnerabilities. Gamification and serious games have proven to be effective tools for enhancing engagement and learning outcomes in cybersecurity contexts [3]–[6]. Gamification enhances learning through reward systems, interactive challenges, adaptive feedback, storytelling, and collaborative competitions, making security concepts more engaging. By incorporating game elements into secure coding education, developers can experience more interactive and engaging learning environments that directly address security risks while reinforcing secure coding principles. The integration of game mechanics into educational platforms has already shown success in raising awareness of cybersecurity threats, teaching best practices, and improving retention of critical security concepts.

Smith et al. developed "CyberAware," a gamified platform that educates users about common cyber threats, such as phishing and malware attacks [7]. Similarly, Jones and Wang introduced "SecureMe," a mobile game that enhances users' understanding of personal data protection and password security [8]. Both studies demonstrate how gamification can improve user engagement and retention in cybersecurity training. However, there is still a gap in addressing secure coding practices specifically through these methods, particularly given the

persistent challenges of insecure code discussed earlier.

For cybersecurity professionals, serious games offer immersive environments to practice and refine essential skills without real-world risks. Serious games help develop skills like intrusion detection, incident response, secure coding, and decision-making under pressure by providing realistic, risk-free simulation environments. Doe et al. introduced "CyberWarrior," a serious game that simulates network defense scenarios, enhancing decision-making skills related to intrusion detection and response [9]. In addition, Lee and Kumar's "PhishSim" helps users recognize and manage phishing attempts through adaptive learning [10]. These examples highlight the potential of gamified training solutions in professional cybersecurity settings. Williams et al. [11] and Patel and Singh [12] further emphasize the value of gamified competition in improving technical competencies through collaborative challenges like "HackathonQuest" and competitive environments such as Capture the Flag (CTF) competitions.

While gamification has been successfully applied in general cybersecurity education, its application to secure coding is relatively underexplored. In this paper, we explore "CodeGuardians," a serious game that leverages AI, specifically large language models (LLMs), to analyze code submissions and provide real-time feedback. This game covers critical secure coding practices, including input validation, authentication management, session management, and cryptography. Input validation prevents injection attacks, authentication management secures user access, session management protects active sessions, and cryptography safeguards data integrity and confidentiality. By incorporating AI-driven feedback mechanisms, "CodeGuardians" aims to create an engaging and interactive environment for learning and reinforcing secure coding practices, directly addressing the insecure coding issues identified earlier. This AI integration marks a significant advancement in the gamification of cybersecurity education, where personalized, adaptive learning can offer tailored feedback to users of varying skill levels.

Despite the growing interest in using AI generative models in gamification, their use in secure coding education remains limited. AI generative models, such as LLMs, offer the potential to dynamically create personalized challenges and feedback that adapt to the learner's individual progress and needs. This not only improves engagement but also ensures that the training is relevant to the learner's proficiency, addressing the limitations of static, non-adaptive learning systems. As this research explores the use of generative AI models within a gamified secure coding framework, pioneers new methods that bridge the gap between outdated learning approaches and interactive, AI-driven educational systems.

Recent research has explored the intersection of gamification and secure coding, highlighting various applications of game-based learning to enhance cybersecurity training. Altunel et al. [13] examined gamification in a large software company, showing that the incorporation of game elements improved developer engagement and adherence to secure coding standards, ultimately reducing security vulnerabilities in the codebase. Similarly, Selvi et al. [14] developed "EscapeScript," a gamified coding platform that used interactive, escape room-style challenges to teach coding skills, including security practices, to future coders. Both studies demonstrate the effectiveness of gamified learning for teaching secure coding, but they do not integrate AI for dynamic, personalized feedback.

Reinsch and Sanders [15] discussed the potential for gamification in expanding virtual learning environments for engineers and project managers, including secure coding practices. Their approach fostered collaborative learning and knowledge sharing through a gamified interface, which improved users' ability to retain critical security concepts. There are several studies that have shown the effectiveness of gamification in cybersecurity [16-19]. However, challenges such as the integration of emerging technologies like generative AI provide avenues for further research in gamified cybersecurity education.

Liu et al. [20] extended gamification with AI in their design of "SmartPal," an AI chatbot that provides real-time learning assistance, but their research focuses on general learning management systems (LMS) without addressing secure coding. Purwar et al. [21] introduced "CultureVo," a serious game utilizing generative AI to create personalized, interactive lessons, showing the potential of AI to dynamically adapt educational content based on learner progress, but this approach was used in cultural education, not cybersecurity or secure coding.

The novelty of the current research lies in the integration of AI generative models, specifically large language models (LLMs), into a gamified platform "CodeGuardians" that provides real-time, AI-driven feedback tailored to secure coding practices. This approach directly addresses gaps in prior research by focusing on personalized, adaptive learning within the context of secure coding, something not fully explored in existing gamified or AI-powered educational platforms. This research differentiates itself by pioneering the use of AI in secure coding education, bridging the gap between static learning models and interactive, responsive AI-driven experiences

II. METHOD

This research uses the ADDIE learning model methodology. ADDIE is an acronym for Analyze, Design, Develop, Implement, and Evaluate. ADDIE is a methodology used to guide the formulation of training or education programs. Jamaluddin et al mentioned that ADDIE and SDLC can be combined because both have similarities that can make it possible to create software designs with educational

purposes [22]. The ADDIE model was chosen because of its structured, iterative framework that ensures the systematic development of effective educational programs, making it particularly suitable for gamified learning solutions like "CodeGuardians." Each phase—Analyze, Design, Develop, Implement, and Evaluate—provides a clear roadmap for addressing educational goals while allowing continuous improvement.

The research steps performed in this study can be seen as fig.1. The research was initiated at the analysis, design, and development steps in the form of designing the CodeGuardians application. At the analysis step, the functional and non-functional requirements of the CodeGuardians application were analyzed. The design step is the process of creating a prototype by paying attention to aspects of the application user's needs. The deployment step is the process of developing the prototype into an application. After these steps are completed, the application implementation step is performed as a secure coding web education media. At the evaluation step, testing is performed in the form of application testing and one group pretest-posttest design to answer the problem formulation and create conclusions.
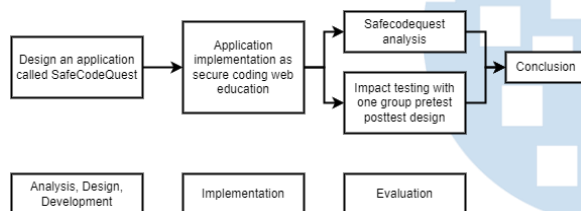
Fig. 1. Research Methodology

A. Analysis

The analysis phase focused on defining the functional and non-functional requirements of the CodeGuardians application. Functional requirements were gathered through a comprehensive review of existing secure coding educational tools, as well as interviews with cybersecurity professionals and educators. These inputs helped identify the core features required to meet user needs effectively. The functional requirements included:

1. User management: Sign up, sign in, logout, and profile management.

2. Educational tools: Challenge management, exam management, and a leaderboard system to encourage competition and engagement.

3. Scalability: Ability to handle multiple concurrent users without degradation in performance.

In terms of non-functional requirements, key aspects such as security, usability, and availability were prioritized. Usability testing focused on ensuring that the application is intuitive and accessible to users with varying levels of technical expertise. Additionally, security requirements included measures to protect user data and prevent unauthorized access, aligning with the core focus of teaching secure coding practices.

B. Design

During the design phase, a prototype of CodeGuardians was developed based on the requirements outlined in the analysis phase. The design process was iterative and included the creation of user personas and use case diagrams (as shown in Fig. 2), which illustrated how users would interact with the system.

The core game mechanics were designed to simulate real-world coding challenges. Users are presented with insecure code snippets and are required to correct vulnerabilities based on the lessons learned. The system includes three levels of difficulty, each corresponding to progressively more complex security issues. The design phase also involved sketching wireframes for the user interface (UI), emphasizing ease of navigation and clarity of instructions, especially for novice coders.

To ensure the robustness of the design, the platform architecture was outlined using UML diagrams. The frontend was designed using React.js, while the backend was built using the Flask Python framework. Data storage needs were addressed by utilizing a MySQL database, ensuring efficient management of user data and results.
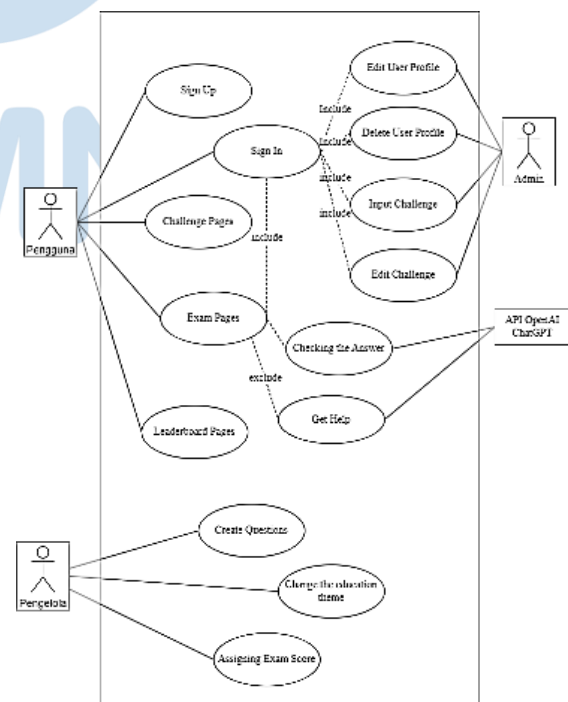

Fig. 2. Use Case Diagram

C. Development

The development phase involved coding the application based on the design specifications. The frontend, built using React.js, was integrated with Flask in the backend to ensure a seamless interaction between user actions and the system's response.

In addition to the technical development, this phase also included prompt engineering for the OpenAI API. Prompt engineering was critical for ensuring that the AI could accurately evaluate user-submitted code and provide real-time feedback. During development, prompts were iteratively tested to refine the accuracy and relevance of the feedback. For example, the OpenAI API was configured to provide specific feedback when users submitted incorrect or incomplete answers. Accuracy testing was conducted by inputting both correct and incorrect code snippets to ensure the AI could distinguish between secure and insecure coding practices. The prompts used are described in fig.3

Furthermore, automated testing frameworks were used to validate the system's performance. Unit tests were written for all major components to ensure the correctness of each functionality, while integration testing ensured smooth interactions between the frontend and backend.

"You act as a code reviewer. Your job is to check the code inputted by the user based on the objective and key. When you check the code with the html type, ignore all case sensitive properties. If the objective and answer key are met and appropriate then the output is true, but if it is wrong then the output is false. If the output is false provide feedback that helps the user to improve their answer."

Fig. 3. Prompt engineering to OpenAI API

The prompt engineering process focused on designing the OpenAI API to function as a code reviewer, evaluating user-submitted code based on objectives and keys while providing actionable feedback for incorrect submissions. Testing involved iterative refinement using a diverse dataset of secure, insecure, and edge-case code snippets to ensure the AI accurately distinguished between correct and incorrect practices. Success criteria included achieving at least 90% accuracy in evaluations, providing clear and specific feedback aligned with secure coding principles, and robust handling of edge cases like incomplete or complex submissions. The system was also validated through integration testing to ensure seamless interactions between the frontend and backend, guaranteeing smooth user experiences in submitting answers and receiving feedback.

The game flows from the home page. When the user presses the start button, the user will be redirected to the challenge page. To take the exam, the user must first log in. After logging in, the user selects the level

of the exam to be done. The user then reads the question description and question instructions, then corrects the wrong code in the game. If the answer is correct, the user will get points.
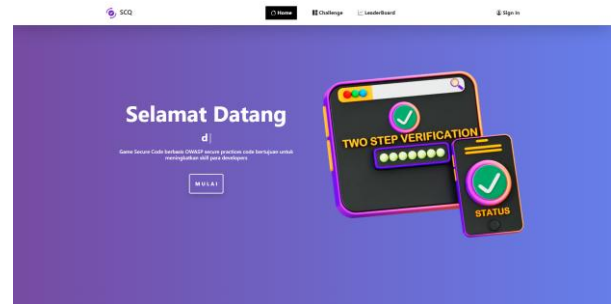

Fig. 4. Home Page

Fig. 4 shows the Home page of the game. When the app is first opened, there is a start button. If the start button is clicked, the player will be directed to the challenge page.
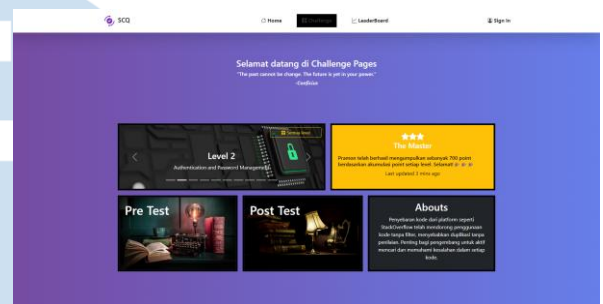

Fig. 5. Challenge Page

Fig. 5 displays the challenge page. On this page there is a menu for doing pretest, exam, and posttest. Players who want to take the exam, are required to log in first.
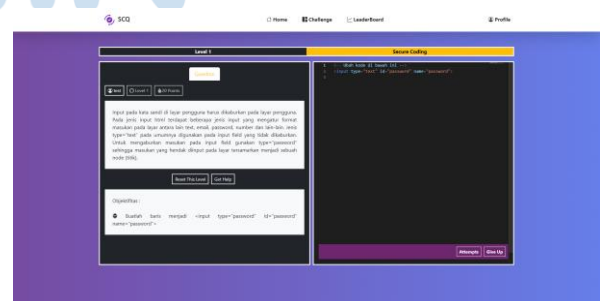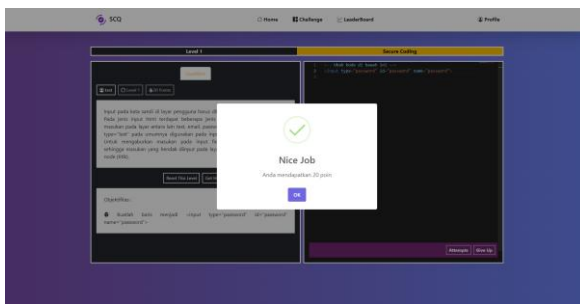

Fig. 6. Exam Page

Fig. 7. Score Achievement

Fig. 6 is the level work page in the game. The level in Fig. 7 is the first level in the game. Users get instructions to disguise the password input on the web application frontend page by changing the type code from text to password. If the user succeeds in doing the instructions correctly, the user will get points as shown in Fig 7.

D. Implementation

The implementation phase involved deploying the CodeGuardians application for actual use by the research participants. Before full deployment, a pilot study was conducted with a small group of participants to identify any usability or performance issues. Feedback from the pilot users was used to make final adjustments to the application.

CodeGuardians was then made accessible to a larger group of participants, consisting of undergraduate students studying cybersecurity. The participants were tasked with completing various levels of coding challenges designed to test their secure coding knowledge. The application was hosted on a cloud-based server, ensuring high availability and scalability to accommodate multiple users The implementation process also included documentation and user guides to help users navigate the application and understand the learning objectives of each challenge.

E. Evaluation

The evaluation phase was crucial for assessing the effectiveness of the CodeGuardians application as a secure coding educational tool. This phase employed both formative and summative evaluation methods. Formative evaluation took place during the development and pilot stages, where feedback was gathered and incorporated into iterative improvements of the system.

For summative evaluation, a one-group pretest-posttest design was used [23]. Participants were tested on their secure coding knowledge before using CodeGuardians (pretest), and again after completing the challenges (posttest). Improvements in secure coding skills were measured by comparing pretest and posttest scores. Statistical analysis was performed to determine whether the improvements were significant. Additionally, user satisfaction surveys were distributed to gather qualitative feedback on the learning experience and usability of the system.

To assess the usability of the CodeGuardians application, the Computer System Usability Questionnaire (CSUQ), based on Cuasqui research [24], was administered to participants after they completed the challenges. The CSUQ measures system usability across three primary factors:

1. System Usefulness: How effectively the system helped participants accomplish the task of learning secure coding.
2. Information Quality: The clarity and relevance of the instructions, feedback, and information presented in the application.
3. Interface Quality: Participants' satisfaction with the interface design, including ease of navigation, visual layout, and overall aesthetics.

Participants rated each item on a 7-point Likert scale, with 1 being "strongly disagree" and 7 being "strongly agree." Key questions focused on the ease of use, whether the system helped them learn secure coding effectively, and whether the feedback provided by the AI component was clear and actionable.

III. RESULT AND DISCUSSION

A. One-group pretest-posttest

Hypothesis testing was conducted to measure the impact before and after the use of the application on users. The t-test is used to determine the decision on the impact of the application. The type of t-test used to analyze the impact of the application is paired sample t-test. Data on the hypothesis is taken through the pretest and posttest that has been collected. Respondents on the questionnaire were cadets of the National Cyber and Crypto Polytechnic who were taken by simple random sampling. The pretest and posttest questionnaires had 15 questions related to input validation, authentication management, session management, and cryptography practices. The questionnaire instrument was validated by experts in the field of cybersecurity and cryptography to ensure compliance with the target [10]. The following are the statistical results of the pretest and posttest calculations.

Table I shows the interpretation that the CodeGuardians application has a significant impact and a significant impact in improving users' ability to understand secure coding practices. With a significance level of $\alpha = 0.05$ and a t-value greater than the p-value, this result shows that there is an almost certain difference, so we reject H0 and accept H1.

TABLE I.   T-TEST STATISTIC

Statistic	Value
t-value	19.50
Degrees of Freedom (df)	28
p-valued (2-tailed)	.048
Mean Difference	82.07
Standard Deviation	22.65
Standard Error Mean	4.28
Confidence Interval (95%)	[73.30, 90.84]

B. Usability Testings

To determine the score of the research results as the first step in measuring the usability of the CodeGuardians application, an assessment recapitulation was carried out. Each statement weight is recapitulated to get an assessment score based on equation (1).

TABLE II.   USABILITY CALCULATIONS

Value	Total	Score
1	0	0
2	0	0
3	1	3
4	5	20
5	40	200
6	142	852
7	363	2541
Sum	551	3616

The highest usability score that can be obtained through equation 1 in this study is

$$highest\ score = 29 * 7 * 19 = 3857\ (1)$$

Furthermore, the usability score (x) is calculated based on the equation (2):

$$x = \frac{3616}{3857} = 0.93\ (2)$$

Based on the usability value (x) obtained from the CSUQ questionnaire, the CodeGuardians application received a value of 0.93. This value is still a quantitative value. Therefore, the usability value (x) is then interpreted into a predicate based on table 1 so that it can be concluded that the CodeGuardians application gets a predicate as Very Good category.

The implementation of the CodeGuardians application was evaluated through a comprehensive analysis that included both knowledge assessment and usability testing. The knowledge assessment involved hypothesis testing using a paired sample t-test to determine the effectiveness of the application in improving users' understanding of secure coding practices. The statistical results indicated a t-value of 19.50, with a degree of freedom (df) of 28 and a p-value of 0.048. The mean difference between the pretest and posttest scores was 82.07, with a standard deviation of 22.65 and a standard error mean of 4.28. The confidence interval (95%) ranged from 73.30 to

90.84, suggesting a significant improvement in users' knowledge after using the CodeGuardians application.

These results indicate that the CodeGuardians application had a statistically significant impact on enhancing users' understanding of secure coding practices. Given the p-value of 0.048, which is below the significance level of $\alpha = 0.05$, the null hypothesis (H0) is rejected, and the alternative hypothesis (H1) is accepted. This means that there is a significant difference between the pretest and posttest scores, demonstrating that the application effectively improved users' knowledge in areas such as input validation, authentication management, session management, and cryptography practices.

This finding aligns with other research in the field, which has shown that serious games and gamified applications can be effective tools for improving cybersecurity education. For example, Selvi et al. found that gamified learning environments significantly enhanced participants' ability to identify and respond to cyber threats [25]. Similarly, J. Lee, and A. Kumar. reported that serious games like "CyberWarrior" led to substantial improvements in cybersecurity skills among participants [26].

In addition to knowledge assessment, the usability of the CodeGuardians application was evaluated using the CSUQ. The usability score was calculated based on users' responses, resulting in a final usability value (x) of 0.93. This value was then interpreted using a predefined predicate table, which classified the application in the "Very Good" category.

The high usability score indicates that the CodeGuardians application is user-friendly, efficient, and provides a satisfying user experience. This is crucial for educational tools, as a positive user experience can significantly influence engagement and the effectiveness of learning. According to Nielsen, usability is a key factor in the success of interactive systems, particularly in educational contexts [26]. The usability score obtained for CodeGuardians suggests that the application not only facilitates learning but does so in a manner that is accessible and enjoyable for users.

Moreover, the strong usability performance of CodeGuardians is consistent with findings from similar studies. For instance, Zandvakili emphasized the importance of usability in gamified learning platforms, noting that applications with high usability scores tend to achieve better educational outcomes [27]. The "HackathonQuest". also highlighted the role of usability in ensuring the effectiveness of collaborative cybersecurity training tools [11].

The results from both the knowledge assessment and usability testing suggest that the CodeGuardians application is an effective tool for improving cybersecurity education. The significant improvement in knowledge, coupled with the high usability score, underscores the potential of gamified applications in this field.

The results of the study, while promising, have several limitations that must be considered when interpreting their applicability. First, the respondents were cadets from the National Cyber and Crypto Polytechnic, a specialized group with likely higher baseline knowledge of cybersecurity compared to the general population. This limits the generalizability of the findings to other user groups, such as novice developers or individuals without formal cybersecurity training.Second, the pretest and posttest questionnaires, while validated by experts, focused on specific secure coding practices (input validation, authentication management, session management, and cryptography). This narrow focus may not reflect a comprehensive understanding of all secure coding principles or their application in broader contexts.

IV. CONCLUSION

The research conducted on the CodeGuardians application has yielded several important conclusions regarding its effectiveness as a cybersecurity education tool. Firstly, the knowledge assessment results demonstrated that the application significantly improves users' understanding of secure coding practices. The paired sample t-test revealed a statistically significant increase in knowledge from pretest to posttest scores, indicating that CodeGuardians effectively enhances users' skills in critical areas such as input validation, authentication management, session management, and cryptography practices. This significant improvement validates the application's potential as an effective educational tool in cybersecurity training. Secondly, the usability evaluation of CodeGuardians, assessed using the CSUQ, resulted in a high usability score of 0.93, categorizing the application as "Very Good." This suggests that CodeGuardians is not only effective in delivering educational content but also provides a user-friendly, efficient, and satisfying experience. The high usability is crucial for ensuring that users remain engaged and motivated throughout the learning process, thereby maximizing the educational benefits of the application.

Overall, the findings indicate that CodeGuardians is a well-designed tool that effectively supports the learning of secure coding practices through an engaging, gamified approach. The significant impact on knowledge acquisition, combined with its excellent usability, positions CodeGuardians as a valuable resource for cybersecurity education. Future research should explore the long-term retention of knowledge gained through CodeGuardians and its applicability in diverse educational contexts.

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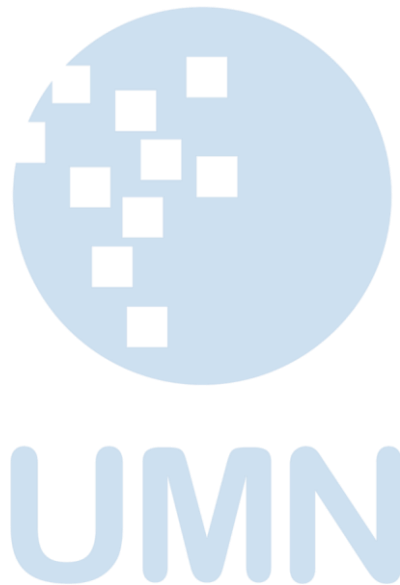
Goal Directed Design Method on UI/UX Design Mobile-Based Application for Preventing Waste Dumping

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Abstract— The issue of waste dumping persists a significant challenge in Indonesia, particularly in the context of South Sumatra Province. In 2022, the quantity of unmanaged waste in South Sumatra Province was documented at 521,075 tons per year. In the course of 2024, South Sumatra was subjected to a total of 58 floods. This illustrates that flooding remains a significant challenge that necessitates the development of innovative solutions, as it can impede the attainment of the Sustainable Development Goals (SDGs), particularly those pertaining to SDG 11, namely the maintenance of sustainable cities and communities. The act of discarding refuse into air ducts represents a significant contributing factor to the occurrence of flood disasters. Accordingly, this research was undertaken with the objective of designing an interface for the Jagoan Sungai application, which is intended to prevent waste dumping. The application was designed with the specific purpose of facilitating the reporting of instances of littering in river environments by individual communities. The application was designed using the Goal Directed Design method and subsequently evaluated using the User Experience Questionnaire (UEQ) method and the Think Aloud method. The UEQ test results indicate that the scores for the six scales exceed 0.8, indicating a high level of user satisfaction. The Think Aloud test results demonstrate that while no significant improvements are necessary, additional information should be incorporated into the application to enhance the user experience further.

Index Terms—goal directed design; sustainable development goals; think aloud; ; UI/UX; user experience questionnaire; waste dumping

I. INTRODUCTION

The issue of waste remains a significant challenge in Indonesia. The results of the South Sumatra Asset and Liabilities Committee Forum meeting, which addressed the issues of waste generation and the performance of waste retribution in South Sumatra, indicate that the province generated 886,632 tons of waste in 2022. Of this amount, 58.77% (or 521,075 tons) was unmanaged waste. This quantity comprises 18.9% plastic waste, 13% wood, twigs, or leaves, and 10.63% paper [1]. The improper management of waste can give rise to a range of environmental and public health concerns, including the exacerbation of flooding events [2]. According to the Indonesian Disaster Information Data, there were 425 floods between 2015 and 2024, with 58 occurring in South Sumatra during 2024 alone. These floods resulted in significant losses, including damage to 716 houses, the deaths of five individuals, the suffering of 8,094 people, the destruction of four educational facilities, and financial losses reaching four million rupiah [3]. This illustrates that flooding is a matter that necessitates the involvement of multiple stakeholders, including the government and the community [4].

Flooding has the potential to impede the realization of the Sustainable Development Goals (SDGs). Floods present a significant risk to the achievement of SDGs point 11, which pertains to sustainable cities and communities [5]. There are multiple factors that can contribute to the occurrence of flooding. One such factor is the accumulation of waste materials around riverbanks, which can result from improper waste disposal practices by local communities [6]. The behavior of the people of South Sumatra Province who dispose of garbage in the river is inextricably linked to the absence of public awareness regarding river hygiene [7]. Various initiatives have been implemented to address the issue of waste dumping in rivers. One such approach is the dissemination of knowledge about waste management, the impact of waste on the environment, and the imposition of penalties on individuals who continue to violate these regulations [8]. Nevertheless, these endeavors have yet to yield sufficient results to effectively address the waste management challenge in Indonesia, particularly in South Sumatra. At present, grievances pertaining to the contravention of waste disposal protocols in rivers are still submitted via email or WhatsApp, or through neighborhood associations. The processing of reports

from the public is a time-consuming process when complaints are made in this way. It is therefore necessary to create a system that allows members of the public to report individuals who are responsible for littering in rivers. However, before this system can be developed, it is essential to design a user interface that is in line with the user's objectives and that allows them to input the information they require. The user interface plays an important role in the development of the system, as the design of the application must be neat, organized and in accordance with the user's needs [9].

The Goal Directed Design method is a user interface (UI) and user experience (UX) design method developed by Alan Cooper (2007) that prioritizes the experience and goals of users [10]. By focusing on the user's goals, it is possible to achieve user satisfaction [11]. The efficacy of the Goal Directed Design method in developing application UI/UX designs that align with user goals and needs is supported by research [12]. The design outcomes produced by this method are well received, as evidenced by research [13]. The refinement stage of the Goal Directed Design method allows for the production of a user-friendly interface design that aligns with user needs [14]. To assess the usability of the application interface design, researchers employed the User Experience Questionnaire (UEQ) method and the Think Aloud method. The User Experience Questionnaire (UEQ) is a usability measurement method that provides a comprehensive measurement of user experience and satisfaction [15]. The Think Aloud method is an application testing method that involves users in continuous verbalization of their thoughts and feelings when using the system [16]. According to Ericsson and Simon (1993), the number of respondents required for the Think Aloud method is limited to approximately 8 to 10 users, as this number is sufficient for understanding user behavior in completing the given task scenario [17]. Based on the aforementioned description, the researchers will design the UI/UX of the Jagoan Sungai application with the objective of facilitating the community in realizing a clean river and public complaint services against acts of garbage disposal in the river.

II. METHODOLOGY

The objective of this research is to identify the underlying causes of waste accumulation in rivers within the South Sumatra Province. The data utilized in this research are primary data, namely qualitative and quantitative data in the form of interview results and questionnaires from prospective application users. The research employs the Goal Directed Design method. Goal Directed Design is a User Interface (UI) and User Experience (UX) design method that prioritizes the user's experience and objectives [12]. Alan Cooper developed the Goal Directed Design method, comprising six stages [11], as illustrated in Figure 1.

A. Research

The initial phase of the process is research, which entails the collection of data through observation and interviews. This stage is designed to identify behavioral patterns among users and subsequently formulate goals and motivations, both specific and general, derived from product usage [14]. This stage yields insights pertaining to user behavioral patterns and user expectations of the product [18].
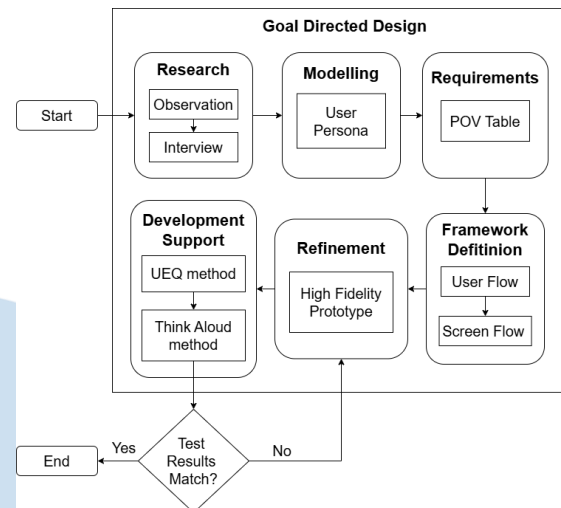

Fig. 1. Goal Directed Design Stages

B. Modeling

Following the completion of the research phase, the modelling stage is initiated. This stage involves the depiction of user behaviour, goals and interactions within the application. At this juncture, an analytical process is undertaken, resulting in the formulation of a user persona [19]. The objective of creating user personas is to identify the actual target users [20].

C. Requirements

The subsequent phase, termed "requirements," is designed to delineate and ascertain the necessities of the functionalities that will be incorporated into the software application [21]. The result of this phase is the delineation of user objectives, user necessities, user conduct, and the technical elements essential for the design phase [18].

D. Framework Definition

The subsequent phase is the definition of the framework. The framework definition stage entails the creation of a preliminary, yet stable, interaction framework and design concept, presented in the form of a user flow and screen flow [22].

E. Refinement

Following the creation of wireframes in the framework definition stage, the subsequent stage is

refinement, which is concerned with the specifics and visualization of the application design [19]. The outcome of this phase is a highly detailed prototype that is capable of interacting with users, who will be subjected to a subsequent evaluation process [21].

F. Development Support

Once the application user interface design has been created, the subsequent stage is development support. This involves the evaluation and testing of the aforementioned design, with the objective of ensuring that the application meets the needs and objectives of the users [14]. The outcomes of this phase are documented in the form of test results and interface design improvements, which are implemented in order to attain an acceptable level of design quality [23].

The testing methods employed are the User Experience Questionnaire (UEQ) and the Think Aloud approach. The Think Aloud method is a technique employed in the evaluation of software applications. It entails the active engagement of users through verbal commentary regarding their experiences and perceptions while interacting with the system. This approach enables observers to identify potential areas for enhancement, particularly in relation to the interface design [24]. Prior to testing, users will be provided with instructions and guidance regarding the completion of their assigned tasks. Users will then perform the tasks in accordance with the scenario that has been established. It is imperative that users refrain from any conscious deliberation during the testing process [16].

Meanwhile, UEQ represents a comprehensive usability testing method that yields detailed insights into user experience and satisfaction [15]. The UEQ comprises six measurement scales, each comprising two or three items, resulting in a total of 26 items and seven answer scales [25]. This is illustrated in Figure 2.

Fig. 2.   UEQ Questionnaire Instruments

III. RESULT AND DISCUSSION

This research presents a user interface design for the Jagoan Sungai application, developed through the Goal-Directed Design method. The following section presents a description of the results and discussion of this research project.

A. Research

In the initial phase of the research, interviews were conducted with prospective users, specifically the Pahlawan Urban Village Office of Palembang City and the community situated adjacent to the river. The findings of these interviews are presented in Table I.

TABLE I.   SUMMARY OF THE RESULTS OF THE INTERVIEW.

No	Question Topic	Answer Conclusion
1.	The following section presents the user feedback on the proposed application.	The proposed interface design for this application was accepted on the grounds that it has the potential to enhance public awareness of river cleanliness and to deter those who continue to dispose of waste in the river.
2.	The objective of this study is to ascertain user goals and expectations with regard to app development.	It is reasonable to anticipate that the application will foster a greater understanding and concern for the importance of maintaining the river's cleanliness.
3.	The objective is to ascertain the user needs and desires in relation to the application.	The objective was to implement a feature that would be advantageous to the community and serve as a deterrent for individuals engaging in the disposal of waste materials in the river.
4.	The information sought by the user is readily available within the application.	The following information pertains to the cleanliness of the river and potential methods for removing the accumulated waste.
5.	The objective is to ascertain user interest and the desired characteristics of the app design.	The app was met with considerable enthusiasm by those who were given the opportunity to test it. They indicated their intention to utilize the app and engage with its features. The target audience desires an application that is straightforward to navigate, with a minimalist design and intuitive functionality.

B. Modeling

The second stage is the modeling stage, which involves the depiction of user behavior, goals, and interactions within the application. At this juncture, an analysis is conducted to generate a user persona that aligns with the findings of the interview. This research presents two user personas: Employees of the Urban Village Office and the Community Around the River as shown in Figure 3 and Figure 4.
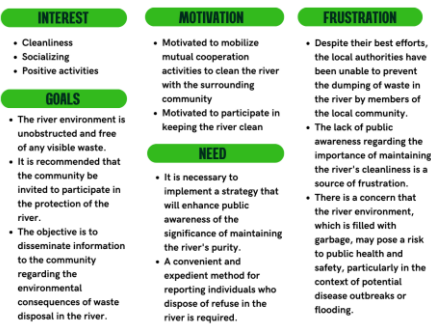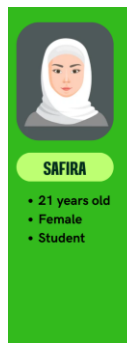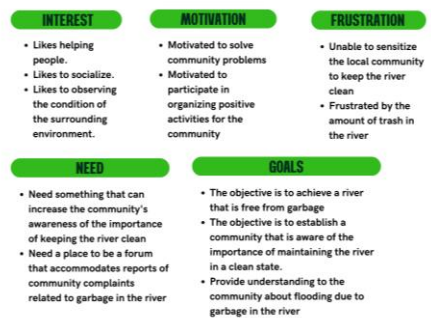
Fig. 3. User Persona 1

Fig. 4. User Persona 2

C. Requirements

The third stage is the establishment of requirements, which entails the creation of a scenario context. This is achieved by formulating goals and requirements in the form of a POV table, in alignment with the objectives of the user persona, as illustrated in Figure 5.
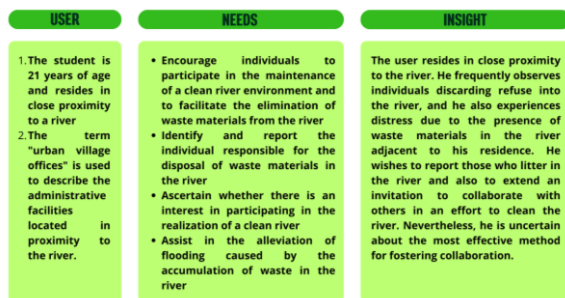
Fig. 5. POV User

D. Framework Definition

The fourth stage is framework definition, which entails the creation of a stable interaction framework and design concept in a preliminary form, typically in the form of a user flow and screen flow diagram. A user flow is defined as a description of the sequence of actions that users can take in order to achieve their desired outcomes when utilizing a given application [26]. The user flow of this application is illustrated in Figures 6 through 11.
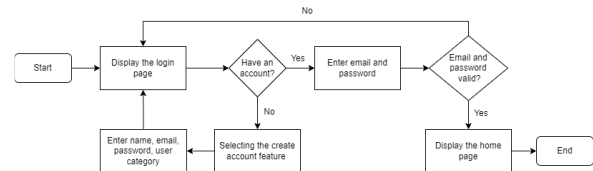
Fig. 6. User Flow Login and Register

Figure 6 illustrates the sequence of actions required for a user to either log in or register. The system will initially present the login page, after which the user is prompted to enter the email address and password associated with their registered account. In the event that an account has not been previously established, the user is first required to create an account and subsequently log in to the system.
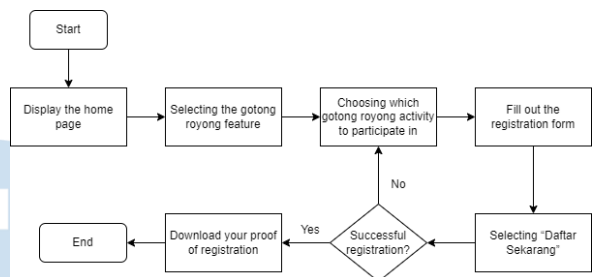
Fig. 7. User Flow Registering Gotong Royong Activities (General User)

Figure 7 illustrates the user flow for registering mutual cooperation activities. Subsequently, the system will display the home page, after which the user may select "Gotong Royong," which will result in the appearance of a list of available gotong royong activities. Subsequently, the user selects the activity in which they wish to participate. Subsequently, users will be directed to the registration form page, where they will complete the requisite registration information.
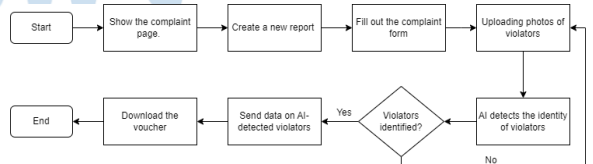
Fig. 8. User Flow of Creating a Violation Complaint (General User)

Figure 8 illustrates the user flow for the violation complaint feature. Subsequently, the system will display the complaint page, after which the user must click the button labeled "Buat Laporan Baru" Subsequently, the user is prompted to complete the complaint form. Subsequently, the system will utilize artificial intelligence (AI) to ascertain the identity of the perpetrator. Subsequently, if the AI is able to successfully identify the perpetrator, the user is prompted to transmit the report to the Environmental Service for processing. In the event of an unsuccessful attempt, the user is prompted to re-upload the

photograph of the violator. It is imperative that the photograph be of sufficient clarity for the AI to be able to accurately identify the individual in question.
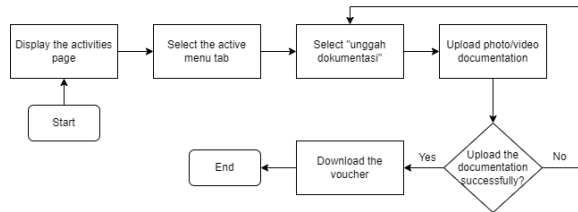
Fig. 9. User Flow Upload Activity Documentation (General User)

Figure 9 illustrates the user flow for uploading activity documentation. Subsequently, the system will display the activity page. The activity page contains three menus: active, upcoming, and history. Subsequently, the user selects the "Aktif" menu tab and clicks the "Unggah Dokumentasi" button. Subsequently, the user uploads the photographic or videographic documentation as evidence of their participation in the gotong royong activity.
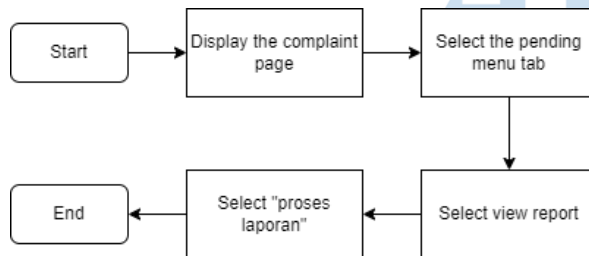
Fig. 10. User Flow Processing Complaints (Officer)

Figure 10 illustrates the user flow for processing complaints by officer. Upon accessing the system, the officer is presented with the complaint page, which features three menu tabs: pending, processed, and history. The officer selects the pending tab to view the report and initiate the processing of the report. Once the officer has completed the requisite actions, the report is transferred to the processed tab, indicating that it is currently under review by officer.
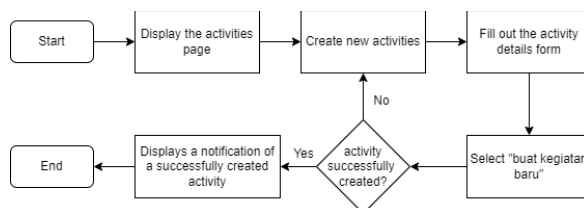
Fig. 11. User Flow of Creating a New Activity (Officer)

Figure 11 illustrates the user flow for creating a new activity. Subsequently, the system will display the activity page, after which the user must click the button labeled "Create New Activity." Subsequently, the officer is required to complete the comprehensive

information form pertaining to the gotong royong activity.

Fig. 12. Screen Flow (General User)

Fig. 13. Screen Flow (Officer)

The screen flow of general users and officer, as illustrated in Figures 12 and 13, respectively, were defined at the framework definition stage.

E. Refinement

The fifth stage is the refinement of the design, which will take the form of a prototype. This prototype will be a high-fidelity representation of the final system and, as such, will be a comprehensive and accurate reflection of the design.
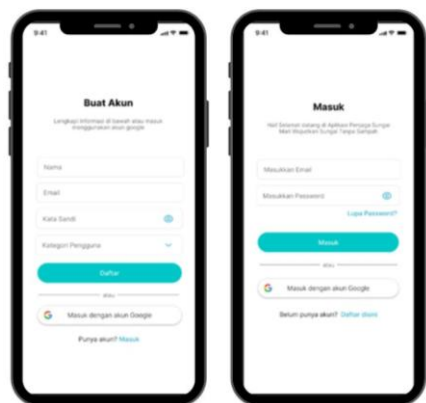
Fig. 14. Login and Sign Up Display

Figure 14 represents a login and sign-up display, or the option to create an account for new users. In order to gain access to the system, users are required to create an account. This entails entering their full name, email address, and password, as well as indicating whether they are a general user or officer. Alternatively, users may opt to register using a Google account. In the event that a user already has an account, they are required to enter the previously registered email address and password, or alternatively, they may log in with a Google account. Furthermore, in the event that a user has forgotten their account password, they may utilize the forgotten password feature to change the old password.
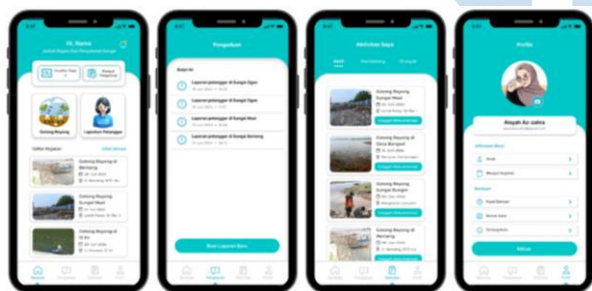
Fig. 15. Hi-Fi General User Display

Figure 15 depicts the home menu, along with the complaints, activities, and profiles for general users. The home menu presents a list of scheduled gotong royong activities. Moreover, the complaint menu enables users to create a new complaint report by completing the requisite form, which is made available upon clicking the "Buat Laporan Baru" button. Moreover, the activities menu contains a list of current and forthcoming activities, as well as a record of those previously undertaken. Additionally, users are able to upload documentation pertaining to their activities within this menu. The profile menu, which follows, comprises profile features, activity history, the help center, contact information, and a section on the application's background. Furthermore, users may exit the application from this menu.
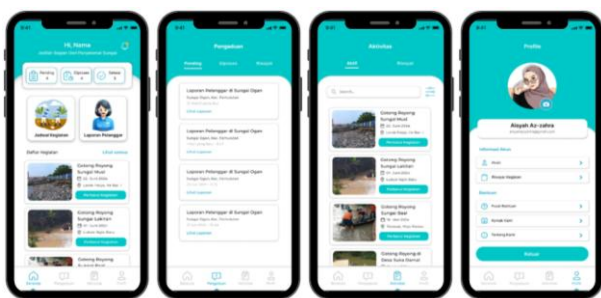
Fig. 16. Hi-Fi Display of Officer

Figure 16 depicts the home menu, along with the complaints, activities, and profiles for officers. The home menu presents a list of scheduled gotong royong activities. The home menu allows officers to update information pertaining to existing activities. Moreover, the complaints menu comprises three primary sections: pending, which encompasses reports that have not yet been processed; processed, which includes reports that are currently undergoing processing; and a historical record of public complaints. Moreover, the activity menu presents a list of current activities and a record of past collaborative endeavors. Subsequently, the profile menu is presented. This menu contains the following features: profile, activity history, help center, contact us, and about us. Additionally, this menu allows officers to exit the application.

### F. Development Support

The final stage is that of development support. At this juncture, usability testing of the application user interface is conducted with 100 respondents using the User Experience Questionnaire (UEQ) methodology to ascertain whether the application aligns with the needs and objectives anticipated by users. The responses provided by the respondents can be observed in Table II.

TABLE II. THE RESULTS OF THE SURVEY

No	Question Item								
	1	*2*	*3*	*4*	*…*	*23*	*24*	*25*	*26*
1	6	6	3	3	…	3	3	3	4
2	6	7	1	1	…	1	1	2	7
3	5	6	2	3	…	3	2	3	7
4	6	6	1	1	…	3	2	3	6
5	7	6	1	1	…	1	1	1	7
…	…	…	…	…	…	…	…	…	…
96	6	6	2	2	…	1	2	6	6
97	6	6	4	3	…	2	2	6	3
98	7	5	7	7	…	1	1	7	6
99	6	5	1	1	…	2	2	7	6
100	6	7	2	2	…	1	1	6	6

Subsequently, the respondent data in Table 3 undergo a transformation to ascertain the negative and positive values associated with each item. The transformed data from the respondents is presented in Table III.

TABLE III. TRANSFORMED DATA.

No	Question Item								
	1	2	3	4	…	23	24	25	26
1	2	2	1	1	…	1	1	1	0
2	2	3	3	3	…	3	3	2	3
3	1	2	2	1	…	1	2	1	3
4	2	2	3	3	…	1	2	1	2
5	3	2	3	3	…	3	3	3	3
…	…	…	…	…	…	…	…	…	…
96	2	2	2	2	…	3	2	-2	2
97	2	2	0	1	…	2	2	-2	-1
98	3	1	-3	-3	…	3	3	-3	2
99	2	1	3	3	…	2	2	-3	2
100	2	3	2	2	…	3	3	-2	2

The average value of an impression and scale variance were then obtained from the results of data transformation, as illustrated in Figure 17.

UEQ Scales (Mean and Variance)		
Attractiveness	↑ 1.702	1.14
Perspicuity	↑ 1.795	0.81
Efficiency	↑ 1.655	1.10
Dependability	↑ 1.440	1.49
Stimulation	↑ 1.970	0.54
Novelty	↑ 1.675	0.85

Fig. 17. Average Impression and Variance

The results demonstrate that all 6 UEQ scales, including Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty, exhibit average results above 0.8. These findings are utilized to analyze the benchmark data, which can be observed in Figure 18.

Fig. 18. UEQ Benchmark Chart

The results of the measurement of the average value of the UEQ score indicate that the Jagoan Sungai application is rated in the "good" category in vari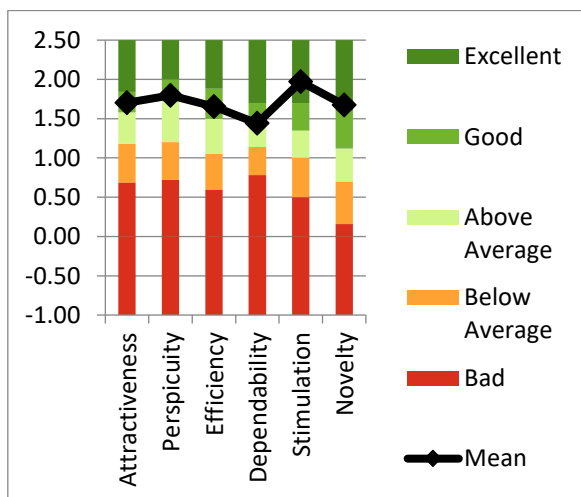ous aspects, including attractiveness (1.7), perspicuity (1.8), and efficiency (1.66). Furthermore, the aspects of stimulation and novelty were rated highly, with scores of 1.97 and 1.68, respectively. The dependability aspect

was rated above average, with an average score of 1.44. These results indicate that users of the Jagoan Sungai application are satisfied with the attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty of the application.

Following the implementation of the UEQ method for testing purposes, the Think Aloud method was employed for a subsequent round of testing. The testing phase involved the participation of 10 users, comprising both general users and village officers, and was conducted in accordance with the task scenario delineated in Table IV.

TABLE IV. TASK SCENARIO

No	Task Scenario
T1	Registration and login to the Jagoan Sungai application (general users and officers)
T2	Search and register for available gotong royong activities (general users)
T3	Upload documentation of gotong royong activities that have been participated in (general users)
T4	Make a violation complaint (general users)
T5	View a list of current, registered, and historical activities (general user)
T6	Processing complaints (officer)
T7	Creating new activities and changing gotong royong activities (officers)
T8	View a list of pending, processed and historical complaints (officer)
T9	Edit profiles (general users and officers)
T10	Exit the app (general users and officers)

In accordance with the fundamental tenets of evaluation as espoused by Jakob Nielsen, the data obtained will be classified and assigned a severity rating based on the mean severity rating value of each problem identified [16]. Subsequently, the problems are sorted to ascertain the priority for improvement, based on the mean value of the highest severity rating and the number of users who have identified the problem [17]. The severity rating value scale is presented in Table V.

TABLE V. SEVERITY RATING VALUE SCALE

Scale	Terms	Description
0	No Problem	This is not a usability issue.
1	Cosmetic Problem	The issues pertain solely to the display aspect and do not impact user comfort.
2	Minor Problem	The issue requires attention, but it is not a high priority.
3	Minor Problem	The following issues have been identified as requiring improvement.
4	Catastrophe	The issues encountered by users are of a significant and intricate nature, necessitating the implementation of enhancements.

The results of the user problem identification process following the testing phase are presented in Table VI.

TABLE VI. SEVERITY RATING GENERAL USERS

User	Task Scenario						
	T1	T2	T3	T4	T5	T9	T10
1	0	1	0	0	0	0	0
2	0	0	0	1	0	0	0

User	Task Scenario						
	T1	T2	T3	T4	T5	T9	T10
3	1	0	0	0	1	0	0
4	0	1	1	0	0	0	0
5	0	0	0	2	0	1	0
6	0	0	1	0	1	0	0
7	0	0	0	1	0	1	0
8	0	0	0	1	0	0	0

TABLE VII. SEVERITY RATING OFFICER

User	Task Scenario					
	T1	T6	T7	T8	T9	T10
1	0	0	2	0	1	0
2	0	1	1	0	1	0

A total of 20 problems were identified based on the results of the user scenario tasks. This results in a total of 16 problems with a severity rating of 1 and 2 problems with a severity rating of 2. The provision of recommendations for improvements to the Jagoan Sungai application presents a challenge in terms of the categories of appearance and information or content. Recommendations are formulated and ordered according to a severity rating scale, commencing with the highest value, designated as 4 (catastrophe), and culminating with the lowest value, 2 (minor problem). The rating of 1 (cosmetic problem) is disregarded, as it is deemed to have a relatively minimal impact on users. The majority of these problems were found in tasks T4 and T7. Conversely, the fewest problems were identified in tasks T1 and T6, with a single problem each, and in task T10, which was rated as very easy to complete by all users.

In general, the application is satisfactory and offers users a convenient means of accessing the desired information. No significant enhancements are required; however, the content within the application would benefit from the incorporation of supplementary details.

IV. CONCLUSION

The findings of the research indicate that the Goal Directed Design method is an effective approach for the design of the user interface and user experience of the Jagoan Sungai application. The user interface design of the Jagoan Sungai application was produced through the stages of the Goal Directed Design method. Subsequently, the user interface design of the River Hero application was evaluated using the UEQ method with 100 respondents.

The results of the test demonstrated that the attractiveness scale attained a score of 1.7, clarity scored 1.8, and efficiency scored 1.66. Furthermore, the stimulation and novelty aspects were rated in the very good category with scores of 1.97 and 1.68, respectively. The accuracy aspect was scored above average with an average score of 1.44. The results of the think-aloud testing yielded 20 issues, as determined by the outcomes of the user scenario assignment. Of these, 16 were classified as level 1 problems and 2 as level 2 problems.

These findings suggest that no substantial enhancements are necessary, but rather that additional information should be incorporated into the application. The results of the tests conducted using both methods indicate that the Jagoan Sungai application is generally well received and aligns with user needs.

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Quality Analysis of Scheduling System Using COBIT 2019 at Ministry of Religious Affairs Pasuruan

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Abstract— **This study aims to measure the quality scheduling information system (SIP KEMENAG) of Ministry of Religious Affairs (MORA) in Pasuruan Regency. In this study, the author used a combination or mixed methods research with a sequential explanatory model. The combination research method with a sequential explanatory model is characterized by the collection and analysis of quantitative data in the initial stage, followed by qualitative data explanation in the next stage. The website quality analysis process using COBIT 2019 produced an average maturity score: BAI3 (4.14), BAI4 (4.34), and DSS5 (4.32). After averaging, the SIP KEMENAG application is at level 4 (quantitatively managed) in the capability maturity model integration. This shows that the application has adopted an approach based on data and numbers to plan, measure, and control the performance of the application process. The desired value is level 5 (optimizing), with a gap of 0.73. After the quantitative data is found, in-depth information mining or interviews will be carried out using qualitative methods.**

Index Terms— **Quality; Information Systems; COBIT 2019; Website; Maturity.**

I. INTRODUCTION

Technological developments are increasingly rapid today. This progress makes information technology a necessity that can no longer be ignored. This phenomenon has driven an increase in the number and complexity of software, along with the evolution of technology and supporting tools used. On a large or small scale, information technology has become a key element in various fields of study. With its abundant benefits, information technology has become inseparable from human life. The application of information technology in various organizations has a significant impact, especially in performance management. One of them is in scheduling services, both within and outside the city, as happened at the Ministry of Religious Affairs (MORA) in Pasuruan Regency [1].

Along with its development, several analysis models have been developed to help measure the quality of a website. Evaluating the quality of a website is very important to ensure that the site meets the expectations and needs of the intended users [2]. However, not all websites are able to achieve a high level of satisfaction in meeting user requirements and needs [3].

The use of a website as a means of managing activities [4] at the Pasuruan Regency Ministry of Religion is an innovative step that aims to increase efficiency and effectiveness in organizing activities [5]. Previously, the MORA in Pasuruan Regency relied on traditional methods such as Google Form and direct submission to the general section, which often resulted in difficulties in accessing information and communication between the parties involved. This method is also prone to errors in scheduling, because the manual process does not have an adequate verification system.

With the presence of the Ministry of Religious Affairs Scheduling Information System (SIP KEMENAG), it is hoped that it can integrate various functions, such as automatic notifications, activity data management, and statistical analysis, making it easier for management to make decisions. In addition, this system will ensure data security and confidentiality of activity information, which has been a challenge in

traditional management. However, the success of implementing this website also depends on the readiness of human resources, which require training and adaptation to new technologies.

Therefore, socialization regarding the benefits and how to use this new system is very important to change the mindset of employees and stakeholders, so that the MORA can move towards a more modern and efficient era in managing activities. To ensure that the system built meets the expected quality standards, the application of the COBIT (Control Objectives for Information and Related Technologies) framework becomes very relevant.

COBIT provides comprehensive guidance and tools for evaluating and managing the quality of information systems, including aspects such as effectiveness, efficiency, and security. By using COBIT, the Ministry of Religious Affairs can conduct audits and assessments of the Ministry of Religious Affairs' SIP, ensuring that the system is not only functioning properly, but also in line with the organization's strategic objectives, so that it can provide maximum benefits for all parties involved.

The objective of this study is to evaluate and enhance the quality of the Scheduling Information System (SIP KEMENAG) at MORA in Pasuruan Regency using the COBIT 2019 framework. This involves assessing the system's effectiveness, efficiency, and security, identifying gaps in performance, and improving activity management through technology. The study also aims to ensure data security, provide training recommendations for human resources, and support the modernization of activity management within MORA.

II. THEORITICAL BASIS

A. Software Quality

The word "quality" is often used to express a relative assessment of something in phrases such as "good quality", "bad quality", and "quality of life" – which have different meanings for different individuals. To effectively manage quality, it is important for us to define quality as "conformance to requirements". With this approach, when a nonconformity is detected, we can conclude that quality is not met.

Thus, the quality problem becomes related to nonconformity, and ultimately quality can be described as the extent to which something meets specified requirements. The system that causes the creation of quality is through prevention, not just assessment. This means that the quality of the system for software in meeting customer needs is by doing the right process from the start.

Software quality is a critical aspect in software development that reflects the extent to which the software meets the specified functional and non-functional requirements. Aspects of software quality include reliability, performance, security, ease of use,

scalability, and so on. To achieve good quality, it is important for software developers to ensure that each stage in the development cycle, from planning to maintenance, is carried out properly and in accordance with established standards.

B. Information Systems

In the basic concept of the system, the definition of "system" refers to an entity consisting of interrelated parts or components that interact continuously with their environment. The purpose of this system is to achieve a bound and integrated goal, which takes place continuously. Each component in the system has its own function and way of working, but still operates in an integrated manner in a single unit that has a specific function or purpose.

Etymologically, the word "information" comes from the Latin "informationem" which means inspiration, outline, or signal. Information can be expressed in various forms, such as notes, pictures, graphs, diagrams, audio, films, and so on. In the Big Indonesian Dictionary (KBBI), information is defined as something that supports a message, as seen in the parts of the message itself. Information is a collection of facts or events that are processed in a certain way so that they have value or purpose for the recipient of the information. Information that is presented well and is useful for the recipient provides an opportunity to share explanations or Insights [6].

An Information system Is a structure consisting of Interrelated components, such as hardware, software, communication networks, and human resources, that work together to collect, store, process, transmit, and manage information in an organization or a particular environment. The main objective of an information system is to provide relevant, accurate, and useful information to users or stakeholders who need it. By using the right technology and processes, information systems help in processing business transactions, decision making, resource management, collaboration support, and data analysis. Thus, information systems play an important role in improving operational efficiency, better decision making, and overall organizational performance.

C. Scheduling Information System

The Ministry of Religious Affairs Scheduling Information System (SIP KEMENAG) is a government agency website-based application created by the MBKM UINSA internship group of the Information Systems study program. This application is intended for the general section as a section that handles correspondence and is also intended for each section head in the Ministry of Religious Affairs to input work schedule data. This application has a dashboard feature to monitor the number of schedules and the number of work schedules, work trips that can be added, edited, and deleted as well as personal data for officers or each section head. While the dashboard feature monitors the number of officers and the number

of services, scheduling and officer data that can be edited and deleted is intended for the Admin or general section. The registration, login, and logout features are mandatory features for officers and Admins.

D. COBIT 2019 Framework

COBIT stands for Control Objectives for Information and Related Technologies. In general, COBIT is an IT governance framework for businesses that want to implement, monitor, and improve IT management. The COBIT framework was created by ISACA to bridge the gap of interests between technical issues, business risks, and controls. COBIT itself can be applied in any organization from any industry to ensure the quality, control, and reliability of information systems.

Governance objectives and management objectives in COBIT are grouped into five domains. Domains have names with verbs that express the main intent and field of activity of the objectives contained therein. Governance objectives are grouped in the Evaluate, Direct and Monitor (EDM) domain. In this domain, the governing body evaluates strategic options, directs senior management on the selected strategic options and monitors the achievement of the strategy. Management objectives are grouped into four domains, namely Align, Plan and Organize (APO) which discusses the overall organization, strategy, and I&T supporting activities. Build, Acquire and Implement (BAI) discusses the definition, acquisition, and implementation of I&T solutions and their integration into business processes. Deliver, Service and Support (DSS) addresses the operational delivery and support of I&T services, including security. Monitor, Evaluation, and Assessment (MEA) addresses the monitoring of I&T performance and conformance to internal performance targets, internal control objectives, and external requirements.

E. COBIT and CMMI integration

CMMI stands for Capability Maturity Model Integration. It is a framework used to develop and improve business processes within an organization. CMMI helps organizations improve the quality of their products and services by providing guidance to measure and improve process maturity. COBIT 2019 supports the Capability Maturity Model Integration (CMMI) process capability scheme ranging from 0 to 5, maturity level 0 is described as an unmanaged organization or no managed process; maturity level 1 as initial; maturity level 2 as managed; maturity level 3 as defined; maturity level 4 as quantitatively managed; maturity level 5 as optimizing [7]. The capability level is a measure of how well a process is implemented and executed.

Figure 1. Capability Maturity Model Integration

F. Usability Testing

The International Standard Organization or ISO 9241-11 (2018) defines usability as the extent to which a product can be used by a specific user to achieve a specific goal with effectiveness, efficiency and satisfaction in a specific context of use. This approach has the advantage of being directly related to user needs, effectiveness means success in achieving goals, efficiency means not wasting time and satisfaction means willingness to use the system.

III. RESEARCH METHODOLOGIES

In this study, the author used a combination or mixed methods research with a sequential explanatory model. The combination research method with a sequential explanatory model is characterized by the collection and analysis of quantitative data in the initial stage, followed by qualitative data explanation in the next stage [8]. This step aims to strengthen the results of quantitative research that has been carried out previously [9]. With a mixed methods approach, the author can produce more complete and valid findings, as well as provide more informative and contextual recommendations. The subjects of this study used the BAI3, BAI4, and DSS5 domains as benchmarks for creating research instruments.

A. Data Collection

Data collection conducted in this study used literature study, interviews, usability testing and questionnaires. The following are the results of data collection from each method used:

1. Literature study involves collecting information from various sources, including articles, journals, books, and other documents relevant to the objectives of this study [10]. This method aims to collect and analyze existing data in order to provide a strong theoretical basis and broader context for the study.
2. Interviews are question and answer activities with related parties related to the development of the SIP KEMENAG application, such as Computer Pranata (Prakom) and users. Interviews are part of the activity of digging up information to be used to strengthen quantitative results.

3. Usability testing is defined by the International Standard Organization or ISO 9241-11 (2018) as the extent to which a product can be used by certain users to achieve certain goals with effectiveness, efficiency, and satisfaction in a certain context of use. This approach has advantages because it is directly related to user needs, effectiveness means success in achieving goals, efficiency means not wasting time, and satisfaction means willingness to use the system [11].

4. A questionnaire is a research instrument that contains a series of questions that aim to collect information from targeted participants. Questionnaires are often considered a form of written interview.

5. Respondents for this study consisted of 3 people from the general division, and the others consisted of 1 person from each division, such as the madrasah education division, Islamic religious education, finance, zakat and waqf, personnel, hajj and umrah organizers, community guidance, Islamic boarding schools, and Hindu community guidance. The reason for choosing respondents in this study was to ensure diverse representation from various divisions in the Ministry of Religion. With 3 people from the general division as admins and the roles of other divisions as officers, this study can capture different perspectives and needs related to the use of the KEMENAG SIP. Each division has specific expertise and experience that is relevant to the function and purpose of the system, so that the feedback obtained is more accurate and in-depth.

B. Data Analysis

After obtaining the required data from the data collection process, the next step is the data analysis stage. This stage is carried out to interpret and describe in the form of findings as a reference for providing recommendations.

1. Domain analysis aims to determine the average response given by participants to the SIP KEMENAG application. Data collection and assessment are carried out in accordance with the COBIT standard management guidelines. In this study, an assessment of the maturity level was carried out on the Build, Acquire, and Implement Domain (BAI3 and BAI4) and the Deliver, Service, Support Domain (DSS5) applied to the SIP KEMENAG application. Based on the results of the questionnaire, answers were obtained which, if analyzed, would describe the maturity level of the IT process [12].

2. Gap analysis was carried out to find the difference between the domain results obtained through the questionnaire, with the expected desired value.

TABLE I. MATURITY LEVEL

No.	Maturity Level	Describe
1.	Level 0 as an unmanaged organization or no managed process	There is a lack of capability foundation, an incomplete approach to addressing governance and management objectives, or processes that do not meet the objectives of the process practices.
2.	Level 1 as initial	The process achieves its purpose through the application of a set of activities that are not very well organized.
3.	Level 2 as managed	The process achieves its purpose through managed activities (planned, monitored and adjusted) and appropriate work products.
4.	Level 3 as defined	The process is performed using a more organized manner using appropriate organizational assets.
5.	Level 4 as quantitatively managed	The process achieves its purpose in a well-defined manner, and its performance is quantitatively measured to understand the process performance and identify ways to improve it.
6.	Level 5 as optimizing	The process achieves its established objectives, its performance is measured to improve performance continuously, and ongoing process improvement is pursued.

3. Researchers also conducted in-depth interviews with parties who had filled out the questionnaire to strengthen the quantitative findings.

4. After conducting in-depth domain, gap, and interview analysis, there are several recommendations that can be implemented to improve the performance of the Ministry of Religion's scheduling information system application according to the expected level.

IV. RESULT AND DISCUSSION

A. Domain Analysis

After data collection using a questionnaire, the next stage is domain analysis to determine the average response given by participants to the SIP KEMENAG

application. Data collection and assessment are carried out in accordance with the COBIT standard management guidelines. In this study, a maturity level assessment was carried out on the Build, Acquire, and Implement Domain (BAI3 and BAI4) will play an important role in managing the development, implementation of features, application workload, compatibility, and design of the SIP KEMENAG [13] and the Deliver, Service, Support Domain (DSS5) because it is related to IT risk management, including security testing [14] or non-functional testing to identify and mitigate risks associated with the SIP KEMENAG application. Based on the respondent interview documents, answers were obtained, which if analyzed would describe the maturity level of the IT process [12].

TABLE II. DOMAIN ANALYSIS RESULTS

Sub	Description	Value
BAI3.1	Does this application have a colour design that matches the organization (MORA)?	3,75
BAI3.2	Has this application been designed with an intuitive user interface so that it is easy to use?	4,16
BAI3.2	Is the application equipped with a search feature to make it easier for users to search for data?	4,08
BAI3.4	Is the app compatible with other devices?	4,33
BAI3.9	Does this app come with activity management features that allow users to easily input, edit, and delete data?	4,41
Average		**4,14**
BAI4.1	Do you agree that managing system availability and capacity is an important step in the process of building or acquiring a new system?	4,25
BAI4.2	Do you agree that this application can be accessed online or does it require an internet connection?	4,33
BAI4.3	How important do you think it is to ensure that the system being built or acquired is capable of managing the anticipated workload well?	4,25
BAI4.4	Does an IT professional need to perform regular application monitoring	4,41

Sub	Description	Value
	and reporting as part of capacity management activities?	
BAI4.5	How important do you think it is to involve end users in the availability and capacity evaluation process to understand their needs and expectations?	4,5
Average		4,34
DS5.1	Does the app have a file download mechanism?	4,16
DS5.2	Does the application have access permission to enter the application?	4,66
DS5.4	Can the application manage access rights?	4,08
DS5.5	Can the app see details of a user?	4,58
DS5.6	Does this application implement robust access mechanisms to input and manage data?	4,16
Average		4,32

From the score calculation in table 1, it shows that for Domain BAI3, BAI4, and DSS5 it has a maturity score of 4. In CMMI, it is included in level 4 (quantitatively managed) which means that the process has succeeded in achieving its goals, the process has been well defined, and its performance is measured (quantitatively).

B. Gap Analysis

Gap analysis is conducted to determine the difference between the domain results obtained through the questionnaire with the desired value expectations. The desired values are obtained from interviews with respondents. The following is a table of average results using the integration of capability maturity models.

TABLE III. GAP ANALYSIS

Sub	Description	Value	Desired Value	*Gap*
BAI3	*Managed Solutions Identification and Build.*	4,14	5	0,86
BAI4	*Managed Availability and Capacity.*	4,34	5	0,66
DSS5	*Managed Security Services.*	4,32	5	0,68
Average		**4,26**	**5**	**0,73**

The assessment results show that the SIP KEMENAG application is at a good level of maturity, with an average score of 4.26. However, there is a gap between the current score and the expected value, which is level 5 (optimizing), with a total difference of 0.73.

There are 4 user expectations from 12 users who have tried the SIP Kemenag application.

TABLE IV. USER EXPECTATION

No.	Division	User Expectation
1.	General Affair	The application is good, there are a few obstacles during registration because the password is the same.
2.	Personnel	More detailed is the signature on the system, such as the community guidance division must sign to the head of the community guidance section. And the typical colors of MORA are not too prominent.
3.	Hajj and Umrah Organizers	There should be feedback on the assignment letter in the application, so as not to ask the admin continuously.
4.	General Affair	The application is okay, unused accounts should be deleted.

In table 4 above has the following conclusions:
1. General Affairs Division: Users reported that while the application is functional, there are issues during registration, particularly with duplicate passwords causing confusion. Suggestions include a notification system to alert users about password duplication.
2. Personnel Division: This division highlighted the need for more detailed signature processes within the system. For example, documents requiring approval from the head of the Community Guidance Division should be facilitated more effectively. Additionally,

they noted that the distinctive colors of MORA should be more prominent in the application design to reflect organizational identity.
3. Hajj and Umrah Organizers: Users emphasized the importance of feedback mechanisms. For instance, the ability to view and download assignment letters directly within the application would reduce dependency on admin staff.
4. General Affairs Division: Another suggestion from this division was to implement a feature for deleting unused accounts, which would help optimize system capacity and reduce clutter.

These expectations underline the need for continuous refinement of the system to meet user needs and enhance overall usability.

Next is phase two after finding quantitative data obtained from the data analysis process shows the level of quality of the SIP KEMENAG application that has not reached the desired value. To understand more deeply about this finding, the researcher continued with in-depth interviews with employees and division heads who had become respondents. This interview revealed that there were several employees who had problems when registering and logging into the application and the distinctive color of MORA which was not very prominent, lacked detail in the signature section of each division head, and had to be given feedback in the form of a pdf on the officer's page. This finding provides additional context and helps explain the survey results, so that researchers can provide recommendations for improving the application.

This study refers to previous research conducted by Albert Riyandi et al. in 2020 [12] entitled Library Information System Audit Analysis Using the COBIT Framework, where they used the COBIT 4.1 framework to evaluate information technology governance in the library system at MTSN 1 Tangerang. Based on these findings, this study uses the COBIT 2019 framework to improve the efficiency and quality of information technology services in the Ministry of Religion's Scheduling Information System (SIP). With a mixed methods approach, this study is strengthened by in-depth interviews to provide a comprehensive understanding of system performance and user experience. In addition, this study involved 12 respondents from various divisions, so that it can cover a broader and more diverse perspective on system usage.

C. Recommendation

The gap resulting from the analysis process is less than 1, which is 0.73. Based on the purpose of creating the website that has been explained in the introduction, it is hoped that the MORA can be more advanced and modern, so the gap does not have a significant effect on the MORA in Pasuruan Regency. Therefore, the main focus can be directed at improving the quality and

functionality of the website on an ongoing basis. The following are the recommendations needed to reach level 5:

Recommendations for BAI3 lie in the application features and design, such as the registration feature. When the password or username filled in by the new user is the same as the password or username that has been saved, a warning should be given that the password is already available so that the user knows that the password or username is already in the database. The design or color of the application must be adjusted to the provisions of the organization (MORA). The print report feature should be integrated with the signature of each section head to be more efficient.

Recommendations for BAI4 lie in the availability and capacity of the application. The internet network needs to be considered so that the application remains available and used online, feedback in the form of a travel letter should appear in the officer section, so that officers can download it again if the letter is lost. The capacity of the application needs to be considered again, such as the work schedule that has been entered requires a filtering process to archive the work schedule that is no longer needed.

Recommendations for DSS5 lie in managing access rights. Many of the accounts that register but forget their passwords, end up creating new accounts and unused accounts will fill the application capacity, so account filtering is needed to remove unnecessary ones.

D. Discussion

The Ministry of Religious Affairs Scheduling Information System (SIP KEMENAG) application aims to improve the efficiency of schedule management at the MORA in Pasuruan Regency. Analysis using COBIT 2019 shows that the system is at maturity level 4 (quantitatively managed), with several areas that require improvement.

Domain BAI3 obtained an average score of 4.14, indicating good application design but needs color adjustment and integration of signature features. Domain BAI4, with an average score of 4.34, shows good capacity and availability management, but requires network infrastructure improvements and additional capacity monitoring. Domain DSS5, with an average score of 4.32, shows good data protection and access rights management, but needs the addition of inactive account filtering features.

Gap analysis shows the difference between the achieved value and the ideal value of 5 is 0.73. Recommendations include improving the registration feature and application design in BAI3, improving infrastructure and capacity monitoring features in BAI4, and managing access rights in DSS5. Continuous improvement is needed to meet user expectations and improve application quality standards.

V. CONCLUSION

This study highlights the strengths and areas for improvement in the Scheduling Information System (SIP KEMENAG) at the Ministry of Religious Affairs in Pasuruan Regency. The system has achieved a maturity level of 4 (quantitatively managed), reflecting its capability to support organizational processes with a data-driven approach. However, a gap of 0.73 from the desired level 5 (optimizing) underscores the need for enhancements.

Key recommendations include improving system usability, aligning features with user needs, and strengthening infrastructure. These efforts align with the research objectives to evaluate and enhance the quality and functionality of SIP KEMENAG, supporting MORA's transition toward a more efficient and modern activity management system.

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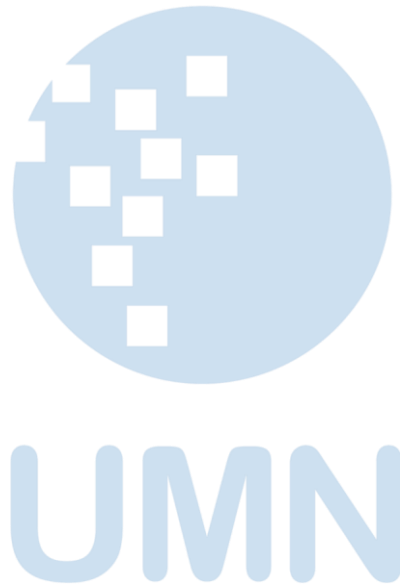
Systematic Literature Review of Knowledge Management in Students Based on Education Level in Indonesia

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Abstract— **Knowledge Management (KM) is a rapidly developing concept across various disciplines and business practices. KM encompasses the collection, storage, dissemination, and utilization of knowledge to enhance learning effectiveness. This study aims to examine the implementation of knowledge management in education across different educational levels using the Systematic Literature Review (SLR) method to analyze a number of related articles. The research findings indicate that the implementation of KM is significantly more prevalent in secondary (approximately 65%) and tertiary education levels (around 70%) compared to basic education (about 30%). Key factors influencing the success of KM implementation include the availability of infrastructure, student participation, support from teachers and staff, and a learning culture that fosters collaboration.**

Index Terms— **Implementation of Knowledge Management; Educational Level; Systematic Literature Review**

I. INTRODUCTION

In the current era of globalization, characterized not only by rapid innovation but also by significant advancements in science and technology, education emerges as a critical sector for development in every country. The ability of educational institutions to leverage science and technology is essential for helping students access and manage information effectively. To achieve national education goals, there is a pressing need for effective, competitive education management, especially in Indonesia [1].

Education, as a fundamental sector in national development, must adapt to the evolving demands of society and the changes of the times. It is imperative that education produces individuals who are not only recipients of information but also capable of processing, adapting, and developing that information. However, in the educational landscape, challenges often arise, such as the lack of continuity and quality in education during structural changes or the loss of key individuals [2].

Knowledge Management (KM) refers to the processes of collecting, storing, disseminating, and utilizing knowledge to enhance learning effectiveness and educational development. Each educational level, from elementary to tertiary, presents unique challenges and characteristics in managing knowledge. At the elementary level, the focus is primarily on developing foundational skills and social competencies, while at the secondary level, the emphasis shifts toward preparing students for higher education or the workforce. In higher education, KM strategies are crucial for producing competitive graduates prepared to excel in a global market [3].

Despite extensive research on KM in education, there remains a gap in understanding how to effectively apply KM practices tailored to different educational levels. This study aims to analyze the application of KM among students using the Systematic Literature Review (SLR) approach. SLR is a rigorous research methodology designed to identify, review, and synthesize relevant literature in a specific field using clearly defined steps. By synthesizing existing literature, this study aspires to provide a deeper insight into the implementation of KM across various educational levels and to identify the factors that contribute to its success [4].

A comprehensive understanding of KM applications is vital for educational institutions to optimize their resources and enhance the quality of learning, thereby better preparing students for future challenges. Furthermore, the findings of this study are expected to contribute to the broader discourse on KM in education, highlighting Indonesia's role in the global educational landscape.

II. METHOD

The Systematic Literature Review (SLR) approach is used in this study. SLR means identifying, assessing, and interpreting research evidence relevant to the subject being studied [5]. The purpose of the Systematic Literature Review is to search, find, and synthesize all existing research articles or literature systematically according to the research topic being conducted.

A. Systematic Literature Review Stages

The research is based on articles to analyze the application of Knowledge Management (KM) to students based on education levels. The stages in the Systematic Literature Review are planning, conducting, and reporting.
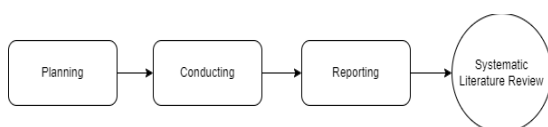

Fig. 1 SLR stages [6]

1) Planning

In this section, the researcher determines the Research Question (RQ) first. This literature study aims to determine the application/implementation of knowledge management in educational institutions.

- RQ1: How is knowledge management applied to students at the primary level?
- RQ2: How is knowledge management applied to students at the secondary level?
- RQ3: How is knowledge management applied to students in higher education?
- RQ4: What are the factors that influence the success of implementing knowledge management at an educational level?

2) Conducting

In this section, the researcher determines the source of the journal database to be used, namely using Google Scholar. After the article search database is determined, the researcher then determines the keywords for the related articles. The search method used is done by keyword searching, namely searching by entering one or more keywords regarding the literature being searched for. By using Boolean Operator terms such as OR, AND, and NOT. The search uses a combination of one or more keywords in Indonesian and English. The keywords used are "Implementation Knowledge Management OR Implementation of Knowledge Management" AND "Knowledge Management Education OR Knowledge Management Education" AND "Implementation Knowledge Management in School OR Implementation of Knowledge Management in Schools", "Knowledge Management in Students", "Knowledge Management in Elementary Education", "Knowledge Management in Secondary Schools", "Knowledge Management in Higher Education".

Inclusion and Exclusion Criteria:
The criteria used for article selection are as follows:
- Inclusion Criteria:
  - Articles published within the last 10 years.
  - Articles discussing the implementation of Knowledge Management in educational institutions from primary to higher education levels.
  - Articles written in Indonesian.
- Exclusion Criteria:
  - Articles that do not focus on the implementation of Knowledge Management in education.
  - Articles not available in full text.
  - Theses, dissertations, and research reports not published in peer-reviewed journals.

3) Reporting

Then, this is the section that contains the writing of the results of the Systematic Literature Review.

III. RESULT AND DISCUSSION

The following are the results of the article search that have undergone a filtering process as seen in Figure 2.
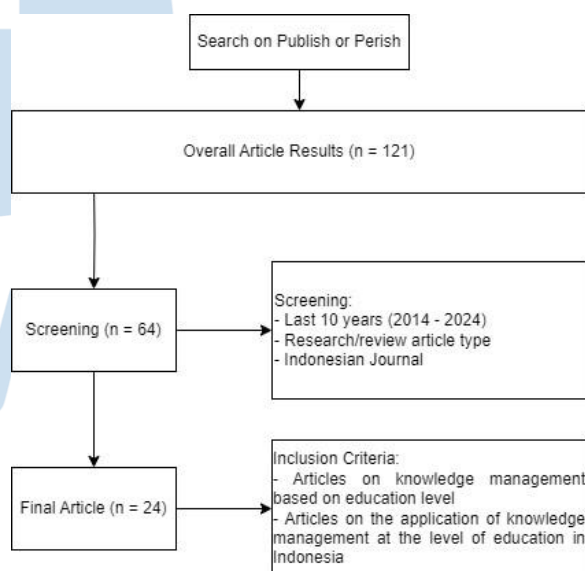

Fig. 2 Inclusion Criteria

Then, Table I shows the results of the search process which are then grouped based on the selected title to facilitate the type of data or articles that have been obtained.

TABLE I. GROUPING SELECTED ARTICLES

No.	Level of Education	Title
1.	Primary	Implementation of Knowledge Management in MI Nurul Huda 2 Mojokerto City

No.	Level of Education	Title
2.		Implementation of Knowledge Management in Muhammadiyah Elementary School
3.		Evaluation of Knowledge Management System (KMS) Based E-Learning Program at ST Joseph International Primary School Jakarta (Program Evaluation Using Modified Hammond Model)
4.		Implementation of Knowledge Management in Al-Azhar 31 Islamic Elementary School Educational Institution Yogyakarta
5.	Junior Secondary	The Influence of Independence and Effectiveness of Knowledge Management on Student Learning Achievement of Private Junior High Schools in Medan City
6.		Junior High School Student Management Counseling System with Knowledge Management System Approach
7.		Knowledge Management System Analysis on the Design of Sipsiba Application at SMK Muhammadiyah 10 Jakarta
8.		Evaluation of the Implementation of Knowledge Management System for E-Learning Application in Senior High Schools
9.		Factors Affecting the Readiness of Knowledge Management Implementation: A Case Study of Senior High Schools in Palembang
10.	Senior Secondary	The Influence of Knowledge Management on the Quality of Education at SMK Kasatrian Solo Sukoharjo
11.		Implementation of Knowledge Management at SMK Diponegoro Depok
12.		UI/UX Design on the Prototype Knowledge Management System for High School Learning Using the Design Thinking Method
13.		Analysis and Implementation of Knowledge Management System: A Case Study at Senior High School 1 Bayang

No.	Level of Education	Title
14.		Knowledge Management-Based E-Learning System at SMK Generasi Madani Cibinong
15.		Implementation of Knowledge Management in College Libraries
16.		Analysis of the Implementation of Knowledge Management System with Task-Technology Fit at Parna Raya Manado College of Informatics and Computer Management
17.	College	Empowerment of Knowledge Management as a Strategy to Improve Learning Achievement of Electronics in Higher Education
18.		Knowledge Management as an Effort of Learning Organization at Yogyakarta Islamic College
19.		Design and Development of Collaborative Learning Resource Application Through Knowledge Management System for Colleges
20.		Implementation of Knowledge Management at NurulFikri Integrated Technology College for Academic Activities
21.		Design of Knowledge Management Model to Monitor Student Academic Achievement at Colleges
22.		Implementation of Knowledge Management at Colleges
23.		Knowledge Management Mapping in Improving College Capabilities
24.		Knowledge Management for Improving Academic Services at Colleges

A total of 24 selected articles have been classified including the type of education level, author name, and article title. The articles above were selected based on their relevance to the search keywords used by the researcher.

RQ1: How is the application of knowledge management to students at the primary level?

TABLE II.   KNOWLEDGE MANAGEMENT AT PRIMARY LEVEL

No.	Content
1.	MI Nurul Huda 2 Mojokerto City students get better access to information and knowledge through innovative learning methods, the result of collaboration

No.	Content
	between teachers and other schools. KKG activities create a collaborative atmosphere where students can learn from various methods and approaches introduced by teachers who continue to develop their knowledge. Through the transfer of knowledge and learning innovations applied, MI Nurul Huda 2 Mojokerto City students can develop critical and creative skills needed in the modern era [7].
2.	Students at Muhammadiyah Elementary School Banguntapan have easier access to information and learning materials, both explicit (e.g. books and documents) and tacit (teacher experience and knowledge). The results of the application of knowledge management are seen in students' academic and non-academic achievements. For example, students have succeeded in achieving high rankings at the Bantul Regency level and its surroundings, often participate in science competitions and receive awards, and many more [8].
3.	Joseph International Primary School Jakarta implements the Knowledge Management System (KMS) to improve the effectiveness of the e-learning program. Students can access learning materials online anytime and anywhere. They feel that e-learning makes learning more interesting than conventional methods, helping them understand the lessons better because the content provided is structured and easy to follow [9].
4.	Students at the Al-Azhar 31 Islamic School in Yogyakarta are involved in the socialization process, where they share experiences and knowledge in social interactions. In addition, students can learn from the experiences of teachers and classmates, which enriches their understanding of the subject matter. Activities such as training, workshops, and seminars held at the school provide opportunities for students to actively participate in learning [2].

RQ2: How is knowledge management for students at the secondary level?

TABLE III. KNOWLEDGE MANAGEMENT AT THE SECONDARY LEVEL

No.	Content
5.	The implementation of knowledge management in private junior high schools in Medan City has had a positive impact, as seen from the increasing academic achievement of students, many students

No.	Content
	participating in competitions such as olympiads and winning awards, learning independence, collaboration between students, and skill development. This shows that effective knowledge management can improve the quality of education and student achievement [10].
6.	The implementation of knowledge management provides benefits in terms of access to information, more effective counseling support, increased self-awareness, development of social skills, and better problem management. With the knowledge management system, students get more focused support from guidance and counseling teachers (BK). Through interaction with counseling teachers and peers in counseling sessions, students develop social and communication skills. All of this contributes to a more positive learning experience and increased student achievement at the secondary level [11].
7.	The implementation of knowledge management in the context of PPDB at SMK Muhammadiyah 10 Jakarta provides easy access, efficient data management, and better support from the school. With an integrated online system, students feel calmer because the registration process is more structured and transparent. Overall, students of SMK Muhammadiyah 10 Jakarta felt a more positive and enjoyable experience in the PPDB process thanks to the implementation of an effective knowledge management system [12].
8.	Through the e-learning platform, students can interact with teachers and classmates. Discussions in forums and class discussions facilitate the exchange of knowledge, which is important in knowledge management. Students are more likely to use smartphones to access e-learning, indicating their adaptation to technology in the learning process. This reflects the implementation of effective KM, where technology is used to improve access and management of knowledge [13].
9.	Senior high school students in Palembang can access various sources of information and learning materials through the implemented system, which allows them to learn independently and flexibly. The implementation of KM in Senior High Schools in Palembang creates a more conducive learning environment for students to develop their knowledge and skills. Students have expectations about how KM can improve the quality of their

No.	Content
	learning. If KM is implemented well, students can feel improvements in learning outcomes [14].
10.	Students at SMK Kasatrian Solo Sukoharjo feel the benefits of using information technology in learning. With access to digital learning devices and resources, they can understand the material better. They are also encouraged to share knowledge with their friends. This creates a collaborative learning culture in the classroom [15].
11.	Students at SMK Diponegoro Depok feel that the existence of a knowledge management system makes it easier for them to access the information and learning materials they need. With the sharing of knowledge, they can learn from the experiences and knowledge of teachers and friends. Students are involved in discussions and knowledge sharing as well as training programs and seminars. However, some students feel challenges in using information technology, especially if internet access is limited or if they are not familiar with the platform. The use of social media such as Instagram has also not been optimally utilized for sharing knowledge [16].
12.	The implementation of a system that supports gamification helps students feel more motivated in learning. Features such as quizzes and discussion forums create a more interactive and interesting learning method. They tend to be more involved in the learning process when there is a game element. However, some students may have difficulty adjusting to new technologies [17].
13.	Students of SMAN 1 Bayang find it easier to access learning materials, even when they cannot attend class. This system allows them to get information and materials from teachers online. With a platform for sharing information, students can interact and discuss with their classmates and teachers [18].
14.	Students find it easier to access learning materials through the e-learning system. This allows them to learn anytime and anywhere. With the discussion and chat features, students can interact more easily with classmates and teachers. Students feel that this system can improve the quality of learning, because the information available is more organized and easy to access [19].

RQ3: How is knowledge management for students in higher education?

TABLE IV. KNOWLEDGE MANAGEMENT AT THE COLLEGE LEVEL

No.	Content
15.	Students feel that the implementation of knowledge management makes it easier for them to access relevant and up-to-date knowledge, thus supporting their learning process. Students can interact more effectively with librarians and fellow students through activities such as book reviews and knowledge sharing, which strengthen their understanding of the material [20].
16.	STMIK Parna Raya Manado students have easy access to information provided through a website-based knowledge management system. This makes it easier for them to obtain learning materials, academic information, and campus-related news. Knowledge management supports interaction between students and lecturers, as well as between students themselves with a platform that facilitates knowledge sharing [21].
17.	The results of the study indicate that students who learn using KM experience a significant increase in learning achievement compared to the traditional learning model (Direct Instruction). This shows that KM is more effective in supporting academic achievement [22].
18.	Knowledge management at STAIYO aims to improve student competence. Students are involved in regular discussions and seminars that require them to share knowledge. Students are encouraged to conduct research every year and publish their results in internal journals [23].
19.	The implementation of collaborative learning resource applications encourages students to actively participate in the learning process by sharing their own materials and experiences. The use of this application helps students develop digital skills and curation abilities, which are important in today's information age [24].
20.	With an integrated academic website, students can easily access important academic information, such as exam procedures, Final Projects, and campus activity information. Discussion forum facilities and social media that support communication between students and lecturers can facilitate the exchange of knowledge and experience [25].
21.	With the KM model, students can find out about their academic progress through available information, such as KHS and GPA. With an integrated system, high-

No.	Content
	achieving students can easily get information about available scholarships. For students who experience a decline in achievement, the KM system recommends mediation with a counselor [26].
22.	Students participate in the knowledge sharing process through social interaction. They can share experiences and tacit knowledge gained from daily activities, such as group discussions or collaborative projects. Students are also involved in research that is part of the tridharma of higher education. Students have the opportunity to provide input regarding knowledge management policies on campus, so that they feel included in the development of the institution [27].
23.	STAIN Gajah Putih students are actively involved in the learning process through platforms such as WhatsApp, Facebook, and e-learning. The availability of facilities such as SIAKAD (Academic Information System) and e-learning helps students access academic information and carry out administration online, thus facilitating the learning process [28].
24.	Students can access academic information quickly and efficiently through an integrated information system. Through knowledge sharing, students participate in discussions and seminar or workshop activities. This gives them the opportunity to share their experiences and knowledge [29].

RQ4: What factors influence the success of implementing knowledge management at an educational level?

TABLE V. SUCCESS FACTORS FOR IMPLEMENTING KNOWLEDGE MANAGEMENT

Educational Level	Factors
Primary School	• Infrastructure Availability: Access to an effective knowledge management system, such as an e-learning platform, is essential to help students better access learning materials. • Learning Culture: An environment that encourages collaboration and sharing of experiences among students can increase their engagement and understanding of the material being taught.
Secondary School	• Infrastructure Availability: An integrated online system makes it easier for students to access information and learning materials, making the learning process more efficient. • Student Participation: Active involvement of students in discussion activities and knowledge sharing greatly contributes to deeper and more collaborative learning. • Teacher and Staff Support: The role of teachers and staff in providing guidance and counseling support can help students manage knowledge and improve their academic performance. • Technology Adaptation: Students' ability to adapt to new technologies plays an important role in the effectiveness of KM implementation, especially in the use of digital tools for learning.
College	• Infrastructure Availability: Easy access to web-based knowledge management systems allows students to quickly obtain learning materials and academic information. • Student Participation: Student involvement in discussions, seminars, and knowledge sharing activities strengthens their understanding and creates a wider learning network. • Lecturer and Staff Support: Good interaction between students and lecturers through discussion forums and academic guidance is essential to support effective learning. • Human Resource Quality: Student competence in managing and utilizing knowledge, as well as lecturers' ability to support the learning process, influences the success of KM implementation. • Institutional Policy: Policies that support KM implementation and provide clear direction for all parties in educational institutions can

Educational Level	Factors
	increase the effectiveness of knowledge management. • Availability of Learning Materials: Easy and structured access to learning materials and academic information allows students to learn independently and efficiently.

The implementation of Knowledge Management (KM) in the realm of education is a strategic step to improve the quality of learning at various levels. This study aligns with the findings of Z. Nuryana (2017), which states that KM can function as a driver in creating an effective learning organization. In the context of education, KM not only manages information but also builds a culture of collaboration among students, teachers, and educational staff. This is crucial, especially in the era of globalization that demands high adaptability and innovation from individuals.

Based on the results of the study, it is evident that the implementation of KM is more dominant at the secondary and tertiary levels compared to basic education. This indicates that higher education institutions have more complex needs regarding knowledge management. This aligns with K.W. Chu's (2016) perception that at higher educational levels, KM plays an important role in supporting a more interactive and adaptive learning process. At the elementary level, the challenges faced are primarily related to the development of basic skills and social understanding, which often leads to suboptimal KM implementation.

While the findings are promising, a critical perspective is needed regarding the current practices of Knowledge Management (KM) implementation. The studies reviewed often focus on specific contexts, which may not be generalizable across different educational settings. Future research should encompass diverse geographical and socio-economic backgrounds to provide a more comprehensive understanding of KM's effectiveness. Despite the highlighted benefits, significant gaps remain in the application of KM at the basic education level. Challenges such as inadequate infrastructure and a lack of teacher training hinder optimal KM practices, making it essential to address these gaps to improve KM in foundational education.

Moreover, the importance of a collaborative learning culture cannot be overstated; however, many institutions struggle to foster such an environment. Enhancing organizational culture and providing adequate educator training are critical steps that require further attention. Future studies should investigate the long-term impact of KM on student outcomes and explore innovative strategies for effectively integrating KM practices at all educational levels. This could include leveraging technology, building community partnerships, and adopting interdisciplinary approaches.

IV. CONCLUSION

This study demonstrates that the implementation of Knowledge Management (KM) across educational levels, from elementary to tertiary, plays a significant role in enhancing the quality of learning. Through the Systematic Literature Review (SLR) approach, it was found that many educational institutions have adopted various methods and systems to manage student knowledge effectively. The findings indicate that KM implementation is more prevalent in secondary schools and higher education institutions compared to elementary schools, reflecting the differing needs at each educational level.

The success of KM implementation is influenced by several factors, including the availability of infrastructure, student participation, support from lecturers and staff, and a learning culture that encourages collaboration. Most educational institutions utilize Explicit Knowledge types to effectively manage their knowledge, as evidenced by the use of e-learning platforms, educational websites, and structured digital resources that facilitate student access to information and learning materials.

For future research, it is recommended that studies explore the long-term impact of KM on student outcomes in various educational contexts. Additionally, future investigations should consider developing innovative strategies for the effective integration of KM practices at all educational levels. This could include leveraging cutting-edge technology, building community partnerships, and adopting interdisciplinary approaches. With these steps, it is hoped that KM can be optimized to support sustainable education that is responsive to the evolving demands of society.

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Web-Based ERP System Prototype for Enhanced Inventory and Supply Chain Management in the Logistics Industry

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Abstract— **Technological advancements have driven companies to adopt innovative solutions to improve efficiency and streamline operations. PT Kesuma Express, a logistics company in Indonesia, faced inefficiencies and frequent errors due to its reliance on manual processes such as transaction recording, document management, and income reporting. This research developed a web-based Enterprise Resource Planning (ERP) system prototype to address these challenges, focusing on Inventory and Supply Chain Management (SCM) modules. The prototype uses the Rapid Application Development (RAD) model and the Laravel framework and includes key features such as transaction recording, customer data management, and financial reporting. The inventory module enhances truck data management, monitors truck availability, and alerts users about data discrepancies, ensuring accuracy and timely actions. The SCM module supports the delivery process by providing real-time delivery status tracking that is accessible to both warehouse staff and administrators, enabling transparency and efficiency in goods distribution. The system replaced PT Kesuma Express manual processes, significantly improving operational efficiency and reducing errors. By integrating inventory and SCM capabilities, the ERP system has streamlined operations, enhanced data accuracy, and improved customer service quality. This research demonstrates the transformative potential of ERP systems for logistics companies aiming to modernize their operations.**

Index Terms— **ERP system, Inventory; RAD; Supply Chain Management; Web-based.**

I.   INTRODUCTION

An information system is a formal system designed sociotechnically and organizationally to collect, process, store, and distribute information, especially in addressing management accounting problems [1]. Information systems comprise hardware, software, and telecommunications networks that collect, create, and distribute valuable information [2]. Over time, information systems have evolved from simple tools to essential and strategic elements integral to modern organizational structures. The optimization of information systems has led to integrated developments, such as Enterprise Resource Planning (ERP) [3].

ERP systems have become a critical tool for companies worldwide, from startups to large enterprises, enabling them to manage resources more effectively and efficiently [4]. ERP integrates hardware and software with various functions, including data coordination, process integration, decision-making support, and timely reporting [5], [6]. By unifying diverse business activities—such as sales, marketing, manufacturing, logistics, and accounting—ERP systems streamline operations and enhance business process efficiency [7], [8].

Advancements in ERP technology have also introduced new functionalities, including cloud-based systems, modular approaches, and real-time analytics, making ERP more accessible and flexible for businesses of all sizes. Recent developments in application development methods, such as Rapid Application Development (RAD), emphasize speed and adaptability in creating ERP solutions. These methodologies ensure systems are developed efficiently while aligning with user requirements, reducing project risks, and enabling iterative improvements.

Previous studies have shown the effectiveness of ERP systems in improving operational efficiency across industries, such as inventory optimization in manufacturing [9] and enhanced delivery accuracy in retail supply chains [10]. However, these studies primarily focused on large enterprises with established digital infrastructures and often used traditional development methods. In contrast, this research targets PT Kesuma Express, a medium-sized logistics company reliant on manual processes, presenting unique challenges like document mismanagement and communication delays. By adopting the Rapid Application Development (RAD) model, this study

develops a web-based ERP system with tailored inventory and supply chain management (SCM) modules, addressing gaps in existing research and offering a practical solution for companies transitioning from manual to digital operations.

Despite these advancements, some companies still face challenges due to manual processes. For instance, at PT Kesuma Express, logistics operations rely heavily on outdated methods for transaction recording, truck availability checks, and communication during goods delivery. These processes often lead to inefficiencies, errors, and delays in decision-making.

Manual record-keeping leads to various inefficiencies, including misplaced documents, redundant data entry, and inaccurate inventory counts, which disrupt operations and increase the risk of errors. It also causes delivery delays due to miscommunication and inconsistent tracking methods, while manual financial reporting often results in calculation mistakes, leading to inaccurate decision-making. Additionally, the time-consuming nature of retrieving and compiling information manually slows down overall processes, further highlighting the need for automated systems like ERP to streamline operations, improve accuracy, and enhance efficiency [11].

This research aims to develop a web-based ERP prototype featuring inventory and supply chain management (SCM) modules to address these issues. Utilizing the RAD model, the prototype incorporates transaction recording, customer data management, income reporting, and real-time delivery tracking features [12], [13]. The system's CMS-based interface allows users to create, manage, and store data while automating key tasks to improve operational efficiency. Testing demonstrated significant improvements in data accuracy, workflow efficiency, and decision-making, providing a practical ERP model for small- to medium-sized logistics companies aiming to modernize their operations.

II. METHODS

The Rapid Application Development (RAD) model is a software development approach that is very suited to the dynamics of modern technology projects, including website development. Compared to traditional methodologies that are more rigid and focus on detailed planning before starting coding, RAD prioritizes fast and iterative development, making it ideal for projects that require speed and flexibility [14]. The flexibility advantage of the Rapid Application Development (RAD) model becomes very significant in a development environment that is fast-paced and full of changes, such as when creating applications or websites [15]. RAD's flexibility allows development teams to adapt to changing needs, leverage the latest technologies, and effectively meet user expectations. With RAD, testing does not just happen at the end of the development phase but is an integral part of every iteration [16]. Every aspect of the website or application

is tested and assessed continuously, reducing the risk of major problems at product launches [17]. This flexibility in testing also allows for immediate adjustments based on feedback, ensuring that the final product is the best it can be under existing conditions. Overall, the flexibility of RAD provides a powerful framework for software development that is effective in addressing challenges and change and optimal in proactively exploiting new opportunities and innovation [18]. This method ensures that the developed product adapts to user needs and changing market conditions [19].
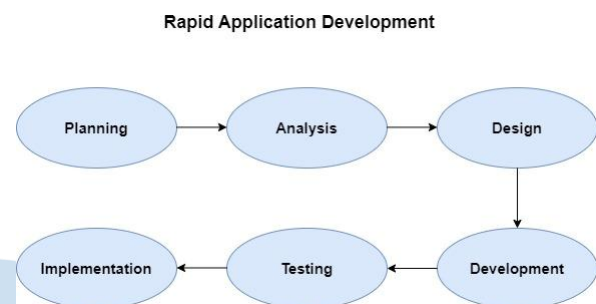
Rapid Application Development

Fig. 1. RAD Model

A. Planning

This part of the planning stage is the initial stage in designing a website using the RAD model. The first step in this planning stage is to determine and identify the purpose of creating and designing this website by addressing the problems within the company through detailed discussions. PT XYZ, a logistics company, currently relies on manual processes for transaction recording, truck availability checks, and communication during goods delivery. These manual methods have resulted in various inefficiencies, such as misplaced documents, inventory records errors, delivery delays, and communication breakdowns between staff and drivers. These issues hinder operational efficiency, increase the likelihood of human errors, and negatively impact customer satisfaction.

By clearly defining these problems during the planning phase, the system to be developed will be designed to address these specific challenges, ultimately creating an automated solution that streamlines operations, reduces errors, and enhances overall productivity. Additionally, identifying the intended users of this technology system, such as administrators, warehouse staff, and drivers, ensures that the system meets their needs and supports seamless adoption.

B. Analysis

The analysis stage was the most critical phase in the development of this project, particularly in the context of Rapid Application Development (RAD). This stage focused on gathering detailed data from users to understand their specific challenges fully. User

involvement was central at this point, as their input provided valuable insights into the problems encountered in their daily operations, such as manual errors and inefficiencies. Through direct interviews and feedback sessions, users contributed detailed information that shaped the system's functional requirements [20]. This process allowed for a clear understanding of the essential features the system needed to include, such as transaction tracking, inventory management, and delivery status updates. By deeply involving users in this stage, we ensured that the system's design directly addressed their pain points, laying the groundwork for a solution aligned with their operational needs. The insights from users guided the creation of system features and helped identify potential obstacles early, ensuring a smoother design and development process moving forward [21].

C. Design

This design stage is where the design of the system you want to create has begun. The technique used to model the development of this system is to use Unified Modeling Language (UML) modeling [24]. UML is a visual language used to model and design software systems graphically. UML allows software developers to describe software systems' structure, behavior, and interactions clearly and structured. A UML Diagram is a graphical representation of various aspects of a software system described using UML. UML diagrams describe various concepts and elements in software systems, including class structure, relationships between classes, system behavior, and interactions between objects in the system [25]. The specifics of this stage are designing a UI/UX design for the website using existing tools such as Figma to simplify the UI/UX design process [22]. The purpose of creating this UI/UX design is to facilitate future development activities so that from this design stage, you can get an idea of the website's appearance, which will be created later by programming. This design needs to pay attention to design arts and design rules so that the appearance of this website looks interactive and comfortable for users who use it.

D. Development

This development stage is where the actual website design has been carried out. A programming activity is carried out so that the website system can run according to the previous stages discussed, including creating features in the web system to be used by future users [23]. The programming carried out, of course, uses a programming language that supports the creation of this website. The programming language used in this research is PHP using a framework, namely Laravel, followed by a CSS library, namely Bootstrap; where this CSS library can simplify design activities for the web you want to create and also a framework that can simplify many activities such as connecting code. With

a database, logic can be created so that features can run according to the plan that was discussed previously.

E. Testing

The testing phase takes place after the development stage is complete. At this stage, the system and its features are tested in detail to ensure they function as intended. If any issues, such as errors or bugs, are identified, the system will be corrected to ensure the features meet user requirements. This research employs the User Acceptance Testing (UAT) method combined with black-box testing, which focuses on testing the system's functionality without examining its internal structures or code.

Users are actively involved in this process to provide feedback on the system's usability and effectiveness. Testing is crucial because a system that does not run well can lead to user dissatisfaction and fail to address their needs. By involving users directly in the testing process, this stage ensures that the final system resolves the problems it was designed to address while meeting user expectations for functionality and reliability.

F. Implementation

The implementation stage is the final stage of the RAD model, where the system has been implemented, and users can interact with this system directly.

III. RESULTS AND DISCUSSIONS

The result of this research is the development of a web-based prototype at PT Kesuma Express by utilizing ERP modules, namely supply chain management and inventory modules. This web prototype was also created using the Laravel framework. Some of the displays on this website are a dashboard for the admin and warehouse, and there are also various features available, such as adding transaction data, transaction reports, checking truck availability, printing a waybill for each existing transaction, and editing the tracking status of goods.
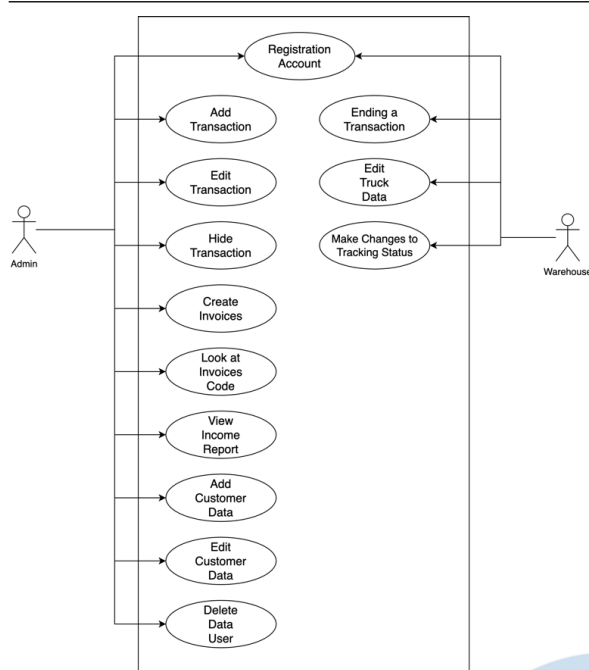
Fig. 2.   Use case diagram of inventory and SCM

From the Fig 2. Use case diagram, there are two actors: admin and warehouse. In the admin actor section, the admin can perform various actions such as adding, editing, deleting transactions, viewing and printing travel documents, viewing income reports, adding customer data, and editing and deleting user data. Next, there is another actor, namely the warehouse actor, who has access to ending a transaction, editing the status of tracking trucks and the number of truck data in the warehouse.

Activity diagrams are visual tools used in modeling business processes or system workflows. It provides a graphical representation of the steps involved in a process, often showing the sequence of activities, decisions, and conditions that may occur [26].

The activity diagram based on the use case diagram highlights three key processes in the system: the **transaction process**, which automates recording and managing transactions; the **invoice process**, which handles invoice generation and management; and the **tracking process**, which enables real-time monitoring of delivery status. These processes are essential to the system's functionality, focusing on improving efficiency, reducing errors, and ensuring accurate and timely updates for users:
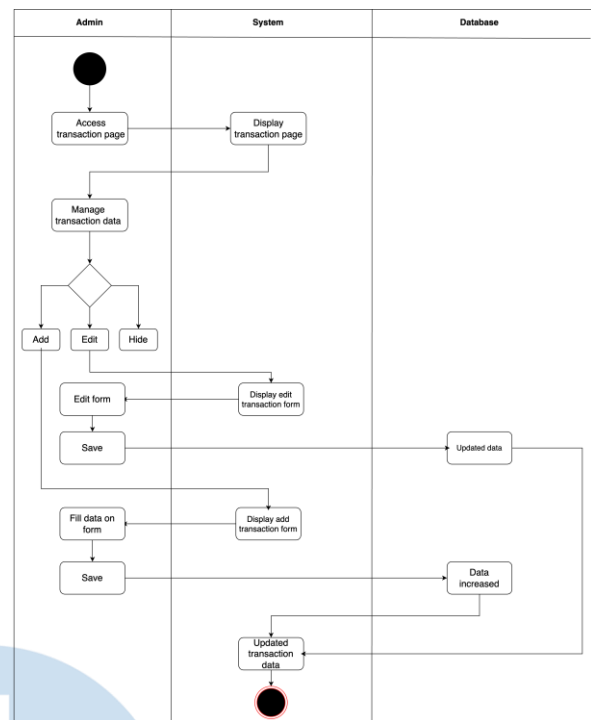
Fig. 3.   Activity diagram of transaction process

Figure 3 explains an activity diagram from the admin side, where the admin can add transaction data, edit transaction data, and delete transaction data. The admin will connect with the systems and the database. These data flow will be start with the initial node and terminated with the final node.
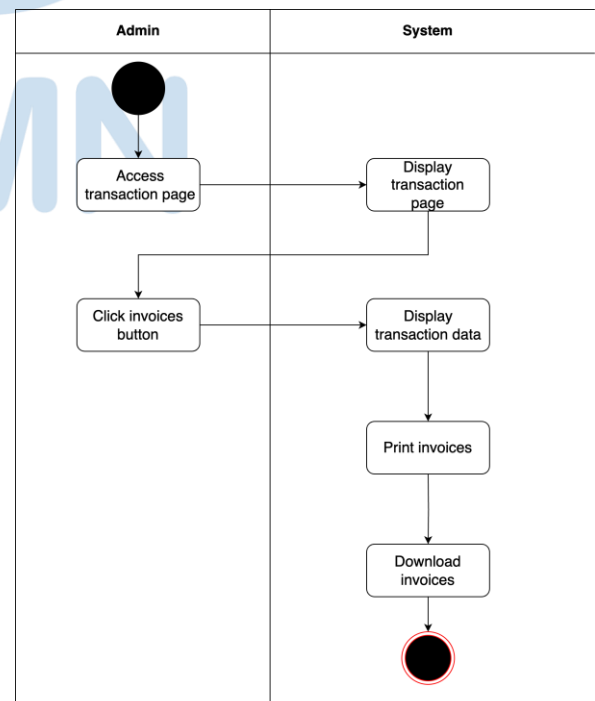
Fig. 4.   Activity diargram of invoice process
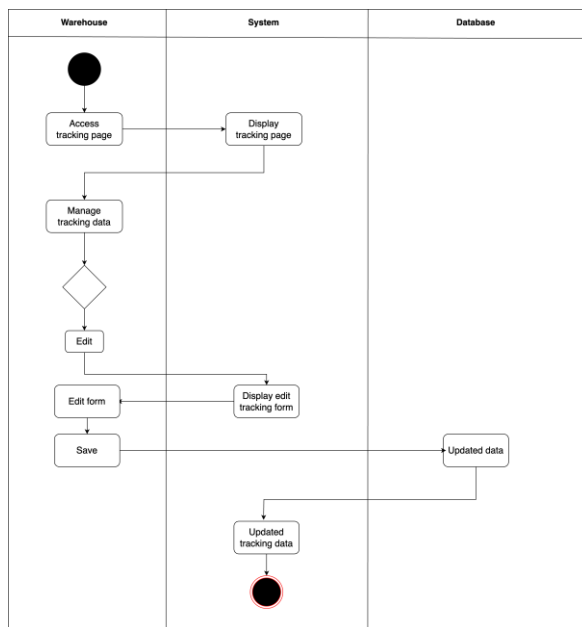
Fig. 5.   Activity diagram of tracking process

Figures 4 and 5 are activity diagrams from the admin for printing travel documents. The admin can select transactions whose data will be printed in PDF format so that the results can be exported later. Next is an activity diagram from the warehouse side to edit the status of each transaction tracking. The warehouse can press a button to display a form, and in that form, the warehouse can change the status of tracking the goods.
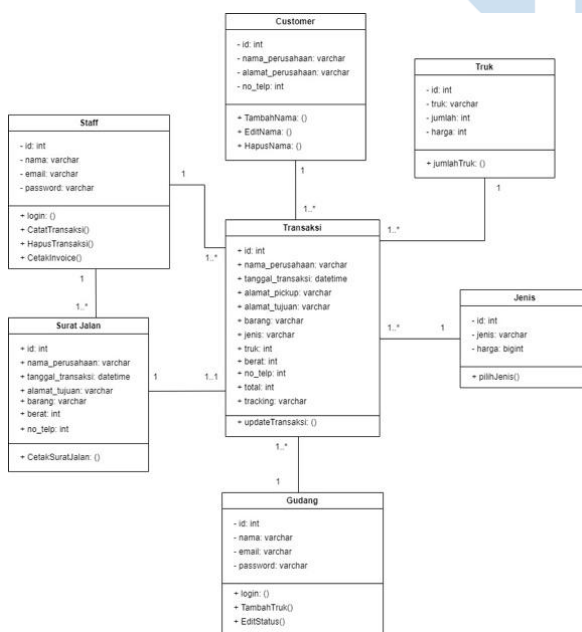

Fig. 6.   Class diagram of web-based ERP system

Class diagrams are a type of diagram used in software modeling to describe the static structure of a system or application. This diagram displays the classes in the system along with the relationships and attributes possessed by each class [27]. Figure 6 is a class diagram in this research and there are 7 classes, namely:

Transaction, Travel Document, Customer, Staff, Warehouse, Truck, and Type.

The result of this research is the development of a web-based prototype at PT Kesuma Express by utilizing ERP modules, namely supply chain management and inventory modules. This web prototype was also created using the Laravel framework. Some of the displays on this website are a dashboard for the admin and warehouse, and there are also various features available, such as adding transaction data, transaction reports, checking truck availability, printing a waybill for each existing transaction, and editing the tracking status of goods.

A. Dashboard
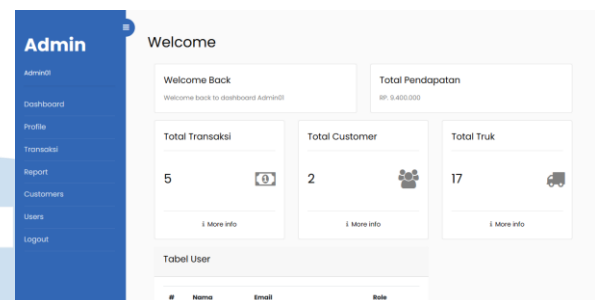
Fig. 7.   Dashboard view of web-based ERP system

The system will display this after the user registers an account and logs in using the previously registered account. Figure 7 shows a display of the admin dashboard menu. This display shows data and information related to the transaction, customer, and truck data on this dashboard page so that the admin can find the amount of data from these three data. This dashboard display also displays the total income from each transaction that occurs.
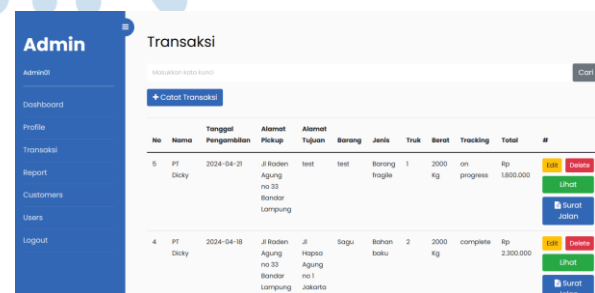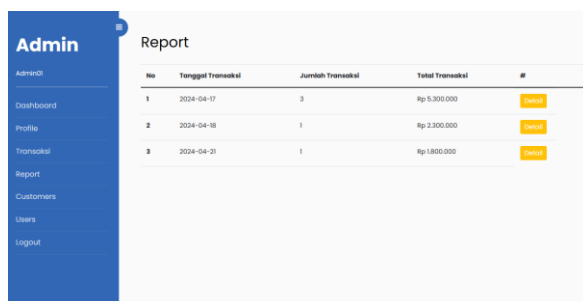
B. Transaction

Fig. 8.   Add transaction simulation

Figure 8 shows a display of the admin section of the transaction page, where this display displays all transaction data that has occurred and has been made previously. This data is taken from tables in the database so that all the data is displayed in a table after it is taken. In the table, there are various columns, namely number, name, pickup date, pickup address, destination address, goods, type, truck, weight,

tracking, and total, and there are four buttons, namely edit, delete, view, and travel documents.

Fig. 9. Transaction report simulation

Figure 9 shows a display of the transaction report, where this display will display all transactions that have occurred and grouped according to the date the transaction occurred. This display also automatically calculates the transaction income according to the date. There is also a button to view detailed transactions that occur on each date in more detail.

C. Logistics and Administration
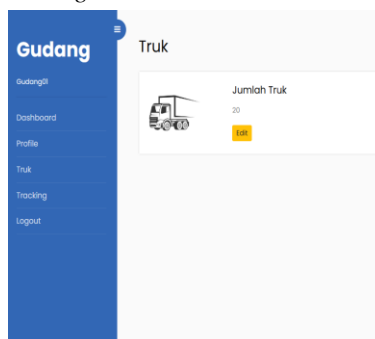
Fig. 10. Checking logistics vehicle availability

Figure 10 shows a display to display the number of trucks in the database. This display displays the number of trucks available in real-time and an edit button to change the number of trucks. The following interfaces display the process of invoice, delivery order, and tracing goods delivery.
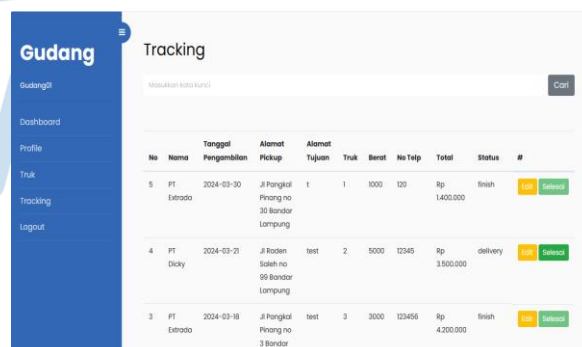
Fig. 11. Create invoice

Fig. 12. Generated delivery order letter

Figure 12 shows a display of one of the transactions that the admin has input, and the transaction data results are displayed in a table. In this part of the table are two buttons, the "View" button and the "Travel Document" button, where two buttons run the feature for creating travel documents for each transaction. The "View" button itself will direct you to a new display that displays all the data from the transaction and also creates a code for each waybill, where this code is unique and will be created for each existing transaction so that the code will continue to be there. Each transaction and the code will not change. The "Travel Letter" button is a button that prints a travel letter for each transaction that occurs. Figure 12 also shows a display in PDF form of the travel document, which will later be downloaded or printed by the user to send the goods. This display will appear after the user saves new data and the unique code for each transaction. Then, the user presses the "Travel Letter" button, leading to a new display that displays all the data as a PDF file ready to be downloaded or printed.

Fig. 13. Tracking goods delivery

Figure 13 shows the tracking status from the warehouse side. This view generally displays a table containing data from transactions input from the admin side. In this view, the warehouse has access to make changes to the status or tracking of each existing transaction; the warehouse can only change the status of the transaction so that from the admin side, it will get information in the form of status changes that occur from each transaction. There is also a "finish" button where the truck database automatically increases the number of trucks used if the transaction is complete.

D. User Acceptance Test (UAT)

After completing the development of a web-based system prototype, the system will be tested to determine its readiness and suitability. Testing is carried out with the company so that the company knows whether the system that has been created is suitable for use in the company. Table 1 shows the results of the user acceptance test.

TABLE I. UAT RESULT

No	Features	Descriptions	Status
1	Add transaction	User presses the "Record Transaction" button to enter transaction data in a form.	Pass
2	Displays detailed transaction reports	Users press a "Detail" button to see more details of the transaction.	Pass
3	Display data and edit truck data	Users open the truck menu in the sidebar of the warehouse page then press the "Edit" button to make data changes.	Pass
4	View and save travel letter codes	The user presses a "View" button to view the travel letter code.	Pass
5	Print invoices	The user presses the "Travel Letter" button to print the travel document in PDF format.	Pass
6	Carry out the tracking status editing process	The user presses an "Edit" button to change the tracking status in a form.	Pass

The inventory management module enabled real-time tracking of truck availability and flagged discrepancies, enhancing accuracy and fleet management. In contrast, the supply chain management (SCM) module allowed warehouse and admin staff to monitor delivery statuses, increasing transparency and coordination. These improvements directly addressed human error and inefficiency issues, ultimately leading to better customer service. However, the system has limitations, such as its basic functionality and lack of mobile support, which could be addressed in future updates to optimize operations further. Compared to larger-scale ERP systems, this prototype offers a cost-effective, tailored solution, though it lacks advanced analytics seen in more complex systems. Unexpectedly, the system revealed inefficiencies in PT Kesuma Express's existing workflows, prompting procedural improvements beyond the system's initial goals. This ERP system.

E. Discussion

The findings of this research demonstrate that implementing a web-based ERP system with inventory and supply chain management (SCM) modules significantly enhances operational efficiency for PT Kesuma Express. These results align with previous studies [9], which highlighted the role of ERP systems in optimizing inventory management through real-time data tracking [10] which emphasized improved delivery accuracy and transparency in supply chain operations. However, unlike these studies, which often focused on large enterprises with advanced digital infrastructures, this research addresses the challenges faced by medium-sized companies transitioning from manual to digital processes, providing practical insights for similar organizations.

In the Indonesian context, ERP adoption is still emerging, particularly among small- to medium-sized enterprises (SMEs), which often struggle with resource constraints and resistance to change. Implementing the ERP system in PT XYZ highlights the potential of ERP to bridge this gap by streamlining manual processes, reducing human error, and improving overall efficiency. The research also underscores the importance of tailoring ERP solutions to the specific needs of Indonesian businesses, considering their operational scale and challenges.

The successful integration of inventory and SCM modules in this study demonstrates the ability of ERP systems to address operational inefficiencies while enhancing customer service quality, providing a strong case for broader adoption of ERP technology in Indonesia's logistics and other SME-dominated sectors.

IV. CONCLUSION

This research succeeded in creating a web-based ERP system prototype that significantly increased the operational efficiency of PT Kesuma Express. This prototype has various features like transaction recording, customer data management, and financial reports. Implementing this system replaced the company's manual recording method, significantly improving work efficiency. The developed inventory module facilitates effective management of truck data, providing the ability to monitor truck availability and alert users if data discrepancies occur during transactions. This ensures the accuracy of information and efficiency in delivery. The supply chain management (SCM) module that was created supports the delivery of goods by providing a delivery status tracking function that users from the warehouse and admin can access. This allows both parties to monitor and update delivery status, ensuring transparency and effectiveness in the goods distribution process. This research shows that by integrating an ERP system equipped with inventory and supply chain management (SCM) modules, PT Kesuma Express can operate more efficiently and effectively and improve customer service quality.

ACKNOWLEDGMENT

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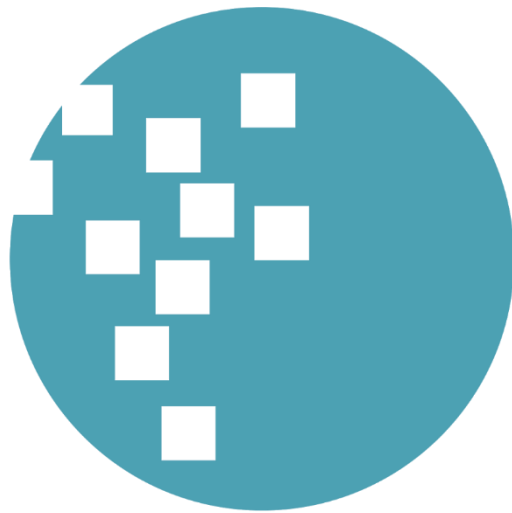
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