Integration of Belmawa Student Competition Dashboard With Artificial Intelligence Using The Waterfall Methodology at The Faculty of Industrial Engineering Telkom University

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Abstract — The rapid development of information technology demands that higher education institutions manage student achievement data optimally through intelligent and interactive dashboards. The Faculty of Industrial Engineering, Telkom University, still uses conventional dashboards with significant limitations in providing analytical insights for strategic decision-making. This research aims to develop an integrated Artificial Intelligence (AI) dashboard system to interactively analyze student achievement in the Belmawa competition and provide data-driven recommendations. The method used is the Waterfall Software Development Life Cycle (SDLC) model, through the stages of requirements, design, implementation, validation, and maintenance. The system is designed using a four-layer architecture with Aiven MySQL Cloud, Google Looker Studio, Flowise AI with OpenAI GPT-4o, and Laravel. The research data comes from 867 student achievement records with 22 essential attributes processed from 6,642 initial data, representing a data reduction of 86.95%. The implementation produces an interactive dashboard with various visual graphs and an NLP-based AI chatbot that answers user questions related to the data. System testing using Laravel Dusk, UAT, and SUS demonstrated excellent results, with a 100% success rate and a SUS score of 90.0, categorized as "Best Imaginable." This research demonstrates that AI integration in dashboards helps improve data-driven analysis and decision-making in higher education.

***Keyword*— dashboard, artificial intelligence, belmawa competition, information system, waterfall model**

I. INTRODUCTION

Advances in information technology have had a wide impact in various sectors, including higher education. Dashboards are becoming a popular tool for presenting and analyzing data, encompassing systematic technologies such as management decision support, data analysis, and human-machine interface [1]. Proper data visualization can help managers make decisions and take necessary actions to improve institutional performance [2].

Many universities are now developing dashboards as data visualization tools to monitor performance achievements set in the institution's strategic plan. Telkom University's Faculty of Industrial Engineering has a Belmawa competition dashboard that displays student achievement data, but it still has significant limitations.

The existing dashboard is only able to display data descriptively in the form of static tables, not yet equipped with Artificial Intelligence (AI) technology that can provide data-based recommendations. This condition causes the process of evaluating student performance achievements to be less effective and time consuming. The integration of AI on dashboards enables more in-depth analysis, including prediction of performance trends, identification of historical data patterns, and relevant data-driven recommendations. AI can also assist faculties in interactively recognizing improvement opportunities and support strategic policy making.

This research aims to develop a dashboard system integrated with AI to monitor and provide interactive analysis of belmawa competition performance, as well as apply AI to support data analysis and the creation of relevant strategic recommendations for decision-making.

II. LITERATURE REVIEW

A. Dashboard

Dashboards are visual and interactive performance management tools that present critical information related to the achievement of one or more organizational goals. These tools enable users to identify, track, and communicate problem areas requiring corrective action [3]. This definition emphasizes interactivity and clarifies the function of dashboards in the context of modern organizations.

In terms of visualization, dashboards can be static or dynamic. Static dashboards are often like printed reports and only provide information for a certain period of time. Dynamic dashboards visualize data directly from the data warehouse, making them interactive and easy to use [3]. The usefulness of dashboards can provide information for various

organizational functions including financial performance, accounting, human resource assessment, inventory tracking, and project management [3].

Although dashboards are very popular in the business world, their implementation in education is still limited. However, dashboards can be successfully applied in the education system at various levels of analysis and visualization: education management, education process management, accreditation, assessment and inspection of institutions as well as realization of inter-institutional relationships at various levels [4].

B. ChatGPT API

ChatGPT is a technology created by OpenAI, designed to communicate with humans in a natural and responsive way using the GPT (Generative Pre-trained Transformer) architecture [5]. ChatGPT is able to understand and generate text that resembles human conversational patterns, enabling more natural interactions between users and the system.

ChatGPT is able to respond to questions posed based on selected topics by providing answers creatively and quickly [5]. This technology has proven effective in a variety of applications, including decision support systems and interactive data analysis. ChatGPT's natural language processing capabilities allow it to understand the context of the conversation and provide responses that are relevant to the user's needs.

C. MySQL

MySQL is an open-source relational database management system that has been widely used in various sectors, such as e-commerce, healthcare, and educational institution information systems [9]. The system relies on a related table structure and supports the use of standard SQL commands, making it easy to retrieve and store data efficiently.

MySQL's performance is one of the main reasons behind its popularity. MySQL is known for its efficiency and ability to manage large amounts of data [10]. With its ability to execute thousands of queries per second, MySQL is well-suited for applications that require high performance and low latency. Furthermore, MySQL has a small memory footprint and can run optimally on a wide range of hardware, making it an efficient choice for many organizations.

D. Flowise AI

Flowise is an open-source platform designed to help developers and users build chatbots or applications based on Large Language Models (LLM) visually and interactively [6]. Flowise AI acts as a visual interface that makes it easy for users to design conversation flows, organize responses, and connect various nodes simply.

The platform enables the development of more sophisticated and functional chatbots without the need for complex programming. Flowise AI is an effective and efficient solution for developing AI-based chatbots powered by LLM, perfect for businesses and developers who want to create intelligent chatbot systems in a fast and simple way [6]. The drag-and-drop interface and integration with various AI models make Flowise the right choice for AI implementation in information systems.

E. Laravel Framework

Laravel is a PHP-based framework that implements a systematic concept using the MVC (Model-View-Controller) architecture [7]. This framework was first launched on June 5, 2011, under the MIT license and utilizes GitHub as a platform for code sharing. After undergoing various refinements and development processes, Laravel has demonstrated a high level of stability in its use.

Taylor Otwell, the creator of Laravel, stated that this framework was created because of the lack of important features in CodeIgniter, such as authentication [7]. Laravel provides excellent features such as Eloquent ORM for database management, Blade templating engine for dynamic view creation, Artisan command line interface for automation of development tasks, and Laravel Fortify for secure authentication.

Laravel's advantages include an organized MVC structure, easy integration with external services, middleware support for security, and a rich ecosystem with various supporting packages. This framework is well suited for developing complex web applications that require integration with various modern technologies.

F. Google Looker Studio

Google Looker Studio is a tool for data visualization and analysis that provides various types of graphs, such as time series, bar charts, pie charts, tables, geographic maps, scorecards, scatter charts, and others [8]. Each type of chart has a specific visualization function, displaying one or more dimensions of information as well as the actual values associated with those dimensions or metrics.

Google Looker offers the first API platform focused on modular business intelligence. The platform provides easy-to-use artificial intelligence-based analytics, with data that is controlled, modeled, and supported by powerful semantic models [8]. Looker also has an intuitive Google-style dashboard as well as comprehensive built-in reporting capabilities.

Top features of Looker Studio include real-time connectivity with various data sources, easy sharing and collaboration capabilities, flexible customization, and seamless integration with the Google Workspace ecosystem. The platform is designed to support daily operational needs and long-term cost optimization strategies.

G. Waterfall Methodology

The waterfall model is an early model used in the history of software development. This model is often referred to as a sequential linear life cycle model because the process occurs step by step. Each stage in this model must be completed before moving on to the next, making it easy to understand and implement [12].

This model offers a clear and easily applicable framework in the software development process. Each stage in the Waterfall model is carried out sequentially without any overlap; meaning, one stage must be fully completed before proceeding to the next stage. Also known as the sequential life cycle model, this approach depicts the software development flow linearly, starting from the stages of requirements analysis, design, coding, testing, to system implementation [13].

The advantages of Waterfall methodology include complete documentation, clear structure, suitable for small to medium-sized projects with a definite scope. However, its main disadvantage is that it is not flexible to changing needs as the process progresses [11].

III. METHODS

A. Conceptual Model

The conceptual model in this study is a framework that describes the relationship between the main components in the development of an AI-based dashboard system. This model adopts a Design Science Research approach that explains how organizational needs (environment) drive the development of technological solutions (information system artifacts) with the support of a strong theoretical and methodological foundation (science base) [14]. The purpose of this conceptual model is to provide systematic guidance in the system development process, starting from problem identification in the organizational environment, designing AI technology-based solutions, to evaluation and implementation that contribute back to the scientific field and organizational practice.

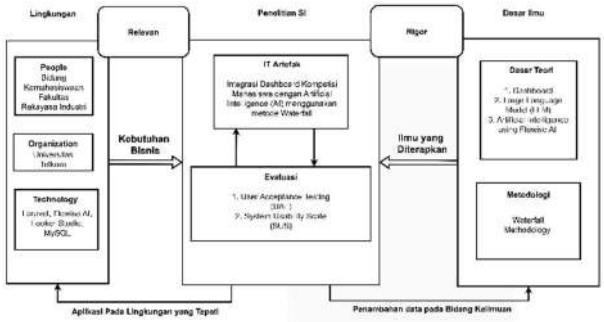


FIGURE 1
Conceptual Model

B. Research Systematic

This research uses the Software Development Life Cycle (SDLC) methodology with the Waterfall model which includes the initial phase, requirement analysis, system design, implementation, validation, and maintenance stages. The selection of the Waterfall methodology is based on the characteristics of a non-iterative project with clearly defined needs from the start [11].

C. Data Collection

Data collection is carried out to obtain the information needed in order to design and build information systems that are in accordance with user needs. The data collection process is carried out through a direct approach to relevant stakeholders through interviews and observations of pre-existing systems to ensure that the system developed is truly based on real needs in the field.

This research employs multiple data collection approaches to ensure comprehensive system development. Primary data collection utilized structured interviews with key stakeholders representing different organizational levels within the FRI environment. The stakeholder interviews involved the Dean of FRI, Student Affairs Staff, and student representatives to identify specific system needs, functionality expectations, and pain points of the existing dashboard system. Interview sessions focused on requirements elicitation covering functional requirements, non-functional requirements, and user experience expectations that would guide system design decisions.

TABLE 1
Data Collection

No	Data Source	Data Type	Description	Collection Objective
1	FRI Student Affairs Stakeholder	Primary Data	Interview and observation process to identify system needs and user expectations	Compile system requirements, analyze the problems faced, and explore stakeholder expectations for system features and functions
2	Excel File "BELMAWA Competition Achievements - Raw.xlsx"	Secondary Data	Data on Belmawa competition achievements of FRI students in various competitions in the last 5 years (2021-2024)	Rearrange the data structure to be cleaner for the purposes of system design and implementation
3	Existing Dashboard Documentation	Secondary Data	Records of old visualization dashboards used previously at Looker Studio	Analyze the weaknesses of the previous system as a basis for designing a new system

D. Data Processing

Data processing is carried out to ensure the quality and relevance of data in accordance with the scope of research focusing on students of the Faculty of Industrial Engineering. Raw data obtained from the student information system goes through a systematic preprocessing stage using Google Colab as a preprocessing tool with the Python programming language. The data cleaning process is carried out to eliminate duplicates, inconsistencies, and invalid data from the initial dataset. Column elimination was performed on duplicate and redundant attributes to improve analysis efficiency and reduce data complexity. The filtering stage is carried out to focus the dataset on students of the Faculty of Industrial Engineering in accordance with the research limitations, so that the analysis becomes more specific and relevant to the purpose of developing a competition dashboard system.

E. System Architecture

The system was designed using a layered architecture approach to create a modular and organized structure, making future development, maintenance, and scalability easier. The architecture consists of four main layers that interact with each other: Data Layer using a cloud database with encryption for secure storage of competition data, Visualization Layer using a business intelligence platform for presentation of interactive graphs and dashboards, Intelligence Layer based on an AI platform integrated with a large language model for natural language processing and intelligent analysis, and Presentation Layer using a web framework with a Model-View-Controller pattern for a responsive and easy-to-use user interface. This layered approach allows each component to have clear responsibilities and communicate effectively through well-defined interfaces, supporting the seamless integration of data visualization technology, artificial intelligence, and web interfaces in one unified ecosystem.

E. Validation Method

System validation was conducted through three comprehensive methods to ensure quality and implementation readiness. Automated testing using Laravel Dusk was conducted with 10 test cases covering authentication, dashboard access, CRUD operations, chatbot integration, and session persistence to thoroughly verify system functionality. User Acceptance Testing (UAT) involved three key stakeholder groups with 25 test cases covering all operational aspects of the system, showing a high level of acceptance. In addition, usability evaluation was conducted using the System Usability Scale (SUS) method through a standardized 10-question questionnaire with a Likert scale of 1-5, which was distributed to 10 respondents to measure the ease of use of the system from the end-user perspective.

IV. RESULT AND DISCUSSION

A. System Implementation

Implementation of the dashboard system achieved successful integration of four distinct technological layers, creating a unified ecosystem for monitoring student competition achievements within Faculty of Industrial Engineering at Telkom University. The system processes a curated dataset of 867 competition records spanning 2021-2024 period, derived through systematic data preprocessing that filtered the original 6,642 institutional records to focus exclusively on Faculty of Industrial Engineering students. Data preprocessing utilizing Google Colab with Python programming reduced attribute complexity from 26 original columns to 22 essential attributes, maintaining data quality and research scope relevance.

System implementation follows the established 4-layer architectural design as demonstrated in Figure 1. Laravel framework serves as the foundation for the Presentation Layer, implementing MVC design patterns with Blade templating for dynamic content rendering. Laravel Fortify handles authentication mechanisms, establishing role-based access differentiation between administrative and student user categories. Administrative privileges encompass complete dashboard access, full CRUD functionality for competition data manipulation, and unrestricted AI chatbot utilization, whereas student access remains limited to read-only dashboard viewing for personal achievement tracking.

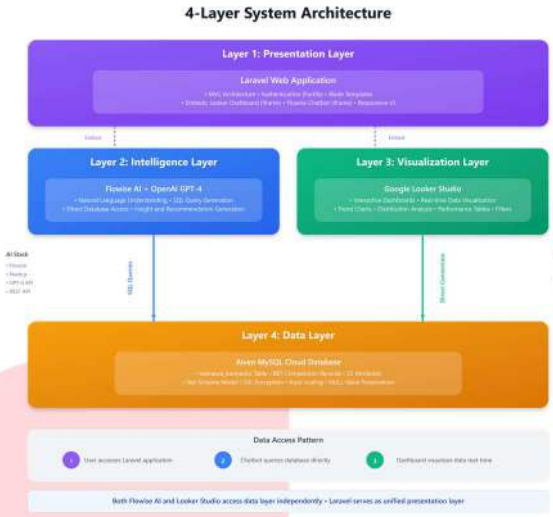
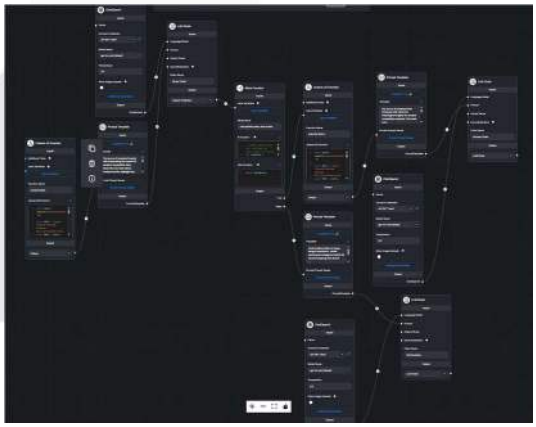


FIGURE 2
4-Layers Architecture

Flowise AI platform constitutes the Intelligence Layer core, integrated with OpenAI GPT-4o model to deliver sophisticated natural language understanding capabilities across Indonesian and English languages. The intelligent system converts conversational queries into executable SQL statements through advanced prompt engineering techniques, generating data-driven analytical responses within 5-second timeframes. This implementation produce contextually relevant insights derived from live database queries rather than pre-programmed responses.

FIGURE 3
Flowise Chatbot Flow



Google Looker Studio powers the Visualization Layer, generating dynamic data representations through multiple chart configurations including column visualizations for temporal trend analysis, funnel displays for program-wise achievement distributions, pie charts illustrating competition category breakdowns, and tabular presentations featuring student ranking systems with advanced filtering mechanisms.

Database synchronization maintains current data availability through secure SSL-encrypted connections to Aiven MySQL Cloud infrastructure, enabling simultaneous multi-layer data access while adhering to established dashboard usability standards for optimal information delivery.

FIGURE 4
Admin Page Dashboard Integrated with Chatbot & Looker

Then, in the image above is the dashboard page view, which is now equipped with an AI chatbot feature based on Flowise. This chatbot is directly integrated on the right side of the page and functions to assist users in answering questions about competition data or searching for information related to student competition data. The chatbot is developed using Flowise AI with the OpenAI GPT-4o model, enabling intelligent, fast, and contextual conversations. Users can type questions directly, and the system will respond based on the available student competition data.

B. System Evaluation

System evaluation was conducted through three comprehensive approaches to validate the quality, functionality, and usability of the developed competition dashboard system. The evaluation process included automated testing for technical verification, user acceptance testing for operational validation, and usability measurements to assess the ease of use of the system from the end-user perspective.

Automated testing was conducted using Laravel Dusk to verify system functionality systematically and consistently. Testing covers all aspects of system functionality from the authentication process, dashboard navigation, CRUD operations, to AI chatbot integration with a focus on system reliability and performance.

TABLE 2
Test case & test Scenario

Test Case ID	Functionality Tested	Test Scenario	Expected Result	Actual Result	Status
TC001	Admin Authentication	Registration & Login Process	Successful login → redirect admin dashboard	Login successful → redirect admin dashboard	Pass
TC002	User Authentication	Registration & Login Process	Successful login → redirect user dashboard	Login successful → redirect user dashboard	Pass
TC003	Role Access Control	User access admin routes	Error 403 Forbidden	Error 403 Forbidden displayed	Pass
TC004	Admin Dashboard Access	Navigate to Belmawa dashboard	Dashboard loads with Looker embed	Dashboard loaded successfully	Pass
TC005	User Dashboard Access	Navigate to user dashboard	Dashboard displays user data	User dashboard displayed correctly	Pass
TC006	Create Competition Data	Add new competition record	Data saved successfully	Data saved to database	Pass
TC007	Update Competition Data	Edit existing competition record	Data updated successfully	Data updated in database	Pass
TC008	Delete Competition Data	Remove competition record	Data deleted with confirmation	Data deleted successfully	Pass
TC009	AI Chatbot Integration	Chatbot presence and interaction	Chatbot responds to queries	Chatbot functional and responsive	Pass
TC010	Session Persistence	Navigation across admin pages	Session maintained throughout	Session maintained successfully	Pass

The UAT results showed a 100% acceptance rate from all stakeholders involved in the testing. All UAT participants provided positive feedback on the functionality and performance of the system, with an assessment that the system successfully meets the operational needs of each level of users. The system is considered effective in supporting strategic decision making, improving operational workflow

efficiency, and providing transparency and easy access to information for all users. The evaluation showed that the system is ready for production implementation with an optimal level of user satisfaction.

TABLE 3
User Acceptance Test result

Stakeholder Role	Features Tested	Test Cases	Success Rate	Feedback
Dean FRI	Authentication & System Management, Dashboard Analytics, AI Chatbot Integration, CRUD Operations	9	100%	Excellent system performance, strategic decision support capabilities enhanced
Student Affairs Staff	Data Management Workflow, System Performance, Access Control, Daily Operations	9	100%	Streamlined operational efficiency, intuitive interface design
Student Representative	User Registration, Dashboard Access, Data Validation, Interface Usability	7	100%	Transparent data access, user-friendly navigation experience
Overall	**System Functionality**	**25**	**100%**	

System Usability Scale assessment was conducted to measure the ease of use of the system from the end-user perspective using a standard 10-question questionnaire with a Likert scale of 1-5.

TABLE 4
System Usability Scale Result

R	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS Score
Admin											
1	5	1	5	1	5	1	5	1	5	1	100.0
2	5	1	5	1	5	1	4	1	5	1	97.5
3	5	1	5	1	4	2	5	1	5	1	95.0
User											
4	4	2	4	2	5	1	4	1	4	2	82.5
5	4	2	4	2	4	2	4	2	4	2	75.0
Average											90.0

The results of the testing on 5 respondents show that the average SUS score is 90.0, which falls into the "Best Imaginable" category according to the SUS interpretation standards. The highest score was obtained by the first respondent (Admin) with a perfect score of 100.0, while the lowest score was 75.0 from one of the User respondents. This indicates that, in general, the system is considered highly usable and supports the needs of users from both the administrator and end-user perspectives.

V. CONCLUSION

Based on the results of research of a competition dashboard system integrated with Artificial Intelligence (AI) using the Waterfall method at the Faculty of Industrial Engineering Telkom University, it can be concluded that this research has successfully developed an integrated dashboard system designed to monitor and analyze student achievements in competitions. This system is built with a layered architecture approach that brings together cloud databases, data visualization platforms, AI technology, and web frameworks into one integrated ecosystem. The implementation results show that this dashboard is able to present interactive analysis and data visualization, and comprehensive monitoring of student achievements, which significantly improves the competition data management and provides information transparency for stakeholders in the academic environment. The integration of AI technology in the system also provides intelligent analysis capabilities through a chatbot feature that can understand questions in natural language and provide analytical responses in real-time. System validation through functionality tests, user acceptance tests, and usability tests showed positive results, proving that the integration of AI in the dashboard is able to provide significant added value in the process of analyzing academic data and supporting data-based decision making in higher education institutions.

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