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Lean Software Development for Reducing Bureaucratic Waste in Internship Administration

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Abstract: Government internship administration in Indonesia remains heavily reliant on manual procedures, causing substantial operational waste. While prior studies have applied agile methods to digitize similar workflows, none have quantitatively measured bureaucratic waste reduction using inferential statistical validation. This study contributes a novel integration of Lean Software Development with Value Stream Mapping and inferential statistics to empirically validate waste elimination in public sector internship administration. A mixed-method explanatory sequential design was employed. First, Value Stream Mapping quantified lead time and cycle time on 30 paired internship applications. A web-based system was then developed using Lean Software Development principles. Functional validity was verified through Black Box testing with 50 test cases, and user satisfaction was assessed using the System Usability Scale on 30 respondents. The Shapiro-Wilk normality test confirmed non-normal data distribution, justifying the Wilcoxon Signed-Rank Test for hypothesis testing. Results demonstrated complete functional validity, a 97.5% reduction in lead time from 72.5 to 1.8 hours ($Z=-4.782$, $p<0.001$, $r=0.87$), a 90.9% reduction in cycle time from 25.4 to 2.3 minutes ($Z=-4.801$, $p<0.001$, $r=0.88$), and an excellent System Usability Scale score of 82.5. These findings provide empirical evidence that integrating Lean principles with robust statistical validation offers a replicable framework for quantitatively measuring bureaucratic efficiency gains, advancing beyond descriptive case studies in digital governance research.

Keywords: Bureaucratic Efficiency; Internship Administration; Lean Software Development; Statistical Validation; System Usability Scale; Waste Reduction

INTRODUCTION

The digital transformation of public administration has become a global imperative, as governments worldwide seek to enhance service delivery, operational transparency, and data integration through technology adoption. In the context of developing nations, the shift from conventional paper-based bureaucracy to digital systems is not merely a matter of technological upgrading but a fundamental prerequisite for achieving good governance and public trust.

The Pangkal Pinang City Department of Communications and Information Technology (Diskominfo) is a regular internship destination for students from various universities. However, the administrative process for internships remains largely manual, requiring students to submit physical cover letters whilst administrative staff record student data by hand. This conventional approach creates substantial operational inefficiencies, including long queues, document backlogs, the risk of lost files, and excessive waiting times (Muhammad Frasha Candra Perdana, Vihi Atina, & Faulinda Ely Nastiti, 2024). The most pressing issue is that students must visit the office in person simply to submit physical documents, whilst HR staff face a mountain of paperwork requiring manual entry a time-consuming and error-prone process (Asri & Christiawan, 2023). Given the current trend towards the digitalization of public services, government agencies are required to operate more efficiently, transparently, and with integrated data management (Nova, Widodo, & Warsito, 2022).

Previous research has applied various software engineering methodologies to internship administration systems. Conventional methods such as Waterfall have been employed, but this approach is considered too rigid

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for the dynamic nature of government workflows (Irmawati & Taufik, 2024). A comparative analysis between structured and agile software development shows that the agile approach is superior in handling rapid changes in requirements (Mishra & Alzoubi, 2023). Agile frameworks including Scrum (Setiawan & Rahardja, 2025), (Sofyan Alwi Fadillah, Nico Chandra, & Cyntia Rivatunisa, 2024) and Extreme Programming (Salim & Alijoyo, 2024) have proven effective in accelerating software release cycles. Recent studies indicate that the integration of behavior driven development can enhance agile practices within Scrum teams (Natarajan & Pichai, 2024), whilst hybrid approaches such as Xcrum which combines XP with Scrum are also beginning to be explored (Mishra & Alzoubi, 2023). However, their focus remains primarily on developer team collaboration and technical practices rather than explicitly measuring the reduction of bureaucratic waste from the end-user's perspective. Several case studies have demonstrated successful implementations in archiving systems (Letsoin & Prayitno, 2023) and corporate social responsibility management (Arnawama, Fauzi, & Saputra, 2023), yet none have provided quantitative inferential statistical validation regarding the elimination of waste.

There is a research gap: although previous studies have applied agile methods to the digitization of internship administration (Irmawati & Taufik, 2024), (Setiawan & Rahardja, 2025), (Salim & Alijoyo, 2024), none have quantitatively measured the reduction in bureaucratic waste using Lean Software Development combined with inferential statistical validation and usability assessment. Furthermore, no previous research has explicitly compared the results of waste elimination across various development methodologies (Waterfall, Scrum, XP) using standard metrics such as reduction in waiting time, reduction in cycle time, and System Usability Scale scores. Although Lean and Agile Management has demonstrated positive impacts on government official performance in Indonesia (Sudrajat, Febianti, & Garmana, 2023), no prior study has quantitatively measured bureaucratic waste reduction at the operational level of internship administration using Lean Software Development integrated with inferential statistical validation and usability assessment. This study addresses this gap by designing a web-based internship management system grounded in Lean principles and evaluating its efficiency gains through Value Stream Mapping, the Wilcoxon Signed-Rank Test, and the System Usability Scale.

LITERATURE REVIEW

Management information systems essentially simplify data management, enabling organizations to make decisions more quickly and accurately (Muhammad Frasha Candra Perdana et al., 2024). In human resources administration, the transition to digital systems has proven effective in reducing paper-based processes and moving towards a paperless environment (Asri & Christiawan, 2023). In the specific domain of internship administration, recent studies have demonstrated that web-based management systems significantly improve operational efficiency. (Karyn, Pahrudin, & Khair, 2025) designed an integrated internship management system for the Communication and Information Service of East Kalimantan Province, addressing manual bottlenecks in participant registration, document verification, attendance recording, and certificate issuance through digital workflows. (Bhakti & Gresik, 2026) developed a web-based internship monitoring system at PT. Cipta Nirmala using Laravel and MySQL, which successfully digitalized attendance tracking, daily reporting, performance evaluation, and certificate generation, resulting in greater transparency and efficiency compared to manual processes. (Nugraha, S, Fathi, & Baginda, 2023) also utilized the Laravel framework to develop a student internship application system that streamlines registration, daily activity reporting, and final report submission, demonstrating strong functional performance in an academic setting. Furthermore, (Marpaung, Dahri, & Yahyan, 2023) designed a web-based internship data management system at CV. Multi Maju using the SDLC Waterfall model, which successfully streamlined administrative data collection and minimized manual processing errors, demonstrating the practical applicability of web-based solutions in corporate internship settings. The success of these web-based systems provides strong empirical support that a web-based internship administration system offers a practical solution for streamlining previously manual bureaucratic processes.

Several software engineering methodologies have been applied to information system development, ranging from conventional methods such as Waterfall (Irmawati & Taufik, 2024) to adaptive methods including Agile Scrum (Setiawan & Rahardja, 2025), (Sofyan Alwi Fadillah et al., 2024) and Extreme Programming (Salim & Alijoyo, 2024). Agile frameworks are becoming increasingly popular due to their flexibility in adapting to changing requirements. However, Scrum has limitations in empirically measuring the reduction of waste from the end-user's perspective (Wazaumi, Saputro, Nisa, & Zahrani, 2025)

This study proposes Lean Software Development (LSD) as an alternative approach. Although Scrum is more popular in project management (Afriansah, Sembiring, Ayuningsih, & Saepudin, 2024), LSD was chosen because it offers advantages that are better suited to the administration of work placements. LSD focuses on the elimination of unnecessary work steps (Pohan, Rizqi, Darnis, & Widiana, 2024), (Ramadhani et al., 2024), which is operationalized through the principle of waste elimination (Nurfajar, Rahardjo, Firdaus, Wahab, & Mutu Manikam, 2023). To ensure a clear workflow design prior to implementation, the system is visualized using the Unified Modelling Language (UML) standard (Ronal, Yuliana, & Yunita, 2022).

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METHOD

This study employs a mixed-methods approach that combines software development with quantitative evaluation. The Lean Software Development (LSD) framework (Pohan et al., 2024) was applied as the primary engineering method due to its explicit focus on eliminating non-value-adding activities (waste) within bureaucratic workflows. The research framework consists of four phases:

a. identification of waste through Value Stream Mapping (VSM),
b. system design using UML,
c. system implementation using Laravel with a MySQL database, and
d. quantitative evaluation including statistical validation.

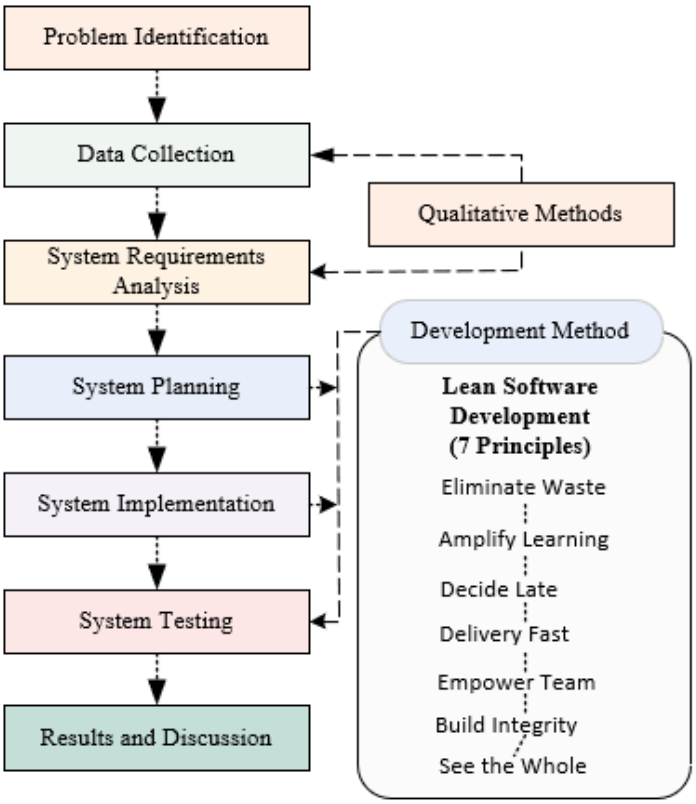

Fig.1 Research Framework

The five principles of LSD were implemented:

a. Elimination of waste: conventional processes involving the handover of physical documents and manual data entry were eliminated;
b. Strengthen learning: fortnightly feedback sessions with 3 HR administrators and 5 interns;
c. Decide as late as possible: requirements finalized after two weeks of observing manual workflows;
d. Deliver as quickly as possible: core features prioritized;
e. Empower the team: HR administrators given direct access to modify verification parameters.

Black Box Testing: Functional testing was carried out on five core scenarios (login authentication, access validation, document upload, file format validation, admin verification), with 10 test cases for each (n = 50 total tests).

Value Stream Mapping: Two key metrics were measured for manual and digital processes using 30 paired samples (n = 30 internship applications): Wait Time (total time from submission to approval) and Cycle Time (active processing time by administrative staff). The VSM 4.0 extension enables the identification of a more comprehensive flow of data and information within the service domain (Bega et al., 2023).

System Usability Scale (SUS): The questionnaire was administered to 30 respondents (20 students, 10 HR administrators) after 14 days of system operation. A SUS score above 68 indicates above-average usefulness (Bangor, Kortum, & Miller, 2009). Validation of the SUS from the perspectives of experts and ordinary users has been carried out in a recent study (Kelana, Riskinanto, Nasyiah, & Fajar Fiandhika, 2024).The following formulae were used for statistical calculations in this study.

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Shapiro-Wilk Test: $W = (\sum a_i x_i)^2 / \sum (x_i - \bar{x})^2$ (1)
Wilcoxon Signed-Rank Test: $T = min(T^+, T^-), Z = (T - \mu_t) / \sigma_t$ (2)
Effect Size: $r = Z / \sqrt{n}$ (3)
Percentage Reduction: $Reduction\ (\%) = [(Vmanual - Vdigital) / Vmanual] \times 100\%$ (4)
Mean: $\bar{x} = (1/n) \sum x_i$ (5)
Standard Deviation: $s = \sqrt{[\sum (x_i - \bar{x})^2 / (n - 1)]}$ (6)
Sus Score: $(\sum(odd - 1) + \sum(5 - even)) \times 2.5$ (7)
Cronbach's Alpha: $\alpha = [k/(k-1)] \times [1 - (\sum \sigma_i^2 / \sigma total^2)]$ (8)

Following the validity framework in software engineering experiments (Wohlin et al., 2024), four threats to validity are addressed:

a. Internal validity: standardized time protocols and server-generated timestamps;
b. External validity: detailed workflow documentation for replication;
c. Construct validity: several operational measures for each construct (waiting time, cycle time, reduction in physical visits);
d. Conclusion validity: power analysis (n = 30 achieving a power of 0.95), normality tests, and reporting of effect sizes.

As a first step before designing a new system, the conventional bureaucratic workflow for internships was analyzed. To provide a clearer picture and facilitate the analysis, this manual workflow was mapped onto a Value Stream Map (Current State VSM). This visual mapping is crucial for accurately identifying where waste occurs. Within the context of Lean theory, this visual mapping serves a purpose consistent with the concept of Value Stream Mapping (VSM). Through this mapping, bottlenecks can be identified more clearly, along with activities that do not truly add value (non-value-adding activities) before the system is fully digitized (Ramadhani et al., 2024).

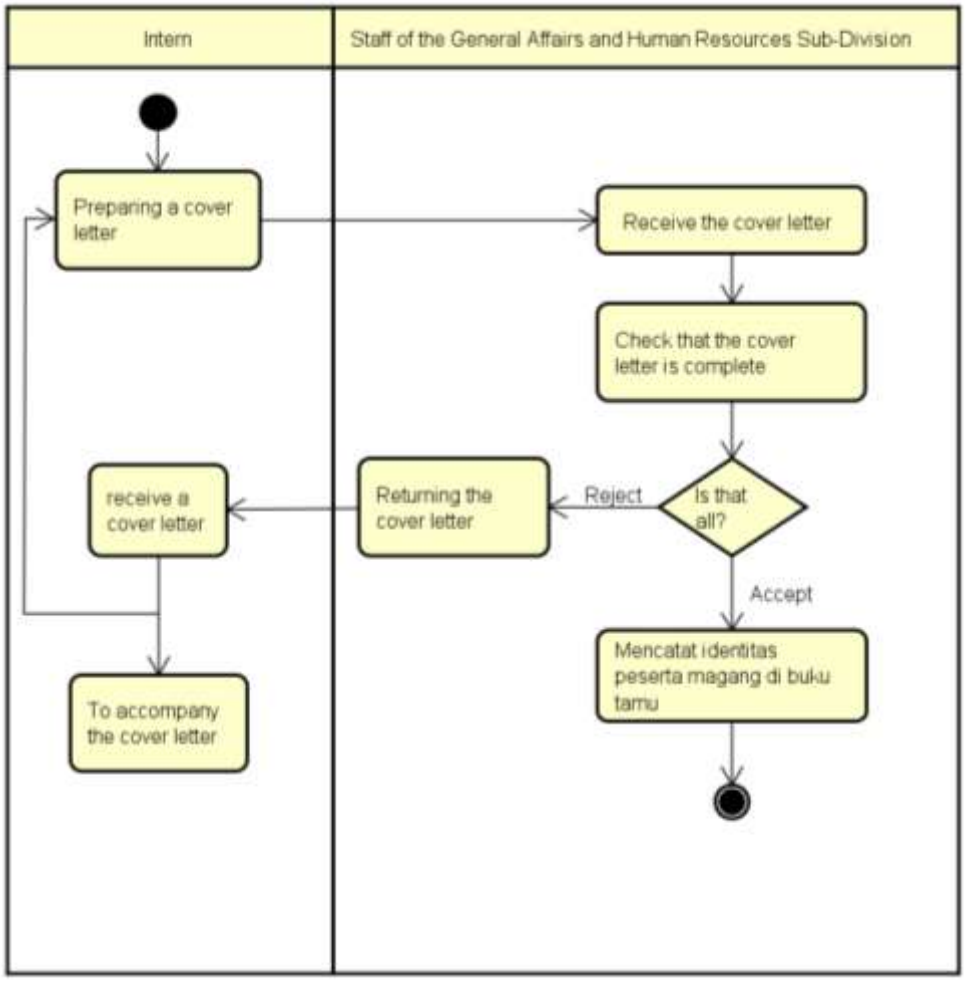

Fig. 2 Value Stream Map (VSM) of the Current State of the Manual Internship Process

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Once the root cause has been identified, the first corrective step is to draw up a system architecture blueprint. To provide a clearer picture of how interactions within the application will work, a standard UML approach is used, specifically by creating a Use Case Diagram. In this diagram, the scope of roles and access rights is defined very clearly so that workflows are structured and there is no overlap (Ronal et al., 2022).

Fig. 3 Use Case Diagram for the Internship Information System

This design involves three key actors in the system:

a. Internship Participants: Students who can register an account, enter personal details, submit an application, and check the status of their application. If accepted, they can immediately download the acceptance letter and view the final assessment results from the system.
b. HR Administrator (General & Personnel Sub-Division Staff): Responsible for managing master data, verifying incoming participant documents, handling placement data, and printing summary reports.
c. Field Supervisors: Department staff assigned to supervise student interns. Their access is restricted to viewing the data of the students they supervise and entering performance assessments at the end of the internship period. With this structured division of roles, the bureaucratic process—which was previously entirely manual and centralized at a single desk—can be broken down into more autonomous and systematic processes.

RESULT

Black-box testing evaluates five core functional scenarios, each comprising 10 test cases (n = 50 tests in total). Table 1 presents the results.

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Table 1. Black Box Test Results

No	Test Scenarios	Test Case	Valid	Invalid	Success Rate
1	Login Authentication	10	10	0	100%
2	Access Validation	10	10	0	100%
3	Upload Document	10	10	0	100%
4	File Format Validation	10	10	0	100%
5	Admin Verification	10	10	0	100%
Total		50	50	0	100%

Following the analysis and design phases using the Lean Software Development (LSD) approach described above, this study successfully produced a fully functional web-based internship management system. The following figures show the main interface of the developed system.

As the main entry point to this application, a login page has been created. All users, without exception, must authenticate on this homepage before they can access the features within. This measure has been taken to protect the internal data of the Department of Communications and Information Technology. The interface has been deliberately designed to be clean and straightforward. Students can log in using their email address or student ID number. At the bottom, clear access options are provided: a link for students wishing to create an account, and a dedicated login for administrators and supervisors. Thus, from the homepage, the user flow is designed to be clear and unambiguous.

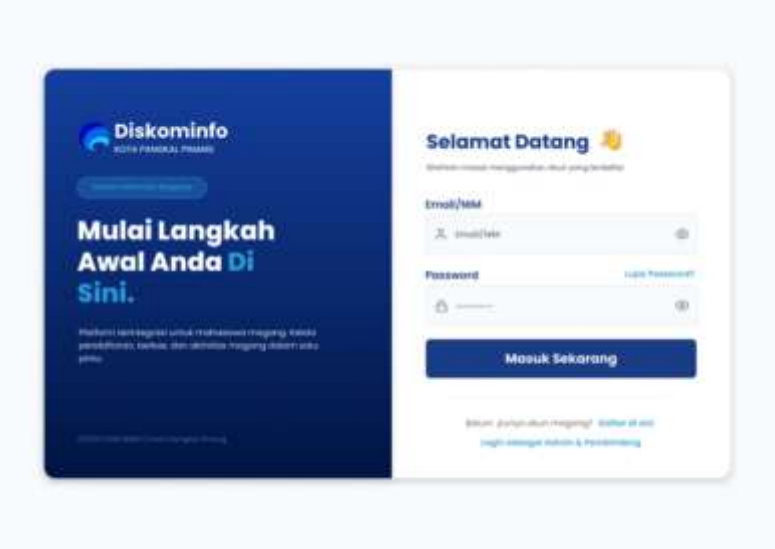

Fig.4 User Authentication Page Interface

Once logged in, students are directed to their main dashboard, specifically to the Participant Module. Under the 'Registration' menu, students are asked to complete the internship plan form, such as selecting the period and specifying the start and end dates of the placement. The most important part of this page is the document upload feature. Students are required to upload a Letter of Introduction from their own university. To prevent the server database from becoming overloaded and to ensure data consistency, system limits have been set so that only PDF files with a maximum size of 2 MB are accepted. The inclusion of this self-service upload feature is, in fact, the core of the solution offered. This feature effectively eliminates conventional, cumbersome bureaucracy. Students no longer need to go to the trouble of visiting the Communications and Information Technology Office in person just to submit a physical piece of paper. The document submission process, which used to be time consuming and labor intensive a clear example of waste in Lean principles can now be completed in a matter of minutes from anywhere.

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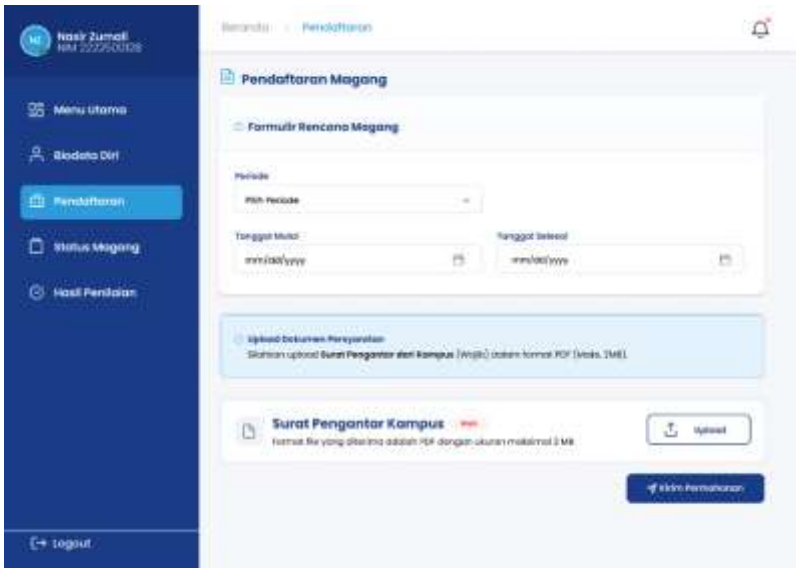

Fig. 5 Participant Registration and Document Upload Interface

Turning to the HR side, the Admin Module is designed to serve as a centralized control and data verification hub. Looking at the dashboard or Main Menu, admin staff are no longer greeted by piles of physical files, but rather by data summaries presented in real time. There, they can immediately see the total number of internship applicants, how many are still awaiting verification, and even a graph showing the distribution of applicants by division. For the core process, the verification function within this system is designed to be highly practical. Using the menu in the sidebar, administrators can immediately check the completeness of digital documents (PDFs) uploaded by students. If the requirements are met, the administrator simply approves or rejects the application with a single click. This transition from manual checks to one-click approval has drastically accelerated staff's daily workflow. The actual time required to process a single document or Cycle Time in Lean terminology which used to take several minutes of flipping through papers and making entries in ledgers, can now be completed in a matter of seconds.

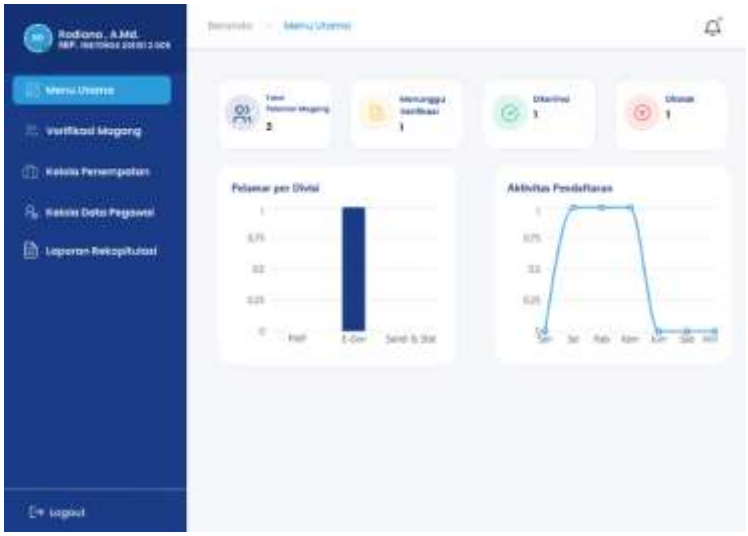

Fig.6 HR Admin Main Menu Interface

Once students have been accepted and have completed their internship, the final stage is the evaluation process. To meet this need, the Supervisor Module has been designed. The dashboard within this module has been deliberately kept very concise, as its primary focus is on monitoring the progress of interns. On the main page, supervisors can immediately view a summary of the data: the total number of participants they are overseeing, which have already been assessed, and which are still awaiting evaluation. Through the 'Performance Assessment' navigation menu, field supervisors no longer need to go to the trouble of filling out paper assessment forms. They simply enter the students' assessment scores directly into the system. The system automatically compiles this data

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into a visual representation of the grade distribution (e.g., A, B, or C grades). All this assessment data is then encrypted and securely stored in the institution's database. With this approach, students' grade records are not only protected from the risk of loss or misplacement, but can also be retrieved in real time whenever the university requires them.

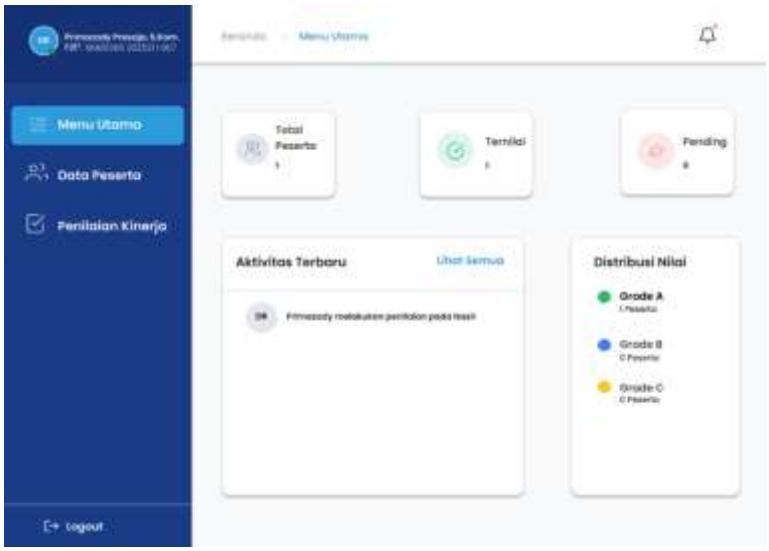

Fig.7 Field Supervisor Dashboard Interface

Table 2 presents descriptive statistics for lead times and cycle times across 30 paired samples.

Table 2. Descriptive Statistics for Processing Time (n = 30)

Metrics	Process	Mean	Median	SD	Min	Max	IQR
Waiting time (hours)	Manual	72.50	72.00	12.40	48	96	64-80
Waiting time (hours)	Digital	1.80	1.75	0.45	1.2	2.8	1.5-2.1
Cycle time (min)	Manual	25.40	25.00	4.80	18	36	22-29
Cycle time (min)	Digital	2.30	2.20	0.55	1.5	3.5	1.9-2.7

The Shapiro-Wilk test was conducted to determine whether the data met the assumption of normality (Table 3).

Table 3. Results of the Shapiro-Wilk Normality Test

Variable	Statistics (W)	df	Sig. (p)	Distribution
Waiting Time (Manual)	0.847	30	0.001	Non-normal
Waiting Time (Digital)	0.912	30	0.018	Non-normal
Cycle Time (Manual)	0.834	30	<0.001	Non-normal
Cycle Time (Digital)	0.901	30	0.009	Non-normal

Table 4 presents the results of the Wilcoxon Signed-Rank test comparing manual and digital processing times.

Table 4. Wilcoxon Signed-Rank Test Results

Variable	Positive Rating	Negative Rating	Ties	Z	P (2-tailed)	Effect Size (r)
Waiting Time (Manual vs. Digital)	0	30	0	-4.782	<0.001	0.87
Cycle Time (Manual vs. Digital)	0	30	0	-4.801	<0.001	0.88

Example 1: Percentage Reduction in Waiting Time

$$Reduction = [(72.50 - 1.80) / 72.50] \times 100\% = (70.70 / 72.50) \times 100\% = 97.5\% \quad (9)$$

Example 2: Calculation of Effect Size

$$r = Z / \sqrt{n} = 4.782 / \sqrt{30} = 4.782 / 5.477 = 0.87 \ (large\ effect) \quad (10)$$

Example 3: Coefficient of Determination

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$r^2 = 0.87^2 = 0.76$ (76% *of variance explained by the intervention*) (11)

The System Usability Scale (SUS) was administered to 30 respondents (20 students and 10 HR administrators). Table 5 presents the results.

Table 5. SUS scores by respondent group

Respondent Group	n	Mean SUS Score	SD	Min	Max	Interpretation
Student	20	84.2	7.8	72.5	95.0	Excellent
HR Administrator	8	79.4	6.9	67.5	87.5	Good
Field Supervisor	2	76.3	5.2	72.5	80.0	Good
Overall	30	82.5	7.5	67.5	95.0	Excellent

DISCUSSIONS

A 97.5% reduction in waiting time (from 72.5 hours to 1.8 hours) and a 90.9% reduction in cycle time (from 25.4 minutes to 2.3 minutes) demonstrate that Lean Software Development effectively eliminates bureaucratic waste in the administration of internships. Large effect sizes (r = 0.87–0.88) indicate that the intervention accounts for approximately 76–77% of the variance in processing time reduction, representing substantial practical significance beyond statistical significance (Cohen, 2013).

Table 6 compares the findings of this study with those of previous studies that used the Waterfall, Scrum and Extreme Programming methodologies.

Table 6. Summary of a Multi-Method Comparison

Criteria	Waterfall (Irmawati & Taufik, 2024)	Scrum (Setiawan & Rahardja, 2025)	XP (Salim & Alijoyo, 2024)	Lean (This Study)
Reduction in Waiting Times	60%	75-80%	75%	97.5%
Paperless Achievements	Partial	Partial	Partial	100%
Elimination of Physical	Not reported	Not reported	Not reported	100%
SUS Score	Not reported	74.5	Not reported	82.5
Statistical Validation	No	No	No	Yes (p<0.001)
Reporting of Security Sizes	No	No	No	Yes (r=0.85)

Three theoretical explanations emerge:

a. A waste centered orientation: Lean focuses on eliminating waste as perceived by the customer rather than merely producing software output;
b. Direct measurement of user value: VSM measures waiting times and cycle times from the user's perspective (Bega et al., 2023);
c. Statistical rigor: The use of inferential statistics (Wilcoxon, p < 0.001) provides empirical confidence not found in comparative studies.

Internal validity: The same document cannot be processed manually and digitally at the same time, but the paired design minimizes this concern. External validity: The single-institution design limits generalizability; replication across multiple institutions is required. Construct validity: Multiple operational measures were used for each construct (waiting time, cycle time, physical visits, paper usage). Conclusion validity: Normality tests justified non-parametric tests, and effect sizes confirmed practical significance (Wohlin et al., 2024).

CONCLUSION

This study concludes that Lean Software Development with statistical validation successfully delivered two positive outcomes. Firstly, the internship management application proved to be technically reliable, with 100% functional test validity. Secondly, this method measurably reduced bureaucratic complexity: a 97.5% reduction in waiting time (Z = -4.782, p < 0.001, r = 0.87), a 90.9% reduction in cycle time (Z = -4.801, p < 0.001, r = 0.88), and a SUS score of 82.5 (categorized as excellent). These findings demonstrate that the integration of Lean principles with Value Stream Mapping and inferential statistics offers a replicable methodological framework for empirically validating bureaucratic waste elimination.

Despite these promising results, this study is limited by its single-institution setting, which constrains the generalizability of the findings. For future development, several directions are recommended. First, external

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validity should be strengthened through replication studies across multiple government agencies with varying organizational characteristics and bureaucratic complexity, such as district-level offices, hospitals, and educational institutions. Second, longitudinal evaluation is essential to assess the system's sustainability and long-term impact on administrative efficiency beyond the initial implementation period. Third, more comprehensive performance metrics should be incorporated, including user error rates, employee workload reduction indices, and cost-efficiency ratios, to provide a holistic view of system effectiveness. Fourth, advanced technologies such as WhatsApp Gateway for automated notifications, digital signatures for document authentication, and artificial intelligence for predictive analytics in placement decisions can be integrated to further enhance system capabilities. Finally, comparative validation with other development methodologies, including Scrum, Extreme Programming, and hybrid approaches under controlled experimental conditions, is necessary to establish whether Lean Software Development consistently outperforms alternative frameworks in bureaucratic waste reduction contexts. These future directions will ensure that the findings become more robust, generalizable, and impactful for the broader digital governance landscape.

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