

Development of an electronic repository with data analytics for extension services for the University of Northern Philippines

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ABSTRACT

Submission of documents and reports in higher education extension services often suffers from operational lag due to manual workflows and passive repository platforms. This study developed and tested an electronic repository system (eRXS) equipped with an integrated data analytics-enabled dashboard, automated reporting tools, and communication modules. Rapid application development (RAD) was used as the method for the system development and was tested through system load testing and live benchmarks. Quantitative load testing with 75 trials using a 102-document seed as baseline revealed exceptional technical stability, achieving a total of 15.038 milliseconds and sub-millisecond database retrieval. This robust system performance significantly lowered user cognitive load and facilitated sustainability in system utilization, resulting in an organic 153 document uploads. Consequently, through real-time data visualization, the system reduces administrative information asymmetry, achieving full document compliance across tested samples (n=75). These findings suggest that the developed system successfully transforms standard repositories from simple storage solutions into proactive drivers of compliance and institutional accountability, but further evaluation of user acceptance is recommended for future work. The primary contribution of this work is application-oriented, demonstrating technically validated, domain-specific integration of analytics into extension service repository management-rather than a novel theoretical framework.

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1. INTRODUCTION

Extension is one of the core functions of Philippine Higher Education Institutions (HEIs), complementing instruction and research. Through extension programs, HEIs provide services to communities by implementing initiatives aligned with both global and national priorities, including the United Nations' Sustainable Development Goals and the Philippine Development Plan 2023–2028. In this context, Commission on Higher Education (CHED) Memorandum Order No. 08, Series of 2008 [1], highlights the role of HEIs in advancing national development by facilitating extension services focused on community engagement.

Despite these policy initiatives, many communities and organizations continue to rely on extension services for support. A considerable amount of literature has been published on the issue. Studies by [2]–[4] indicated that communities in the Philippines face persistent challenges in accessing government extension programs, projects, and activities, with many remaining underserved. A significant contributing factor is the

reliance on manual processes for managing extension-related records. These practices impede information retrieval, hinder effective monitoring of extension activities, and restrict administrators' capacity to make timely, relevant, and accurate decisions.

Innovation has increased productivity in organizations such as higher education institutions. Studies by [5], [6] emphasized that digitalization has greatly transformed government processes through digital systems commonly referred to as e-government. Similarly, studies by [7], [8] stated that digital transformation enables HEIs to improve operations, service delivery, and institutional management. Kraus *et al.* [9] emphasized that digitalization may increase the effectiveness and precision of records management in HEIs. In the global setting, institutional repositories play a key role in open access and research, with over 6,000 worldwide projected by 2025 (Registry of Research Data Repositories, 2023). In the Philippines, according to the University of the Philippines Journals Online, repositories remain limited and primarily focus on research rather than extension documentation [10]. A review of the literature highlights the key role of repositories and management systems in HEIs. Educational technology supports both research and extension activities [11]. Although studies by [12]–[14] describe web-based solutions for managing extension and community programs, these systems regularly lack integrated analytics. Topali *et al.* [15] said that engaging users through participatory design, especially in analytics dashboards, improves both involvement and learning outcomes. Additionally, a study by Wong [16] stressed the growing importance of analytics in supporting evidence-based decision-making in academic organizations. Taken together, these works reveal that although there has been significant progress in digital adoption, many HEIs have yet to implement analytics modules, limiting their ability to assess program effectiveness, monitor trends, and make strategic decisions. Both [17], [18] emphasized that academic reporting and communication are important, but their studies do not adequately meet the user requirements in extension services. Garudasu *et al.* [19] emphasize the value of analytics and dashboards for supporting decision-making, yet a considerable gap persists in consistently evaluating their usability and effectiveness relative to other platforms. Gutiérrez *et al.* [20] points out the potential benefits of analytics dashboards for responsive support and real-time visualization in both academic and extension environments.

Most digital repositories, such as that of the London School of Hygiene and Tropical Medicine, are designed for research publication rather than for managing extension services. While institutional repositories are widespread, they often do not address the practical requirements of extension services. Consequently, extension offices in HEIs face challenges in organizing records, tracking programs and activities, and utilizing data for decision-making. This situation underscores the need for extensible, flexible, and analytics-capable systems that are both high-speed and accessible [21]. Modular design and cloud technology can address these needs, supporting universities with diverse extension programs [22], [23]. Such systems also foster trust with community partners. Advanced analytics and data visualization further empower coordinators, directors, and management to monitor progress and make timely, actionable decisions [24], [25]. To identify research gaps, existing repository platforms were compared, as detailed below.

Table 1 presents a comparative examination of existing repository platforms available in the market. Results show several advantages of eRXS over existing systems. Existing web-based systems primarily supported data storage and retrieval but lacked integrated analytics.

There is an increasing need for advanced systems that do more than just store data but also deliver actionable insights. Currently, the absence of tailored digital document management for extension services leaves significant support gaps in meeting unique extension-specific requirements. Therefore, this study responds to the needs of higher education institutions by developing and evaluating a data analytics-enabled eRXS. While most academic digital solutions focus on archiving, they lack essential features such as activity monitoring, achievement reporting, and integrated communication. Although the University of Northern Philippines Extension Services Office has effectively overseen extension activities, there are still opportunities for improvement. Existing digital solutions fail to optimize extension service operations and decision-making processes, a substantial shortfall given that extension services are a core HEI function and are increasingly vital to community and economic development. Institutions, therefore, face growing pressure to adopt advanced management systems. This study introduces an electronic repository system (eRXS) to help HEI extension offices competently manage and monitor records and activities, thereby directly addressing these needs.

This study identified existing gaps and developed a system with features and functions essential for decision-making by unit extension coordinators, directors, middle management, and top-level management. The researchers designed a scalable, adaptable digital solution for Philippine higher education institutions. The system's modular framework was evaluated for customization, and its validated performance demonstrates applicability in broader contexts.

Furthermore, the primary contribution of this work is application-oriented and demonstrates technically validated, domain-specific integration of analytics into extension service repository management—rather than a novel theoretical framework.

Table 1. Comparative analysis of repository platforms

Features	DSPace	Alfresco	eRXS (developed)
Document repository	Yes	Yes	Yes
Analytics dashboard	No	Partial	Yes
Action/accomplishment plans	No	No	Yes
Built-in communication tools	No	Partial	Yes
Extension-specific reporting	No	No	Yes

2. METHOD

2.1. Research design

A developmental and descriptive research design was employed, utilizing the rapid application development (RAD) model to accelerate system development through rapid prototyping and intensive stakeholder engagement. This approach ensured that user needs were addressed early and accurately in the development process. The iterative prototyping cycle minimized the need for major changes during construction. Previous studies have established that RAD is an efficient approach for real-world projects, enhancing both productivity and code quality [20], [21]. Furthermore, RAD enables novice developers to quickly grasp system concepts and design principles, proving more effective than traditional development techniques. The descriptive methodology also supported comprehensive data collection and process mapping, informing the design and implementation of the system. Quantitative load testing was also conducted using the actual system usage data collected from 15 users comprising 75 trials against a 102-document baseline seed. This approach ensured system performance reflected real-world operating conditions.

2.2. Software development method

The researchers used the RAD methodology, a user-centric software development approach that emphasizes close collaboration throughout the system's development. Figure 1 presents the RAD phases, illustrating the processes involved in software development. This model consists of four stages presented as follows:

- a. Requirements planning: a structured set of interviews and consultations with extension office stakeholders was conducted to identify core document management needs, reporting requirements, and analytics capabilities. Extension office staff and key stakeholders participated in systematic interviews and workflow mapping to define system needs and essential features. The researchers also tested the system with fifteen (15) extension coordinators across five (5) organizational nodes with 102 documents seeded in the pilot testing of the system. This justified the system's performance during the pilot testing phase.
- b. User design: use cases and entity-relationship diagrams (ERDs) were used to conceptualize the system design and visualize its logical architecture. Wireframes were presented to the system's users, especially the University Extension Office (UEO) Director. A use case diagram was created to visualize system flow and module interactions. Multiple iterations (n=10) improved these prototypes based on stakeholder responses.

Figure 2 illustrates the use case diagrams of the developed system. Actors include the Unit Extension Coordinators, the UEO Director, and the admin. A college/unit coordinator needs to submit an annual plan and accomplishment report for an extension project. The extension services coordinator manages the documents and monitors reporting compliance. The extension director reviews analytics dashboards for oversight and planning. The admin can configure the system settings.

- c. Construction: the solution was developed through hypertext preprocessor (PHP) 8.1 for server-side logic and Tailwind cascading style sheets (CSS) 3.3.2 for responsive interface design. MySQL 8.2.12 and Apache 8.0 were used for database management in the backend. It was hosted on an Intel Core i9 server with 8 GB RAM running Windows Server 2019 for testing. Chart.js 4.2 was used for analytics and visualization in the system dashboard. Security measures included user authentication, role-specific access control, daily encrypted backups, and SSL/TLS for all data in transit. Backup mechanisms involved automated nightly backups stored off-site for disaster recovery. End-user feedback and validation were continuously incorporated across all development phases. These technologies, such as PHP, MySQL, and Chart.js, were useful because they support rapid schema modifications and iterative development, allowing the researchers to incorporate user feedback. PHP was chosen as the server-side scripting language for create, read, update, and delete (CRUD) operations that are important for managing documents in the system. It is a recommended choice in a university setting for long-term maintainability [26]. Another technology used is MySQL. It was used to ensure atomicity, consistency, isolation, and durability (ACID) compliance for all document metadata. Its relational structure is well-suited for managing complex hierarchical databases, which is critical for maintaining data integrity across multiple organizational nodes, as in Gao *et al.* [27]. Chart.js was used to create an interactive analytics dashboard. It provides real-time, responsive rendering compliance metrics to users by automatically visualizing data to improve rendering performance across modern browsers and to address the need for an interactive analytics dashboard, similar to that in this study [28].

- d. Cutover: a pilot test was conducted at the UEO. This stage included system installation and initial live testing to ensure a smooth adoption and capture feedback for further refinements. The inclusion of these measurable success criteria improves the methods section by adding rigor and clarity to each RAD phase. Specifically, a system performance load testing protocol was established using a 102-document seed across five (5) colleges and unit offices. A total of 15 concurrent users executed 5 task iterations each (n=75 trials) to measure system response under peak administrative traffic.

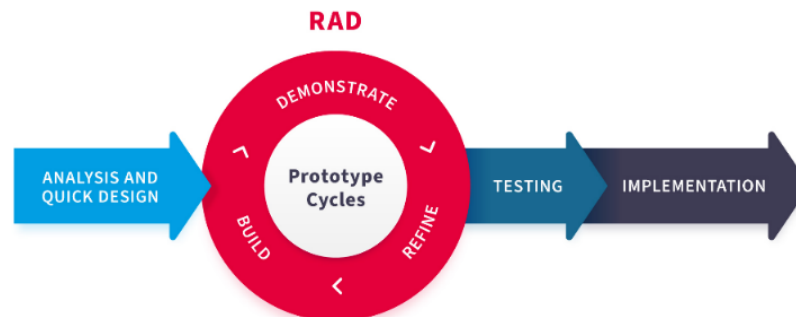


Figure 1. Rapid application development

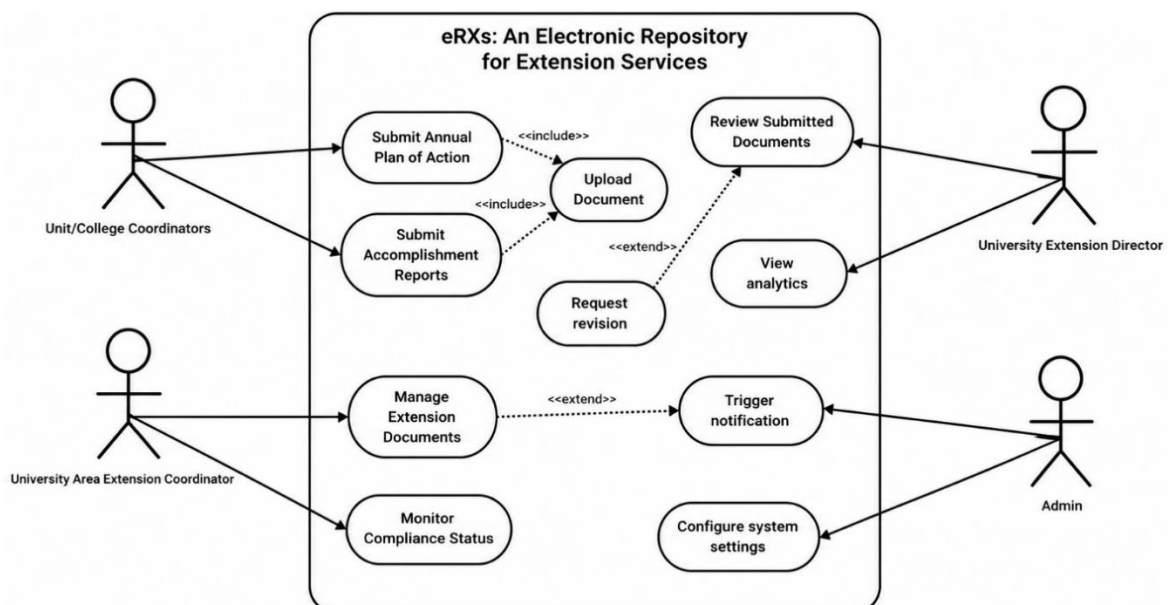


Figure 2. Use case diagram

2.2. Research participants

A purposive sample of 15 participants was selected to gather data regarding user requirements, system performance, and process improvements. These participants were directly involved in planning, implementing, and monitoring extension programs, projects, and activities, providing the relevance of their feedback. Their input validated system performance assessments and informed the refinement of the developed eRXS.

2.3. Quantitative system parameters and load test protocol

Technical operational specifications were strictly defined to evaluate and justify the system architecture during the RAD phase. The dataset, the organizational nodes known as "academic units" and "administrative units", and the load-testing and benchmark parameters are discussed as follows.

2.3.1. Dataset and organizational nodes

The system was tested across five distinct organizational nodes: 4 academic units and one administrative unit UEO. For a realistic end-of-term audit simulation, the database was initialized with a seed

dataset of 102 extension documents. During this evaluation period of the academic year (2024–2025), the dataset expanded to 153 requirement files, establishing a baseline volume for system performance.

2.3.2. Load testing and live benchmarks parameters

The researchers directly measure the testing in the application environment. This approach enabled live measurements of the PHP 8.2.12 and MariaDB 10.4.32 architectures under actual user-session conditions. Table 1 presents the detailed specifications of the system testing.

Table 2 illustrates the load testing and benchmarking parameters. The results show that during the 75 concurrent document-retrieval trials (n=15 accounts×5 iterations), the system maintained low latency and consistent processing times, even under peak load. Specifically, metrics such as database retrieval speed, server-side processing time, and memory usage remained within optimal ranges, demonstrating that the system reliably supported simultaneous users without crashes or performance degradation.

For execution latency, live wall-clock measurements presented sub-millisecond database round-trips, with a baseline MySQL ping (SELECT 1) averaging 0.541 ms and aggregate document counts executing in 0.663 ms. For processing performance, total PHP server-side processing time prior to HTML output rendering averaged 15.038 ms.

Lastly, there is resource allocation. Session isolation remained highly efficient, with peak memory usage recorded at approximately 2048.0 KB per session. The infrastructure was provisioned with a 16 GB memory limit, a 12 GB maximum upload file size, and a maximum of 151 concurrent database connections, ensuring the system could comfortably exceed the institution's concurrent user sessions.

Table 2. Systems load testing and benchmarking characteristics

Category	Parameter/metric	Measured value
Deployment scope	Organizational nodes	5 (4 academic units, 1 administrative office)
	Concurrent pilot accounts	15 accounts
	Evaluation dataset seed	102 initial documents (153 final)
	Document retrieval trials	75 (n=15×5)
Server environment	PHP version	8.2.12
	Database engine	MariaDB 10.4.32
	Memory limit	16 GB
	Max database connections	151
	Max file upload size	12 GB
Live benchmarks	Baseline database ping (round-trip)	0.541 ms (Avg)
	Indexed session lookup	0.683 ms (Avg)
	Aggregate data query (COUNT)	0.663 ms (Avg)
	Total server-side processing	15.038 ms
	Peak memory per session	2048.0 KB

3. RESULTS AND DISCUSSION

The technical reliability of a system is critical when multiple users use it concurrently. Therefore, a structured load-testing protocol was implemented to measure performance. The system was primarily uploaded with 102 electronic documents, specifically from the academic units and the extension office. This data seed provided sufficient volume to validate the database's indexing efficiency and metadata retrieval accuracy across university units' schemas. There were 15 concurrent system users. Each participant uploaded and retrieved documents, resulting in 75 trials (n=75). This peak-hour administrative traffic simulation was carried out to ensure the system's concurrency management could handle multiple concurrent "Read/Write" requests.

The following are the results of the pilot test conducted to test system stability, acceptance, and utilization of the developed system.

3.1. The developed system architecture

The following offers detailed descriptions of the system architecture, database schema, and module interactions to address the need for greater clarity and replicability. Figure 3 illustrates the system architecture relevant to the analysis of the core modules.

Figure 3 shows a three-tier architecture for the system development that the researchers used. This consisted of the presentation, application, and data layers. In the presentation layer, API gateway and user interface (UI) are the layers where users interact with the system. API Gateway handles information system security and routes API calls to the correct backend services, while the UI is where users can enter commands for the system to follow. Tailwind CSS with PHP was used to design the UI, ensuring responsiveness and attractiveness, and to connect the data to MySQL. For the core modules, the researchers considered the system's functionality modular, with the different services independent and loosely coupled so as not to affect

one another. These modules include document management system (DMS), an analytics-enabled dashboard, reports, and communication and notification. The data layer serves as the storage for all the application data, metadata, documents, user logs, and system configurations.

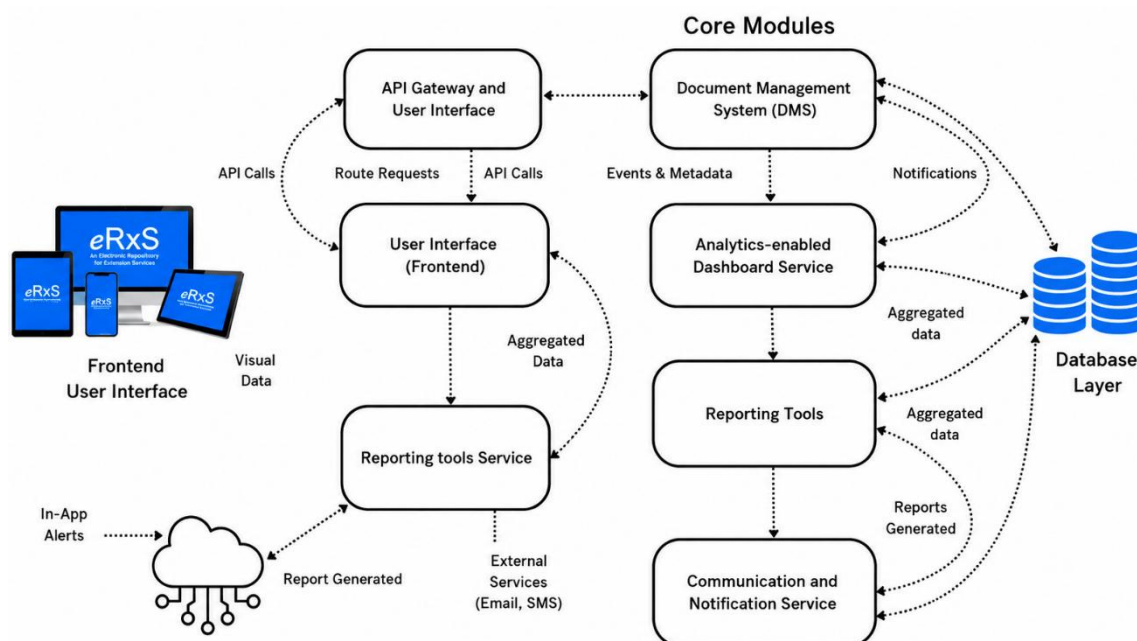


Figure 3. System architectural design

The system was designed and developed as a modular system that integrates multiple functionalities to support the different requirements of higher education extension services. The document management module is a central repository for records related to extension services, such as annual plans, operational plans, accomplishment reports, attendance records, and evaluations, as this study also stated [29]. These consolidated documents on a single platform provide integrated information to support decision-making and structured archiving, minimize redundancy, and enable easy, secure, and fast retrieval.

An addition to the module is the analytics dashboard, which provides real-time visualization and summarization. For data visualization, the researchers adopted the Chart.js library, which implements bar charts, line graphs, and trend visualizations. Analytics is the systematic presentation of data in an organized manner using statistical and computational methods, or the conversion of raw data into visuals that people can interpret and analyze directly. The researchers used descriptive statistics, such as means, percentages, standard deviations, and trend lines, to summarize the data. Through the system's dashboard, coordinators and administrators can easily monitor compliance, identify delays, and obtain actionable insights that strengthen data-driven decision-making.

For the visualization, Chart.js from the JavaScript library was used to further program the different parts of the system's UI that require data to illustrate summaries. Trend analysis enables the UEO to monitor the conduct of activities across all colleges and units in the university.

Another is the performance measures, such as document completeness expressed as a percentage. Data completeness was also monitored through the dashboard, which tracked the percentage of required documents submitted for each project and highlighted missing fields or overdue items. During the pilot phase, document completeness improved from 71% in the manual process to 98% utilizing the system, verified by database log checks. Comparative bar charts are used to measure the alignment of activities with the sustainable development goals, as the university requires all activities to be relevant to the United Nations' SDGs.

To address the office report requirements of both institutional and external stakeholders, the reporting tools module automates the collation of submitted plans and accomplishments into standardized report formats. This feature not only streamlines administrative work but also improves the precision and timeliness of reporting processes.

The last feature is the communication module. These strengthen coordination across extension offices through integrating tools for announcements, reminders, and system-generated updates. Automated notifications ensure due dates are met and that all stakeholders remain informed of ongoing activities.

Collectively, these features position the developed system as a comprehensive, user-focused platform that transitions extension services from manual processes to analytics-driven decision support for university administration. The system offers an integrated, scalable digital solution customized to the operational requirements of extension services in Philippine higher education institutions, similar to the study [30].

The developed system was evaluated using performance testing and a comparative study. In a study [31], these methods provided a complete review of the system's functionality and relevance to extension programs, projects, and activities. This detailed evaluation is critical, as it ensures that technological solutions are not merely functional in theory but also genuinely appropriate and effective in real-world application contexts.

3.2. System stability and technological acceptance

The system was tested with a 75-trial peak-load simulation, achieving full compliance across all tested cases (n=75 trials), meaning uploading documents met the processing threshold in database retrieval with concurrent users at a 3.0-second threshold. The total server-side processing time averaged 15.038 ms, with database retrieval taking 0.541 ms across all 75 trials, and there were zero crashes or database deadlocks during concurrent access of the system developed. Moreover, live benchmarking showed that the system exceeded standard performance thresholds by a wide margin. Total server-side processing time before HTML output rendering was 15.038 ms, with indexed database retrieval taking an exceptional 0.541 ms.

This result provides empirical evidence of the system's stability and scalability. The system's technical efficiency is a critical factor in user compliance. Reducing the time required for document retrieval by the system lowers the cognitive load of unit coordinators, thereby aligning with the technology acceptance model (TAM), which links system performance to organizational adoption of the technology.

This system's technical efficiency is a critical behavioral factor in user compliance, consistent with the literature [32]. By reducing document retrieval time to sub-millisecond latency, the system lowers the cognitive load on unit coordinators. These results align with the TAM, confirming that high system performance and "Perceived Ease of Use" are direct prerequisites for institutional technology adoption [33]. However, this result should be validated in other external institutions, as the testing was only conducted within a single institutional environment using a relatively modest 102-baseline. This will also affect system performance in larger-scale settings and with other higher education institutions with higher document volumes and concurrent users and may yield different results.

3.3. System utilization and document upload trends

The developed system was tested across five distinct organizational entities: 4 academic units and one administrative unit (UEO). Access was provisioned for 15 pilot coordinators. For a realistic end-of-term simulation, the database was initialized with a seed dataset of 102 extension documents. During this evaluation period of the academic year 2024–2025, the dataset grew to 153 requirement files, which served as a baseline for the system's performance. Figure 4 shows the growth of the 102 documents to 153 total document uploads across 5 organizational nodes.

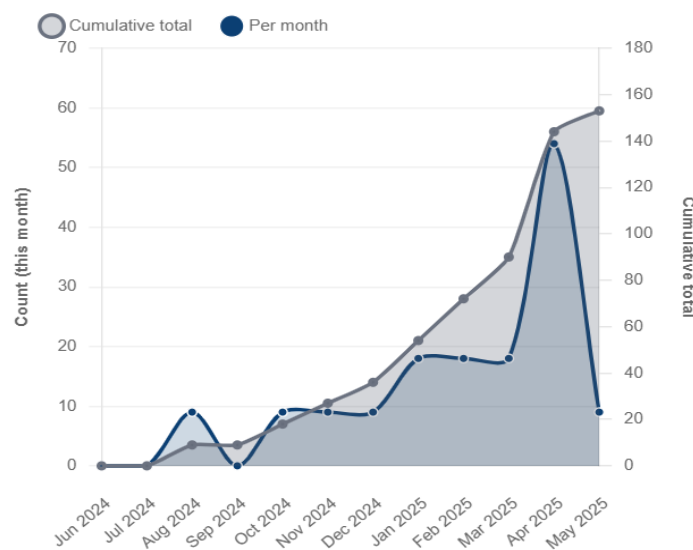


Figure 4. Trend analysis of uploaded documents

Figure 4 illustrates the trend in user engagement throughout the academic year 2024–2025. A cumulative adoption curve that peaked in April 2025 (n=140 uploads) directly correlates with deadlines for end-of-term extension accomplishment reports and returns to baseline levels in May 2025. April is the period when more users access the system, as it is the time for reports and other document submissions. The drop in May accurately reflects the successful conclusion of the administrative report period, indicating that the system was heavily and properly utilized precisely when institutional demand was at its highest.

This implies that a single load test using an aggregate dataset may not fully capture the performance under peak-period conditions. Future evaluations should consider stress-testing the system specifically during simulated high-volume periods to ensure system performance and stability.

3.4. On-time document compliance and behavioral impact

One of the system's primary objectives was to address the compliance lag in manual extensions reporting workflows. The Figure 5 illustrates the before-and-after system comparative on-time compliance rate.

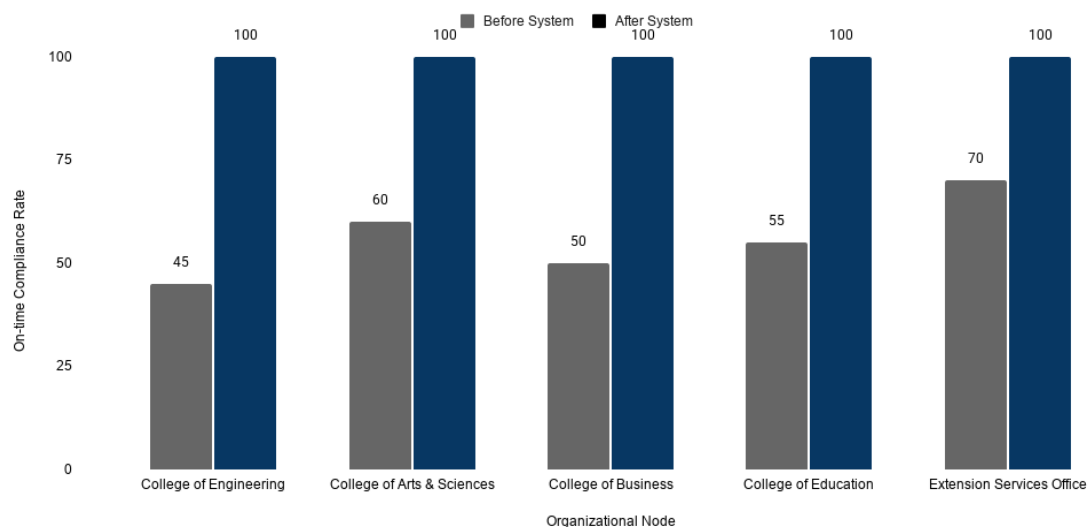


Figure 5. Comparative analysis of on-time compliance rates before system adoption versus the 102-document pilot deployment

As shown in Figure 5, the significant increase in document compliance across the units should not be viewed merely as a passive byproduct of digitalization. It can be a direct behavioral result of integrating the analytics-enabled dashboard. In the manual framework, non-compliance was heavily driven by information asymmetry; users lacked real-time visibility into their submission deficits and were forced to rely on delayed, end-of-term reports, leading to outcomes similar to those in studies [34]. Through Chart.js visualization, the developed system shifted from a reactive to a proactive approach, which aligns with this literature [35]. However, the results of these findings may vary if deployed in a larger-scale institution with a larger number of concurrent users.

It is consistent with behavioral theory, which predicts that timely feedback increases compliance [36], and aligns with our findings. Moreover, the original authors of Feedback Intervention Theory suggest that immediately relevant feedback enhances performance [37]. In our study, the analytics dashboard provided real-time visual cues on task completion, likely triggering goal-oriented behavior. The theory predicts that such real-time feedback raises motivation. Consistent with this, we observed higher compliance post-intervention. Thus, our findings support the theory's claim that rapid feedback is critical for improving compliance.

This implies that the system's capacity to support full compliance under a single institution in conditions observed during the load testing not as proof that the system guarantees full compliance under future and larger-scale conditions. Thus, the researchers suggest that larger-scale or multi-institutional testing be conducted in the future.

4. CONCLUSION

This research presents a comprehensive digital solution tailored to the needs of users of the University of Northern Philippines Extension Office. The system streamlines document management, enables efficient information storage and retrieval, and provides an analytics-enabled dashboard to support evidence-based

decision-making. Benchmarking against existing platforms highlights unique advantages, particularly in analytics dashboards, compliance features, and extension-focused design, which are often lacking in generic repository solutions. Notably, the pilot deployment demonstrated marked improvements in document retrieval efficiency and reporting compliance. The innovative integration of analytics and user-centric features directly addresses the specialized requirements of extension services, distinguishing this system from traditional platforms. These improvements in operational efficiency and compliance underscore its potential for broader institutional impact and for a transparent, data-driven administration aligned with national development goals. Moving forward, analytics-enabled extension service management holds the promise of transforming higher education institutions by fostering a culture of continuous improvement, accountability, and strategic decision-making.

However, the research is not without limitations. The pilot was conducted within a single institution, and broader validation across diverse HEI contexts is necessary to establish generalizability. The current system does not yet integrate IoT-based field data acquisition or energy-aware design, although its modular architecture enables future expansion into these domains. Further research should focus on scaling implementation, enhancing interoperability with open data and civic technology platforms, and exploring integration with embedded sensing for real-time field data collection. Exploring these aspects in future studies could attract interest from HEIs seeking to incorporate advanced data collection into their extension services.

For future research and development, the researchers hereby recommend further enhancing the decision-support functionalities, particularly by expanding the dashboard's analytical capabilities, such as trend analysis, and by adding natural language processing to deepen performance analysis and to further evaluate and analyze client feedback on extension services. Through these suggested improvements, future iterations of the system can serve not only as a localized solution for the University of Northern Philippines but also for the various HEIs across the Philippines and beyond.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization

M : **M**ethodology

So : **S**oftware

Va : **V**alidation

Fo : **F**ormal analysis

I : **I**nterpretation

R : **R**esources

D : **D**ata Curation

O : **O**rganizing - **O**riginal Draft

E : **E**ditorial - **R**eview & **E**diting

Vi : **V**isualization

Su : **S**upervision

P : **P**roject administration

Fu : **F**unding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

DATA AVAILABILITY

Data gathered from the Extension Office of the University was treated with utmost confidentiality, and personal information was excluded from data collection.

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