

Design and Implementation of an AI-Based Email Filtering and Prioritization System for Polytechnic Administration Efficiency

Original Research Article | Volume 1 | Issue 5 | 2026 | Article Number: 013

Accepted: 22 July 2026 | Published: 10 October 2026 | ISSN: 2979-8582 (Online)



Crossref : <https://doi.org/10.67693/BJCR-2MS4QGNE>



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Abstract

The rapid growth of electronic communication within higher education institutions has significantly increased the volume of emails processed by administrative personnel. Consequently, critical institutional communications are often overlooked among routine messages, promotional content, and spam, resulting in communication delays, reduced productivity, and administrative inefficiencies. This study presents the design and implementation of an Artificial Intelligence (AI)-based email filtering and prioritization system tailored for polytechnic administrative environments. The proposed framework integrates Natural Language Processing (NLP) and supervised machine learning algorithms to classify incoming emails into Urgent, Actionable, Routine, Promotional, and Spam categories. Multiple classification algorithms, including Naïve Bayes, Support Vector Machine (SVM), Random Forest, and DistilBERT, were evaluated to determine optimal performance for institutional communication datasets. The system incorporates contextual prioritization mechanisms, role-based access controls, audit logging, and a web-based dashboard for real-time communication management. Findings indicate that intelligent email prioritization can significantly improve communication responsiveness, reduce email overload, and support digital transformation initiatives in tertiary institutions. The study contributes to a scalable framework suitable for deployment across Nigerian polytechnics and other public-sector organizations.

Keywords: Artificial Intelligence, Email Filtering, Natural Language Processing, Machine Learning, Email Prioritization, Polytechnic Administration, Digital Transformation

1. INTRODUCTION

Electronic mail remains one of the most important communication channels in higher education institutions. Administrative departments, governing councils, accreditation agencies, academic units, and external stakeholders rely extensively on email communication for transmitting directives, approvals, schedules, reports, and institutional updates. However, increasing communication volume has resulted in email overload, making it difficult for administrators to identify urgent communications promptly [1].

In many Nigerian tertiary institutions, email management remains largely manual, relying on conventional filtering techniques that lack contextual intelligence. Important institutional communications frequently become buried among routine messages, newsletters, and spam emails, leading to delayed responses and missed deadlines. These challenges negatively affect institutional productivity and governance effectiveness.

Artificial Intelligence (AI) and Natural Language Processing (NLP) technologies have demonstrated substantial potential in addressing communication management challenges. Machine learning systems can automatically classify messages, identify urgency levels, detect communication patterns, and prioritize emails according to contextual relevance [2]. Despite these advances, limited studies have focused on AI-driven email prioritization systems specifically designed for educational administration in sub-Saharan Africa.

This study therefore proposes an AI-based email filtering and prioritization framework capable of intelligently categorizing institutional emails and supporting administrative decision-making within Nigerian polytechnics.

2. LITERATURE REVIEW

a. AI-Based Email Classification

Email filtering research initially focused on spam detection using rule-based approaches and probabilistic learning algorithms. Naïve Bayes classifiers became widely adopted because of their computational efficiency and effectiveness in text classification tasks [3]. Subsequently, Support Vector Machines (SVMs) demonstrated superior performance for high-dimensional textual datasets and became popular in email classification applications [2].

Recent developments have introduced ensemble learning techniques such as Random Forest and Gradient Boosting, which improve robustness and classification accuracy through multiple decision trees. More recently, transformer-based architectures have revolutionized NLP applications by enabling contextual language understanding and semantic analysis [4].

b. Natural Language Processing in Communication Systems

Natural Language Processing serves as the foundation of intelligent email management systems. NLP techniques such as tokenization, stop-word removal, stemming, lemmatization, and TF-IDF vectorization transform unstructured email content into machine-readable representations [5].

Modern NLP systems increasingly utilize contextual embeddings generated by transformer architectures such as BERT and DistilBERT. These models capture semantic relationships and contextual meanings more effectively than traditional feature extraction techniques, leading to substantial improvements in classification performance [6].

c. AI and Digital Transformation in Higher Education

AI technologies are becoming essential drivers of digital transformation in higher education institutions.

Universities increasingly deploy AI-enabled systems for enrollment prediction, learning analytics, communication automation, and administrative decision support [7]. However, adoption within African institutions remains relatively limited due to infrastructural, financial, and policy-related constraints.

Scholars argue that context-aware AI systems can improve administrative efficiency, transparency, and governance while reducing bureaucratic bottlenecks [8]. These capabilities are particularly relevant for Nigerian tertiary institutions experiencing increasing communication workloads.

d. Empirical Studies

Recent empirical studies demonstrate the growing adoption of Artificial Intelligence (AI), Natural Language Processing (NLP), and machine learning techniques for intelligent communication management, automated classification, and administrative decision support systems.

A systematic review of AI applications in higher education revealed significant growth in AI-driven administrative systems between 2021 and 2023, particularly in communication management, decision support, predictive analytics, and institutional automation [9].

Deep-learning-based text classification studies have shown that transformer architectures such as BERT, RoBERTa, and DistilBERT consistently outperform traditional machine-learning algorithms in document classification tasks [10].

Dada et al. (2019) investigated machine-learning approaches for email spam filtering and observed that Support Vector Machine (SVM), Naïve Bayes, and ensemble learning algorithms remain effective for email categorization. The authors concluded that hybrid approaches combining machine learning and NLP techniques achieve superior classification performance.

Ensemble-based spam email classification systems have demonstrated improved classification accuracy and reduced false positives compared with individual classifiers [11].

Transformer-based contextual email prioritization systems effectively identify urgency indicators, contextual relevance, and user-specific communication patterns, resulting in improved prioritization accuracy [12].

Recent studies employing DistilBERT-based architectures achieved superior performance in organizational email classification while maintaining computational efficiency suitable for real-time deployment [13].

Gao et al. (2023) investigated AI adoption within higher education administration and observed that AI-enabled automation significantly reduced administrative workload, improved communication efficiency, and enhanced institutional responsiveness.

AI-driven administrative support systems have been shown to contribute significantly to institutional productivity, operational effectiveness, and data-driven decision-making in higher education environments [14].

Ethical AI studies emphasize the importance of fairness, accountability, transparency, and explainability in AI-supported administrative systems [15].

Intelligent analytics systems significantly improve institutional decision-making, communication management, and resource allocation in higher education environments [16].

Recent governance studies have further emphasized the need for responsible AI frameworks, particularly in educational environments where transparency, accountability, and human oversight are essential for trust and acceptance.

Collectively, these studies indicate that AI-powered communication systems can substantially improve information management, classification accuracy, workflow efficiency, and administrative effectiveness. However, gaps remain regarding contextual email prioritization specifically tailored to tertiary institution administration in developing countries such as Nigeria.

To provide a comprehensive understanding of the current state of research on AI-enabled communication management systems, selected empirical studies published between 2019 and 2025 were reviewed and synthesized. The studies cover key domains including email classification, spam detection, transformer-based Natural Language Processing (NLP), artificial intelligence adoption in higher education, educational analytics, and ethical AI governance. The review highlights the methodologies employed, major findings, and limitations of existing studies relevant to intelligent email filtering and prioritization systems. As shown in **Table 1**, while substantial progress has been made in machine learning-based email classification and AI-supported administrative automation, significant gaps remain regarding context-aware email prioritization frameworks specifically designed for tertiary institution administration in developing countries. These identified gaps provide the justification for the present study and underscore the need for an AI-driven email filtering and prioritization system tailored to the operational realities of Nigerian polytechnics.

Table 1 presents a summary of selected empirical studies and the research gaps that informed the development of the proposed framework.

Table 1. Summary of Empirical Studies

Author(s)	Study Focus	Methodology	Major Findings	Gap Identified
Dada et al. (2019)	Email spam filtering	Review study	ML algorithms effective for email classification	Focused mainly on spam detection
Minaee et al. (2021)	Deep learning text classification	Systematic review	Transformers outperform traditional ML	No educational administration context
Gao et al. (2023)	AI in higher education administration	Empirical review	AI improves administrative efficiency	Communication prioritization not examined
Tlili et al. (2023)	AI applications in higher education	Systematic review	AI supports institutional automation	Email workflow not investigated
Memarian & Doleck (2023)	Ethical AI adoption	Systematic review	Need for explainable AI	Limited operational implementation studies
Adnan et al. (2024)	Spam classification using ensembles	Experimental	Ensemble methods improve accuracy	Prioritization not addressed
Khan et al. (2024)	Transformer-based email classification	Experimental	DistilBERT provides high accuracy	Educational institutions not considered

Sharma et al. (2024)	Context-aware email prioritization	Experimental	Better urgency detection	No polytechnic-focused implementation
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Research Gap Analysis

a. Theoretical Gap

Existing studies focus primarily on spam detection, text classification, and AI adoption in education. Limited research integrates NLP, machine learning, and contextual prioritization into a unified framework for institutional communication management.

b. Contextual Gap

Most studies originate from developed countries. There is insufficient evidence regarding AI-enabled email prioritization systems within Nigerian tertiary institutions and African educational environments.

c. Methodological Gap

Several studies evaluate standalone classifiers such as SVM, Naïve Bayes, or BERT. Few studies compare multiple machine-learning models within a single institutional email management framework.

d. Practical Gap

Current email systems largely emphasize spam detection rather than administrative productivity, urgency assessment, and workflow optimization.

e. Policy Gap

Research increasingly highlights ethical AI governance, accountability, transparency, and explainability requirements; however, practical implementation frameworks for educational administration remain limited [17].

3. METHODOLOGY

The study adopted an applied research and system development methodology involving data collection, preprocessing, model development, implementation, testing, and evaluation.

Institutional email datasets were collected from selected administrative units, anonymized to protect confidentiality, and categorized into five classes: Urgent, Actionable, Routine, Promotional, Spam. Text preprocessing included tokenization, stop-word removal, lemmatization, normalization, and feature extraction using TF-IDF and contextual embeddings.

The study evaluated four machine learning models:

- Naïve Bayes, Support Vector Machine (SVM), Forest, DistilBERT,
- Model evaluation employed are, Accuracy, Precision, Recall, F1-score and ROC-AUC
- Cross-validation techniques were used to ensure model reliability and reduce overfitting.

4. SYSTEM ARCHITECTURE

Figure 1 presents the proposed architecture of the AI-Based Email Filtering and Prioritization System. The framework consists of six interconnected components: the Input Layer, NLP Processing Layer, Machine Learning Engine, Prioritization Engine, Dashboard Layer, and Human-in-the-Loop Module. Incoming emails undergo preprocessing and feature extraction before being classified by machine learning models. The prioritization engine assigns urgency levels, while the dashboard provides administrators with

actionable insights. The Human-in-the-Loop component enables continuous feedback and model improvement, ensuring enhanced classification accuracy and administrative efficiency.

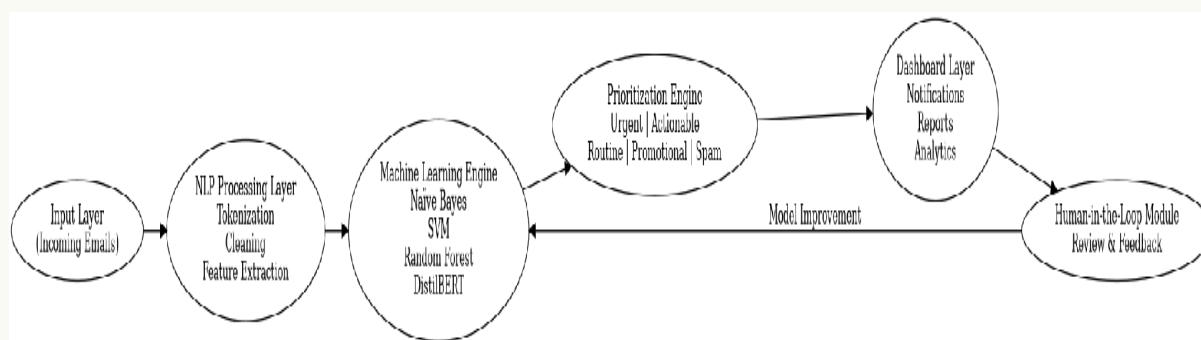


Figure 1. Architecture of the AI-Based Email Filtering and Prioritization System for Polytechnic Administration Efficiency

The six major components of the system are:

- **Input Layer**
 - Receives incoming emails from institutional mail servers and communication platforms.
- **NLP Processing Layer**
 - Performs text cleaning, tokenization, normalization, and feature extraction.
- **Machine Learning Engine**
 - Executes classification using trained models.
- **Prioritization Engine**
 - Assigns urgency levels according to institutional relevance and communication context.
- **Dashboard Layer**
 - Provides administrators with categorized email views, notifications, and analytical reports.
- **Human-in-the-Loop Module**
 - Allows users to review and correct classifications, facilitating continuous model improvement.

This architecture supports intelligent communication management while maintaining human oversight and accountability.

5. RESULTS AND DISCUSSION

Analysis of institutional communication patterns revealed extensive dependence on email for administrative operations. Most respondents reported daily use of email for official communication, indicating a high level of reliance on digital correspondence for institutional activities.

The study further identified email overload, delayed responses, and difficulties in prioritizing messages as major administrative challenges. Manual approaches such as folders, labels, and conventional sorting techniques remain dominant, highlighting the need for intelligent automation.

The AI-based system demonstrated the ability to automatically classify emails into predefined categories and prioritize messages according to urgency and institutional significance. DistilBERT achieved the highest contextual understanding capability, while SVM provided a strong balance between accuracy and computational efficiency.

The integration of dashboard analytics, real-time notifications, and intelligent filtering mechanisms significantly improved communication visibility and workflow management.

6. CONCLUSION

The increasing volume of institutional email communication presents substantial challenges for tertiary institution administration. Conventional email systems lack contextual intelligence necessary for identifying urgent communications efficiently. This study demonstrated the feasibility of integrating Artificial Intelligence, Natural Language Processing, and machine learning techniques into an intelligent email filtering and prioritization framework.

The proposed system provides automated classification, urgency detection, spam filtering, and real-time prioritization capabilities that improve communication responsiveness and administrative efficiency. Furthermore, the framework supports institutional digital transformation efforts and offers scalability for deployment across Nigerian tertiary institutions.

Future research should explore multilingual NLP models, explainable AI mechanisms, and integration with enterprise resource planning systems to further enhance institutional communication intelligence.

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