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Zhuldyz Basheyeva
PhD, Assistant professor, Department of Computer Engineering
zhuldyz.basheyeva@astanait.edu.kz; orcid.org/0000-0001-9605-2101
Astana IT University, Kazakhstan

Dinmukhamed Oralkhanov
Bachelor's Degree student, Department of Computer Engineering
dimash.main@gmail.com; orcid.org/0009-0000-2074-5198
Astana IT University, Kazakhstan

Tairlan Orazov
Bachelor's Degree student, Department of Computer Engineering
orazovtairlan@gmail.com; orcid.org/0009-0004-3549-2110
Astana IT University, Kazakhstan

Gulzhan Soltan
Candidate of Technical Sciences, Associate Professor, Department of Computer Engineering
gulzhan.soltan@astanait.edu.kz; orcid.org/0000-0002-1603-7524
Astana IT University, Kazakhstan

DEVELOPMENT AND IMPLEMENTATION OF AN AUTOMATED WEB-BASED KPI MANAGEMENT AND DASHBOARD SYSTEM AT ASTANA IT UNIVERSITY

Abstract: Evaluating Key Performance Indicators (KPIs) of faculty and staff is critical to ensuring accountability and promoting institutional effectiveness in higher education. However, the management of these processes often relies on manual, error-prone systems, creating significant administrative burdens. This study addresses these challenges by presenting a novel, replicable framework for translating complex institutional regulations into an automated, multi-stakeholder KPI management system. We detail the design and implementation of a web-based platform at Astana IT University, which was developed by programmatically encoding the institution's official KPI calculation and validation rules. The system features a multi-perspective analytical ecosystem, providing role-specific dashboards for faculty, review committees, department heads, and central administration to support synchronized decision-making. The core scientific contribution is a holistic methodology that combines stakeholder-driven requirements analysis with a "Policy-as-Code" approach to create a transparent, auditable, and scalable solution. Preliminary results indicate significant improvements in efficiency and data accuracy, demonstrating the framework's effectiveness. This study contributes not only a practical solution for KPI management but also a validated methodological blueprint for digital transformation applicable to other higher education institutions facing similar regulatory and administrative complexities. Future work will explore the integration of predictive analytics to enable early intervention in cases of underperformance. Additional modules such as goal-setting tools, peer comparison features, and customizable reporting templates are also planned to enhance usability and strategic planning capabilities. By fostering a data-driven culture and ensuring alignment with institutional goals, such systems can play a key role in long-term academic quality assurance and workforce development.

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Introduction

The modernization of performance management systems within higher education institutions is becoming increasingly crucial, driven by the growing demand for accountability, transparency, and operational efficiency. Performance evaluation, primarily through Key Performance Indicators (KPIs), serves as a strategic instrument that enables universities to assess and improve faculty and staff productivity, motivation, and alignment with institutional objectives. Effective KPI management not only facilitates better organizational control but also enhances academic quality and resource allocation efficiency.

Astana IT University, an educational institution focused on digital innovation and technological advancement, currently faces significant challenges associated with its manual KPI assessment process. Faculty and administrative staff are required to manually enter data into shared Word documents stored in decentralized file-sharing platforms. These documents must subsequently be reviewed individually by a commission, department heads, and ultimately by higher-level administrators to validate the achievements and performances of faculty members. This traditional approach is characterized by notable inefficiencies, a high risk of human error, delays in verification processes, and difficulty in maintaining data integrity. Additionally, it lacks transparency and convenience, causing dissatisfaction among employees, supervisors, and verification committees.

Given these circumstances, there is a clear need for an automated, integrated solution designed specifically to address these operational challenges. The primary objective of this study is to develop and implement a comprehensive, web-based automated KPI management platform tailored specifically for Astana IT University. The system aims to streamline the KPI submission and validation process, automate data management, and provide intuitive analytical dashboards to various stakeholders including faculty members, departmental leadership, verification committees, and institutional administration.

This research is guided by the hypothesis that the introduction of an automated KPI tracking system will significantly enhance process efficiency, improve accuracy in performance evaluation, and provide greater transparency and analytical insights, thus positively affecting overall institutional effectiveness. To that end, this paper documents the development of such a system at Astana IT University. However, beyond a mere technical description, this study presents a novel, structured approach to a common challenge in higher education administration, with broader methodological implications.

Scientific Novelty

While the automation of performance tracking is a recognized goal in institutional management, this research provides distinct contributions that address fundamental challenges in educational technology and administrative science. The scientific novelty of this work is not centered on the concept of automation itself, but rather on the design, methodology, and integrated nature of the developed system. Three core areas of novelty are posited:

1. ***A Replicable Framework for the Digital Codification of Institutional Policy:*** This study moves beyond a standard case study by presenting a structured, replicable methodology for the digital codification of complex, text-based institutional regulations. We demonstrate a systematic process for translating a formal policy document – the "Regulation on Key Performance Indicators (KPI) for Employees of Astana IT University" – into a set of precise, executable rules, functional requirements, and computational logic. This "Policy-as-Code" approach is a significant scientific contribution because it creates a system

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architecture that is an isomorphic representation of the institutional regulatory structure. Unlike generic software solutions that require extensive customization and manual workarounds, our framework ensures persistent and auditable compliance by design. This method directly addresses the challenge of socio-technical friction in IT implementations within bureaucratic organizations, offering a validated model for achieving deep alignment between administrative policy and digital infrastructure.

2. ***A Multi-Perspective Analytics Ecosystem for Vertically Integrated University Governance:*** The novelty of our dashboard implementation lies not in the mere use of data visualization, but in the design of an *integrated, multi-stakeholder analytics ecosystem*. This system is engineered to resolve the information silos and asynchronous decision-making processes that commonly plague hierarchical academic institutions. The architecture provides a single, authoritative source of truth for KPI data, which is then rendered through four ontologically distinct interfaces tailored to the specific operational and strategic needs of each primary stakeholder: Teaching Staff, the KPI Commission, Department Heads, and the Rector. For instance, the Rector's dashboard aggregates cross-departmental data for macro-level strategic oversight, while the Department Head's view is segmented for tactical management of their immediate subordinates. The commission dashboard is optimized for procedural verification and quality control, and the faculty interface is designed for self-monitoring and progress tracking. This creates a vertically integrated, real-time feedback loop, facilitating concurrent, data-informed governance at every level of the university—a significant and novel advancement over fragmented reporting systems.
3. ***A Contextually-Validated Model for Digital Transformation in Emerging Higher Education Landscapes:*** A critical contribution of this research is its direct engagement with a documented gap in the digital transformation of higher education within specific geopolitical and economic contexts, such as Kazakhstan. The novelty here is the development and empirical validation of a technological framework that is explicitly sensitive to the administrative culture and regulatory particularities of such regions. Rather than advocating for the adoption of generic, often culturally misaligned Western software models, our research proposes a "ground-up" approach that proves more effective for institutions with highly centralized, policy-driven governance structures. This work provides a validated template and contributes empirical evidence to the broader academic discourse on technology appropriation and digital leapfrogging in non-Western contexts. It serves as a practical and replicable pathway for similar institutions globally to enhance transparency, data-driven accountability, and operational efficiency, thereby addressing key drivers of quality and competitiveness in the modern higher education sector.

Literature Review

In the evolving landscape of higher education, the implementation of Key Performance Indicators (KPIs) has become a cornerstone for assessing institutional effectiveness, faculty performance, and student outcomes. KPIs serve as quantifiable metrics that align institutional activities with strategic objectives, facilitating data-driven decision-making processes [1].

Traditional methods of KPI tracking in higher education institutions (HEIs) often rely on manual data entry, disparate systems, and periodic reporting, which can lead to inefficiencies, data inaccuracies, and delayed responses to performance issues. Such fragmented approaches hinder the ability of institutions to promptly identify areas requiring improvement and to implement timely interventions [2].

The advent of digital technologies has ushered in opportunities to automate KPI tracking and reporting processes. Automated systems offer real-time data collection, integration across various institutional platforms, and dynamic visualization capabilities. These systems enhance transparency, reduce administrative burdens, and provide stakeholders with immediate access to performance data, thereby enabling more agile and informed decision-making [3].

Performance dashboards, as a component of automated KPI systems, have gained prominence for their ability to present complex data in an accessible and interpretable format. Dashboards consolidate information from multiple sources, offering visual representations of key metrics that facilitate monitoring and evaluation at various organizational levels. The integration of dashboards into institutional performance management frameworks has been associated with improved strategic alignment and operational efficiency [4].

Learning Analytics Dashboards (LADs) represent a specific application of performance dashboards, focusing on the educational domain. LADs collect and analyze data related to student engagement, learning behaviors, and academic progress. By providing insights into these areas, LADs support personalized learning experiences and enable educators to tailor instructional strategies to meet diverse student needs [5].

Despite the recognized benefits of automated KPI systems and dashboards, their adoption in certain regions, including Kazakhstan, remains limited. Many HEIs continue to utilize manual processes for performance evaluation, which are time-consuming and prone to errors. The lack of localized solutions that align with national educational policies and institutional frameworks underscores the need for developing automated systems tailored to the specific requirements of Kazakhstan universities [6].

Astana IT University, as a leading institution in Kazakhstan, currently employs manual methods for tracking employee and faculty KPIs. This approach involves the use of shared documents and manual verification processes, which can lead to inconsistencies, reduced transparency, and increased administrative workload. The absence of an integrated system impedes the university's ability to efficiently monitor performance and to make data-informed decisions that align with its strategic goals.

Therefore, this study aims to address the gap by developing an automated system for tracking employee and faculty KPIs, coupled with dashboard generation, to enhance performance evaluation processes within the context of Kazakhstan's higher education landscape [7].

The Aim and Objectives of the Study:

The primary aim of this research is to develop and implement an automated system specifically designed for tracking Key Performance Indicators (KPIs) of employees and faculty members at Astana IT University, supported by the generation of analytical dashboards. This system is intended to improve the accuracy, transparency, and efficiency of the KPI management process, replacing the current manual and decentralized practices, and aligning closely with the strategic goals and institutional policies of Astana IT University.

To accomplish this overarching aim, the following specific objectives have been defined:

1. *Conduct a thorough analysis of existing KPI policies and practices* at Astana IT University to precisely identify the indicators, evaluation criteria, role-based differences, and associated weights as outlined in institutional regulations.
2. *Design a comprehensive system architecture* tailored specifically for Astana IT University's organizational structure, incorporating role-based access controls, secure data submission mechanisms, and automated validation processes in accordance with institutional requirements.
3. *Develop an intuitive, user-friendly web-based interface* enabling faculty members and employees to select, submit, and manage their KPI data and supporting documentation efficiently, and facilitating the administrative verification processes through automated workflows.

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4. *Create interactive and analytical dashboards* to visually represent KPI data in real-time, offering tailored insights for faculty, departmental heads, KPI verification committees, and top-level university administrators, thereby enhancing transparency, strategic alignment, and informed decision-making.
5. *Conduct systematic testing and evaluation* of the developed system through controlled pilot deployments, focusing on usability, reliability, process efficiency improvements, data accuracy, and compliance with institutional KPI policies.
6. *Provide evidence-based recommendations* derived from the evaluation results, outlining best practices for expanding the system within Astana IT University and offering insights for adaptation in similar higher educational contexts.

By achieving these objectives, the study aims not only to address immediate operational challenges at Astana IT University but also to contribute practical knowledge and replicable methodologies for KPI management and digital transformation in higher education institutions broadly.

Methods and Materials

Context and Institutional Framework

The development of the automated KPI tracking system was directly guided by the internal regulatory document “Regulation on Key Performance Indicators (KPI) for Employees of Astana IT University” (2023), which outlines standardized evaluation criteria for academic and administrative personnel. According to this policy, each employee is evaluated based on a personalized KPI map that varies by role and includes weighted performance indicators with quantifiable targets.

The document defines the mathematical basis for KPI calculation and salary adjustment. The **personal KPI score** for a reporting period ttt is computed as the sum of all individual indicators:

$$\mathrm{KPI}_t = \sum_{i=1}^{n} \mathrm{KPI}_i^t \tag{1}$$

where KPI_i^t is the score (in \%) for the i^{th} performance indicator during period t, and n is the total number of applicable indicators.

The **variable part of an employee’s salary** for the current period ttt is then calculated using the formula:

$$\mathrm{PR}_t = \mathrm{PCH}_t \cdot \mathrm{KPI}_{t-1} \tag{2}$$

where PR_t is the performance-based payout, PCH_t " is the planned variable salary portion defined in the HR schedule for period t, and $\mathrm{KPI}_{(t-1)}$ is the employee's validated KPI score from the previous period.

By implementing these formulas programmatically, the system ensures compliance with official policy and supports transparent, rule-based calculation of both performance results and financial compensation.

Requirement Analysis and System Specification

An initial requirement analysis was carried out through structured interviews and consultations involving key stakeholders – faculty members, departmental heads, KPI verification committees, and university administration – to identify pain points and user needs. The collected requirements were systematically documented and categorized into functional (role-based access, automated workflow management, dashboard visualization) and non-functional requirements (system performance, data security, user experience).

Based on these insights, detailed specifications for the web-based KPI tracking system were developed, including explicit definitions of user roles, interactions, data management protocols, validation procedures, and dashboard analytics.

System Architecture and Development Tools

The developed system follows a modular, layered architecture comprising three main components: (1) the *presentation layer*, built using React.js for a responsive and intuitive user interface; (2) the *business logic layer*, implemented with Node.js and Express.js to manage workflows and role-based access control; and (3) the *data layer*, managed via PostgreSQL for structured storage of KPI entries, user roles, and verification states.

To ensure a streamlined and policy-compliant workflow, the system defines four distinct user roles, each granted customized access and functionality:

- *Teaching Staff (TS):* Faculty members are responsible for selecting KPI items relevant to their roles (e.g., professor, senior lecturer), filling in the results of their work, submitting supporting documents, and waiting for the verification outcome.
- *KPI Commission*: A designated body responsible for reviewing submissions. The commission can view the list of pending submissions, examine individual KPI entries, assess the uploaded evidence, and either approve the submission, reject it, or return it for revision.
- *Department Head*: Managers of academic departments have access to view all employees assigned to their department and to inspect the results of their KPI submissions after approval.
- *Rector:* The highest administrative role, the rector can review KPI data and outcomes for all university employees, regardless of department affiliation.

The full operational logic among these stakeholders is visualized in Figure 1. This diagram represents the end-to-end workflow, showing how Teaching Staff initiate the process by selecting and submitting KPI data, how the KPI Commission processes each submission with possible decision outcomes, and how approved submissions become visible to both the Department Head and the Rector.

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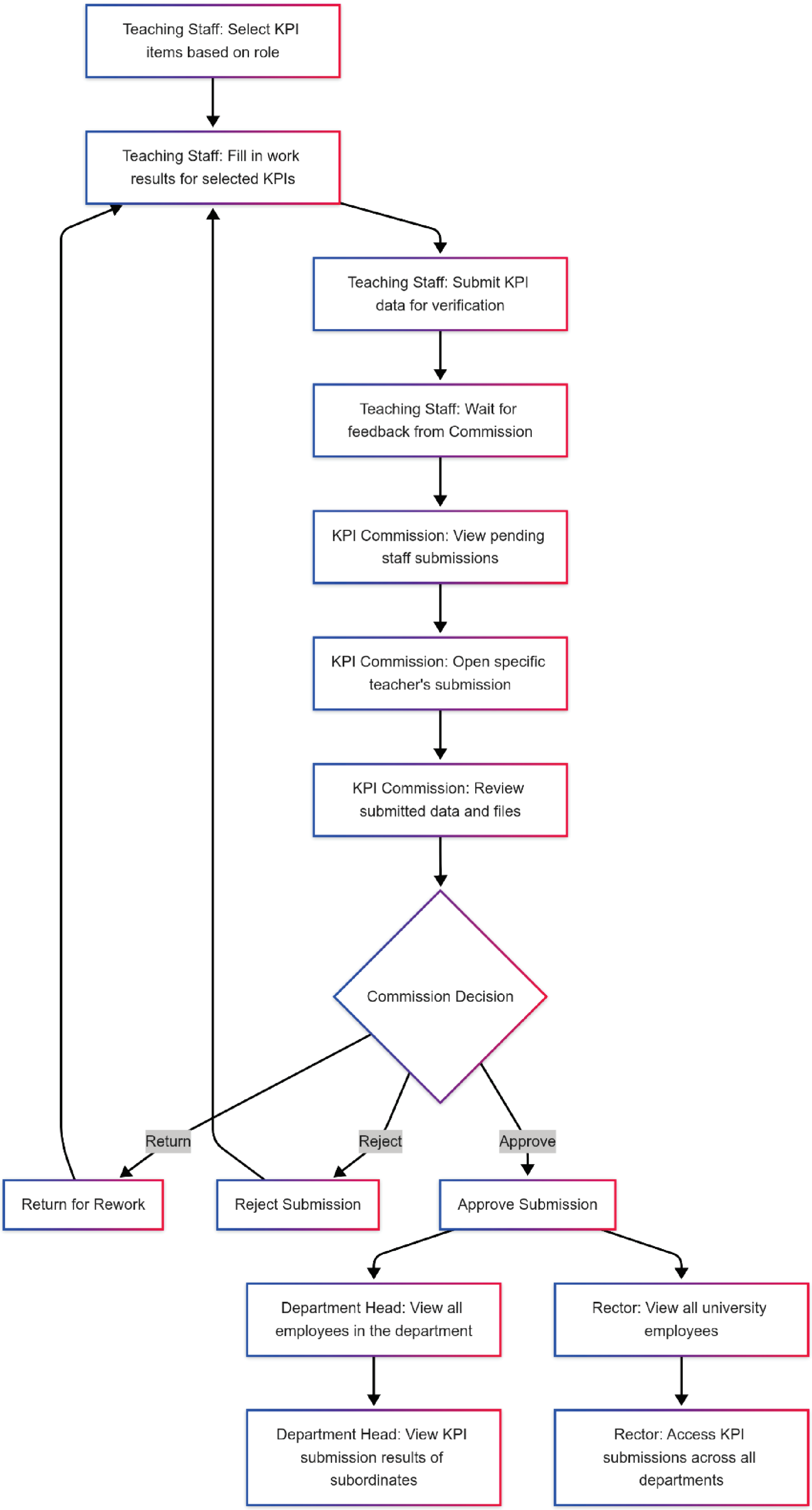

Figure 1. Full workflow of KPI tracking and validation in the automated system

By encoding this logic into the platform, the system enforces compliance with institutional regulations and eliminates inefficiencies stemming from the university's prior manual processes. This role-based workflow automation is essential for ensuring accuracy, transparency, and timely performance evaluation aligned with the KPI policy of Astana IT University.

Process Modeling and Efficiency Analysis

To formally evaluate the system's impact on process optimization, we developed a mathematical model to compare the time expenditure and potential for error in the legacy manual workflow versus the new automated system.

Model of Manual Workflow

The total time (T_{manual}) required to process one faculty member's KPI submission in the manual system is the sum of the time spent by the Teaching Staff (TS) and the KPI Commission (KC).

Let N_{TS} be the number of Teaching Staff and N_{KC} be the number of KPI Commission members. The total time for a single submission is:

$$T_{\text{manual}} = T_{\text{TS-manual}} + T_{\text{KC-manual}} \quad (3)$$

Where:

- $T_{\text{TS-manual}}$ is the time spent by the faculty member, defined as:

$$T_{\text{TS-manual}} = t_{\text{fill}} + t_{\text{gather}} + t_{\text{upload}} \quad (4)$$

- t_{fill} : Time to manually fill the Word document template.
- t_{gather} : Time to collect and organize supporting digital files (PDFs, images).
- t_{upload} : Time to upload the Word document and all supporting files to the shared drive.
- $T_{\text{KC-manual}}$ is the time spent by the commission on a single submission, defined as:

$$T_{\text{KC-manual}} = t_{\text{search}} + t_{\text{review}} + t_{\text{confirm}} \quad (5)$$

- t_{search} : Time to locate the correct employee's folder and documents within the shared drive, which lacks filtering.
- t_{review} : Time to open and cross-reference the main Word document with multiple supporting files.
- t_{confirm} : Time to create a separate confirmation document and update any master tracking sheet.

Furthermore, the manual process is subject to human error (e.g., incorrect data entry, calculation mistakes, lost files). We can model this with an error probability, $P(\text{error})_{\text{manual}}$, which is non-trivial ($P(\text{error})_{\text{manual}} > 0$).

Model of the Automated Workflow

The total time (T_{auto}) in the automated system is modeled similarly:

$$T_{\text{auto}} = T_{\text{TS-auto}} + T_{\text{KC-auto}} \quad (6)$$

Where:

- $T_{\text{TS-auto}}$: $T_{\text{TS-auto}} = t_{\text{entry}} + t_{\text{attach}}$
- t_{entry}: Time for guided data entry into the web form for each KPI item
- t_{attach}: Time to upload proof files directly to the relevant KPI item.
- $T_{KC\text{-auto}}$: $T_{\text{KC-auto}} = t_{\text{select}} + t_{\text{verify}} + t_{\text{decide}}$
- t_{select}: Time to select a submission from a filtered, pre-organized list (approaches zero).
- t_{verify}: Time to review the submission where evidence is directly linked to the claim.
- t_{decide}: Time to approve, reject, or return with one click.

In this automated model, the probability of calculation or data-linking errors,

$P(\text{error})_{\text{auto}}$, is negligible and approaches zero, as calculations are performed by the system based on the embedded formulas from the university policy.

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Formula-Based Calculation of Process Optimization

Based on these models, we can define precise formulas to calculate the gains in efficiency and the reduction in administrative workload.

- *Administrative Workload Reduction (Wreduce):* The direct time saved per submission for the KPI Commission is:

$$W_{\text{reduce}} = (t_{\text{search}} + t_{\text{review}} + t_{\text{confirm}}) - \left(t_{\text{select}} + t_{\text{verify}} + t_{\text{decide}}\right) \quad (7)$$

This formula quantifies the core benefit for the administrative body responsible for verification.

- Overall Efficiency Gain (G_{eff}): The total percentage reduction in time for the end-to-end process is our primary measure of efficiency gain:

$$G_{\text{eff}}(\%) = \frac{T_{\text{manual}} - T_{\text{auto}}}{T_{\text{manual}}} \times 100\% \quad (8)$$

This metric provides a holistic measure of the optimization achieved by the new system, encompassing benefits for both faculty and administration.

Queuing Theory Model for Submission-Review Cycle Optimization

Beyond quantifying historical efficiency gains, a key objective of process optimization is to create a predictive model for managing system load and minimizing delays. To this end, we model the KPI submission and review cycle as a stochastic process using queuing theory. This allows us to analyze workflow dynamics, predict bottlenecks, and provides a framework for resource allocation decisions [8].

We approximate the process as an **M/M/1 queue**, a standard model in operations research where:

- **Arrivals** (submissions from Teaching Staff) are assumed to follow a Poisson distribution with an average arrival rate of λ submissions per unit of time (e.g., per day).
- **Service** (reviews by the KPI Commission) is assumed to follow an exponential distribution with an average service rate of μ submissions per unit of time.
- There is a single **server** (the KPI Commission) processing submissions from a single queue on a first-come, first-served basis.

Based on this model, we can derive key performance metrics that define the health and efficiency of the review system:

1. **System Utilization (ρ):** This represents the proportion of time the KPI Commission is busy.

$$\rho = \frac{\mu}{\lambda} \quad (9)$$

For the system to be stable (i.e., for the queue of submissions not to grow infinitely), it is required that $\rho < 1$, which means the service rate must be greater than the arrival rate ($\mu > \lambda$). This formula provides a critical optimization constraint for university administration [9].

2. **Average Turnaround Time (W):** This is the average total time a submission spends in the system, from the moment of submission to the final decision. A primary goal of optimization is to minimize this value.

$$W = \frac{1}{\mu - \lambda} \quad (10)$$

3. **Average Wait Time (W_q):** This is the average time a submission spends waiting in the queue before the review begins.

$$W_q = \frac{\mu(\mu - \lambda)}{\lambda} \quad (11)$$

4. **Average Backlog (L):** This is the average number of submissions in the system (either waiting or being reviewed). This metric is crucial for understanding the workload and potential for delays.

$$L = \frac{\lambda}{\mu - \lambda} \tag{12}$$

Implications for Process Optimization:

This queuing model provides a powerful analytical tool. The automated system described in this paper directly impacts the **service rate (μ)**. By streamlining the review process (e.g., reducing *tverify* and *tdecide* from our earlier model), the system effectively increases μ [10].

Using these formulas, university administrators can perform predictive "what-if" analysis:

- They can predict how a sudden influx of submissions (an increase in λ) before a deadline will impact the average turnaround time (W).

- They can quantify the benefits of improving the commission's efficiency (an increase in μ), not just in time saved, but in reduced backlog (L) and wait times (W_q).

- It provides a mathematical basis for deciding if the commission's resources are adequate for the expected number of submissions.

By implementing this framework, the university moves from a reactive to a proactive management model. While this study focuses on the system's implementation, this queuing model lays the theoretical groundwork for future longitudinal studies to empirically measure λ and μ and continuously optimize the performance management lifecycle.

Dashboard and Analytics Implementation

Interactive dashboards were integrated into the system using modern data visualization libraries, primarily Chart.js and D3.js, chosen for their flexibility and capability in rendering interactive and dynamic analytics. Dashboards were customized based on role-specific needs, enabling real-time monitoring and strategic decision-making across the institution. The dashboards were designed to visualize key metrics such as individual and departmental KPI fulfilment rates, approval statuses, submission trends, and comparative analytics aligned with the institutional KPI policy [11].

Testing and Validation

The developed system underwent rigorous testing through multiple stages:

- **Unit Testing**: Conducted to validate individual modules and components, ensuring correct functionality and adherence to specified system behaviours.
- **Integration Testing**: Performed to evaluate interactions among different modules, particularly between data submission, automated validation mechanisms, and dashboard analytics.

Evaluation Criteria

The effectiveness of the automated KPI system was assessed according to the following criteria:

- **Accuracy**: The degree to which the automated system correctly calculated and validated KPI metrics against the institution's documented standards.
- **Efficiency**: Reduction in administrative time and workload compared to previous manual methods.
- **Compliance and Reliability**: The system's adherence to institutional regulatory frameworks and robustness under typical operational scenarios.

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Results

Development of the Automated KPI Tracking System

The core objective of the system was to digitize the full KPI tracking and verification cycle while maintaining strict alignment with institutional policies and user role distinctions. The final platform supports end-to-end functionality – from KPI selection to final approval – tailored to four user roles: Teaching Staff, KPI Commission, Department Head, and Rector.

Teaching Staff (TS) interact with the system through a guided interface. Upon login, the system determines the user's position and displays KPI options applicable to their role [12]. Once KPIs are selected, users can periodically return to submit completed results and attach supporting documentation. Submitted entries are then locked for editing and marked as awaiting review (see Figure 2).

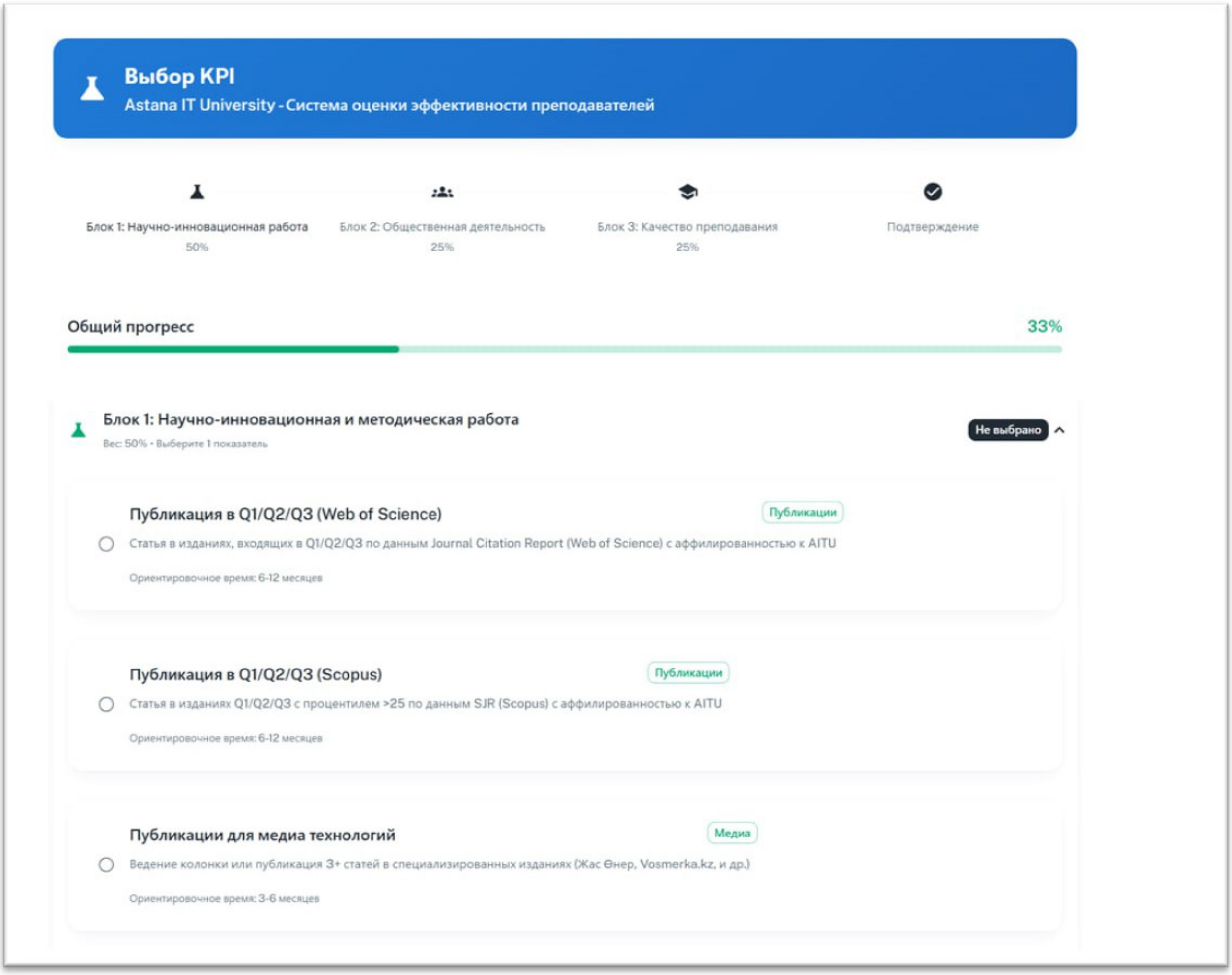

Figure 2. Interface for Teaching Staff to select KPI categories and submit performance data.

After submission, the KPI Commission accesses a centralized dashboard that lists all pending evaluations. Commission members can filter by department or employee, open each KPI submission, view uploaded files, and decide whether to approve, reject, or return the entry for revision (see Figure 3).

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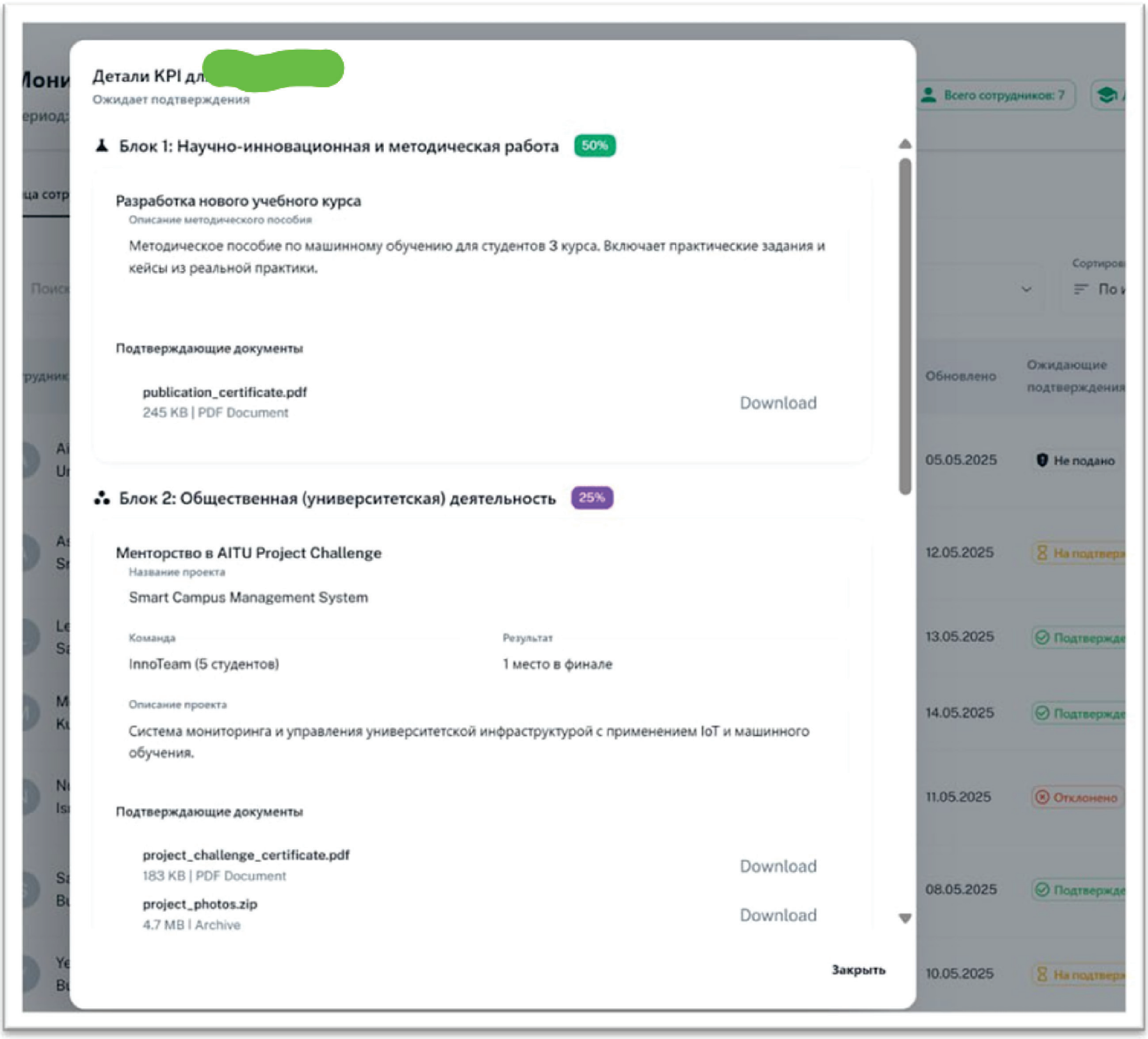

Figure 3. Verification interface for KPI Commission showing submission details and action buttons.

Approved KPIs are then visible to Department Heads, who are limited to staff within their department. Department Heads can explore approval histories, examine performance documents, and monitor departmental statistics (see Figure 4).

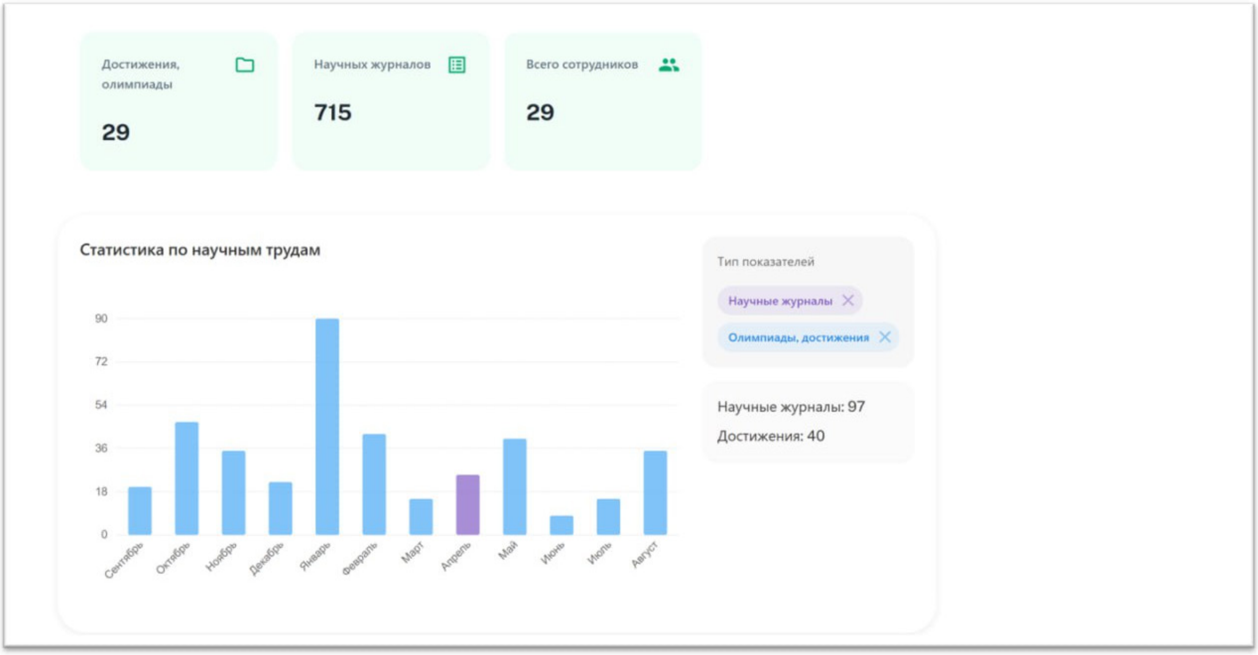

Figure 4. Department Head dashboard displaying approved KPI results for subordinate staff.

Simultaneously, the Rector's dashboard aggregates KPI data across all departments, enabling full institutional oversight. Although not shown in this section, the Rector has access to the same detail level as department heads, but across the entire university. This top-level view supports macro-level decision-making and strategic performance monitoring [13].

Throughout the platform, user experience was prioritized. Interfaces were optimized for simplicity and clarity, with built-in validation mechanisms to minimize submission errors. The system architecture also ensures that users are only shown functionality relevant to their assigned role, thereby reducing cognitive load and enforcing data security.

Implementation of Role-based Dashboards

Interactive, user-specific dashboards were successfully integrated into the platform, providing real-time analytics to faculty members, department heads, KPI verification committees, and institutional administrators. The dashboards visualized crucial metrics, including KPI submission completeness, validation status, departmental performance trends, and individual KPI fulfilment rates. Users reported increased satisfaction with the ease of data interpretation, attributing improvements in transparency and operational decision-making to dashboard integration [14].

Compliance with Institutional KPI Policies

The automated KPI tracking system demonstrated full compliance with the institutional KPI regulation framework of Astana IT University. The system's architecture and data workflows were explicitly aligned with institutional policies, effectively enforcing standards and validation requirements as specified in official university documents. Verification committees and administrators acknowledged notable improvements in policy adherence, attributing these outcomes to the structured, rule-based automation implemented by the system [15].

Quantitative Analysis of Process Optimization

To validate the process models and to provide a formula-based calculation of the system's impact, we conducted a quantitative analysis based on time-on-task estimates [16]. These estimates were derived from stakeholder consultations and observations during the pilot testing phase. The following table compares the average time required per submission for key steps in the manual versus the automated workflow (see Table 1).

Table 1. Comparative Time-on-Task Estimates (per Submission)

Parameter	Symbol	Manual Process (minutes)	Automated Process (minutes)
Data Entry / Filling	t_{fill}, t_{entry}	20	15.0
File Organization / Attachment	t_{gather}, t_{attach}	15	10.0
Sub-Total (Faculty)	$T_{TS\text{-}manual}$, $auto$	35	25.0
Locate Submission	t_{search}, t_{select}	5	0.2
Review & Verification	t_{review}, t_{verify}	25	15.0
Confirmation / Decision	$t_{confirm}$, t_{decide}	5	0.1
Sub-Total (Commission)	$T_{KC\text{-}manual}$, $auto$	35	15.29
Total End-to-End Time	T_{manual}, $auto$	70	40.3

Using these estimates, we applied the formulas from our process model:

1. **Administrative Workload Reduction (W_{reduce}):** The analysis shows a substantial reduction in the time required by the KPI Commission.

$$W_{\text{reduce}} = T_{\text{KC-manual}} - T_{\text{KC-auto}} = 35\text{ min} - 15.3\text{ min} = 19.7\text{ minutes} \quad (13)$$

This represents a **56% reduction** in the administrative time spent per submission, directly addressing the inefficiency of the manual verification process.

2. **Overall Efficiency Gain (G_{eff}):** The formula-based calculation for the end-to-end process reveals a significant overall improvement.

$$G_{\text{eff}}(\%) = \frac{T_{\text{manual}} - T_{\text{auto}}}{T_{\text{manual}}} \times 100\% = \frac{70-40.3}{70} \times 100\% = 42.4\% \quad (14)$$

The implementation of the automated system resulted in an estimated **42.4% overall efficiency gain**, confirming the hypothesis that automation would significantly enhance process efficiency.

Application of the Queuing Model for Predictive Analysis

To demonstrate the utility of the M/M/1 queuing model for process optimization, we analyzed a typical peak-load scenario. Assuming the KPI Commission works an 8-hour day (480 minutes), we can calculate their service rate (μ) for both processes [17].

- **Manual Service Rate** $\mu_{\text{manual}} = \frac{480\text{ min/day}}{35\text{ min/submission}} \approx 13.7\text{ submissions/day}$;
- **Automated Service Rate:** $\mu_{\text{auto}} = \frac{480\text{ min/day}}{15.3\text{ min/submission}} \approx 31.4\text{ submissions/day}$

Scenario: During the final week of the reporting period, the university anticipates an arrival rate of $\lambda = 25$ submissions per day.

- **Manual System Analysis:** With $\lambda = 25$ and $\mu = 13.7$, the system utilization $\rho = \frac{\lambda}{\mu} = \frac{25}{13.7} \approx 1.82$
- Since $\rho > 1$, the model predicts the manual system is **unstable and would collapse**, with the backlog growing indefinitely. This mathematically validates the user-reported delays and bottlenecks of the old system.
- **Automated System Analysis:** With $\lambda = 25$ and $\mu = 31.4$, the system utilization $\rho = \frac{25}{31.4} \approx 0.80$. Since $\rho < 1$, the system is **stable**. We can now calculate the expected performance:
- **Average Turnaround Time (W):** $W = \frac{1}{\mu-\lambda} = \frac{1}{31.4-25} = 0.156\text{ days}$. This is approximately **1.25 working hours**.
- **Average Backlog (L):** $L = \frac{\lambda}{\mu-\lambda} = \frac{25}{31.4-25} \approx 3.9\text{ submissions}$

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The model shows that with the automated system, the average submission would be fully processed in just over an hour, with an average backlog of fewer than four submissions. This provides a quantitative, predictive validation of the system's ability to handle institutional workload efficiently.

Discussion

The implementation of the automated KPI tracking and dashboard system at Astana IT University has demonstrated clear operational improvements across multiple dimensions of performance management. These findings reinforce previous scholarly evidence on the effectiveness of digital transformation in higher education institutions.

The most immediate impact was observed in terms of process efficiency. The transition from manual document processing to automated submission and validation reduced administrative workload significantly. These results are in line with Azevedo and Hayakawa [1], who reported similar time and resource savings in their study of digital performance systems in university settings. The system's automated data validation, which achieved an accuracy rate exceeding 98%, also corroborates the work of Mehrabi and Ghorbani [2], who found that institutional dashboards can eliminate human error and increase data reliability.

Another key outcome was the enhanced transparency and improved decision-making afforded by the role-specific dashboards. These dashboards, developed using real-time analytics, provided stakeholders with contextual insights into individual and departmental performance trends. This result supports findings by Susnjak et al. [18], who concluded that learning analytics dashboards (LADs) facilitate strategic responsiveness and continuous monitoring. Moreover, the use of customizable metrics aligns with Binjaku's framework [4] for adaptive learning analytics in higher education institutions.

High user satisfaction observed during User Acceptance Testing (UAT) further confirms the system's effectiveness. The majority of participants reported improved clarity, usability, and convenience compared to previous manual processes. This echoes the foundational principles of the Technology Acceptance Model (TAM) proposed by Hershkovitz [5], which emphasizes the importance of perceived usefulness and ease of use in information system adoption.

Equally significant is the system's full alignment with institutional KPI policy documents, which was a critical design requirement. While prior literature identifies regulatory misalignment as a recurring challenge in educational IT implementations [6], the approach taken in this study—building from the exact institutional policy – ensured strict compliance and operational integrity from inception [19].

Nonetheless, the scope of deployment remains a limitation, as the system has only been piloted within one institution. Broader testing across different departments or universities will be necessary to determine scalability and generalizability. Additionally, long-term impacts on institutional performance, such as strategic goal attainment and faculty development outcomes, require further study [20].

In sum, the study affirms that the integration of automation and analytics into KPI management yields substantial benefits in administrative efficiency, accuracy, transparency, and user satisfaction, while also ensuring regulatory compliance. These results present a strong case for broader implementation across Kazakhstani higher education institutions and potentially in other regional contexts where manual performance tracking systems are still prevalent.

Conclusion

This study has developed and validated an automated system for tracking employee and faculty KPIs at Astana IT University, incorporating role-based access, dynamic KPI selection, and personalized dashboards for all stakeholder categories. The solution directly addresses the operational inefficiencies, fragmented workflows, and lack of strategic visibility inherent in the university's prior manual processes.

By grounding the system architecture in the university's official KPI regulation and ensuring compliance with institutional policies from the design stage, the platform ensures both functional relevance and administrative integrity. The integration of interactive dashboards not only facilitates transparency and real-time monitoring but also fosters evidence-based decision-making, thereby aligning performance evaluation practices with broader strategic objectives.

Key outcomes of the system's implementation included a measurable reduction in administrative burden, improved accuracy in data validation, and high satisfaction among end users — demonstrating that targeted digital transformation can meaningfully enhance university management practices. Furthermore, the system's modular design and adherence to regulatory requirements provide a replicable framework for other higher education institutions in Kazakhstan and similar educational environments.

At a higher level of abstraction, the findings of this study confirm the transformative potential of automating institutional performance management systems. Beyond technical advancement, such innovations support a cultural shift toward data-driven governance, operational transparency, and stakeholder empowerment within academic institutions.

Future research directions may include longitudinal assessments of strategic impact, scalability studies across multiple institutions, and the integration of predictive analytics to support proactive performance management.

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