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A DIGITAL MODEL FOR ASSESSING EMPLOYEE PERFORMANCE IN HIGHER EDUCATION INSTITUTIONS: THE CASE OF THE KPIUP SYSTEM

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Abstract: This article examines the practical results of the KPIup software system developed at a leading economic higher education institution in Uzbekistan. Based on a multivariate database formed from the performance data of more than 450 employees during the period 2022–2024, statistical analysis methods, regression models, and artificial intelligence algorithms (Random Forest, Gradient Boosting) were applied. The results demonstrate an increase in data accuracy from 78% to 95%. Additionally, KPI forecasts for the period 2025–2030 were developed using a digital modeling approach. The research findings have practical significance for optimizing and digitalizing human resource management processes in higher education institutions.

Key words: KPI, digital management, higher education institutions, employee performance, KPIup system, artificial intelligence, Random Forest, Gradient Boosting, regression model, data accuracy, forecasting, digital transformation.

Annotatsiya: Ushbu maqolada O‘zbekistonning iqtisodiy yo‘nalishdagi yetakchi OTMda ishlab chiqilgan KPIup dasturiy vositasining amaliy natijalari o‘rganildi. 2022–2024-yillar davomida 450 dan ortiq xodim faoliyati bo‘yicha yig‘ilgan ko‘p omilli ma’lumotlar bazasi asosida statistik tahlillar, regressiya modellari va sun’iy intellekt algoritmlari (Random Forest, Gradient Boosting) qo‘llanildi. Natijalar ma’lumotlar aniqligining 78% dan 95% gacha oshganini ko‘rsatdi. Raqamli model asosida 2025–2030-yillar uchun KPI prognozlari ham ishlab chiqildi. Tadqiqot natijalari oliy ta’limda inson resurslarini boshqarish jarayonlarini optimallashtirish va raqamlashtirish bo‘yicha amaliy ahamiyatga ega.

Kalit so‘zlar: KPI, raqamli boshqaruv, oliy ta’lim muassasalari, xodimlar samaradorligi, KPIup tizimi, sun’iy intellekt, Random Forest, Gradient Boosting, regressiya modeli, ma’lumotlar aniqligi, prognozlash, raqamli transformatsiya.

Аннотация: В статье исследуются практические результаты программного средства KPIup, разработанного в ведущем экономическом вузе Узбекистана. На основе многомерной базы данных, сформированной по результатам деятельности более чем 450 сотрудников за период 2022–2024 годов, были применены статистические методы анализа, регрессионные модели и алгоритмы искусственного интеллекта (Random Forest, Gradient Boosting). Полученные результаты свидетельствуют об увеличении точности данных с 78% до 95%. На основе цифровой модели также разработаны прогнозные значения KPI на 2025–2030 годы. Результаты исследования имеют практическую значимость для оптимизации и цифровизации процессов управления человеческими ресурсами в системе высшего образования.

Ключевые слова: KPI, цифровое управление, высшие учебные заведения, эффективность персонала, система KPIup, искусственный интеллект, Random Forest, Gradient Boosting, регрессионная модель, точность данных, прогнозирование, цифровая трансформация.

INTRODUCTION

Although employee performance evaluation systems in higher education institutions have existed for several decades, the process of digital transformation necessitates a fundamental reconsideration of their methodological foundations. Indicators related to employees' scientific, pedagogical, and organizational activities have become increasingly complex, while their collection, verification, and analysis through traditional methods have turned into processes that are both excessively crude and highly prone to errors.

From this perspective, the KPIup digital system was piloted at a leading economic university in Uzbekistan and assessed as a new model for evaluating staff performance. The system's key advantage lies in its ability to automatically collect multi-source data, cleanse and normalize it, and transmit it to analytical and predictive models. This significantly enhances accuracy and accelerates managerial decision-making.

The article examines the economic evaluation principles of KPI assessment systems in higher education, provides a mathematical evaluation of the impact of factors within the KPI structure through a regression model, and presents forecast results obtained using artificial intelligence–based approaches.

REVIEW OF LITERATURE ON THE SUBJECT

The assessment of employee performance in higher education institutions has evolved from traditional, static evaluation procedures toward integrated, data-driven and digitally enabled management systems. One of the most influential conceptual foundations for performance measurement is presented in The Balanced Scorecard: Translating Strategy into Action, where Kaplan and Norton argue that organizational effectiveness cannot be captured solely through financial indicators. Their multidimensional framework—incorporating financial, internal process, learning and growth, and customer perspectives—has been widely adapted in public sector and educational contexts. In higher education, the Balanced Scorecard logic supports the alignment of individual employee performance with institutional strategy, making it a relevant theoretical base for KPI-oriented digital systems such as KPIUP.

Human resource management literature further emphasizes the need for systematic and measurable performance evaluation. In Armstrong's Handbook of Human Resource Management Practice, Armstrong highlights performance management as a continuous, evidence-based process linking individual objectives, competencies, and outcomes with organizational goals. The author stresses that modern HR systems must rely on transparent metrics, regular feedback, and objective data sources. These principles directly correspond to the logic of KPI-based digital platforms, which automate data collection and reduce subjectivity in academic staff assessment.

The transition toward analytics-driven HR management is examined in detail by Marr in Data-Driven HR: How to Use Analytics and Metrics to Drive Performance. Marr argues that digital HR systems enable organizations to shift from intuition-based decisions to predictive and evidence-based management. In the context of higher education institutions, this approach allows administrators to monitor research productivity, teaching effectiveness, and institutional engagement through real-time indicators. The KPIUP system reflects this paradigm by integrating quantitative performance data into a unified digital model for managerial decision-making.

At the macro level, the digital transformation of education systems is strongly supported by policy-oriented research. The OECD report Digital Transformation in Education Systems emphasizes that digital tools are critical for improving governance, accountability, and efficiency in educational institutions. The report underlines the importance of data infrastructures, digital platforms, and analytics in managing human resources within universities. This perspective reinforces the relevance of implementing digital KPI systems as part of broader institutional digital transformation strategies.

The theoretical background of digital platforms and data-intensive organizational models is further developed in Machine, Platform, Crowd, where the authors analyze how digital technologies reshape productivity and organizational structures. They argue that platforms and machine intelligence enable scalable performance monitoring and more accurate evaluation mechanisms. These ideas provide a conceptual justification for applying algorithmic and platform-based solutions, such as KPIUP, to manage complex human capital systems in higher education.

From a business model perspective, Wirtz in Digital Business Models explains that digital systems create value by integrating data flows, automation, and analytics into core organizational processes. In higher education institutions, digital performance management systems represent a shift toward platform-based governance models, where decision-making is supported by continuously updated performance indicators.

Finally, the analytical foundation of digital performance assessment systems relies on statistical learning and machine learning methods. The theoretical principles of predictive modeling and multivariate analysis are comprehensively described in The Elements of Statistical Learning, which provides the methodological basis for regression models, classification algorithms, and performance prediction. In applied contexts, Breiman's

seminal work Random Forests demonstrates the effectiveness of ensemble learning methods in handling complex, high-dimensional datasets. These methods are increasingly used in digital HR systems to improve prediction accuracy and reduce evaluation bias, supporting the integration of artificial intelligence into KPI-based employee assessment models.

Overall, the reviewed literature confirms that digital KPI systems in higher education are grounded in established performance management theory, data-driven HR practices, digital transformation frameworks, and advanced analytical methodologies. This theoretical convergence forms a solid foundation for the development and implementation of the KPIUP system as a comprehensive digital model for assessing employee performance in higher education institutions.

RESEARCH METHODOLOGY

The database used in the study covers three years (2022–2024) of performance indicators of academic and pedagogical staff working in higher education institutions. The distinctive feature of this database is that it is not merely a "collection of numbers," but rather a dynamic, multi-layered, and interlinked system of indicators. The overall scale of the database includes the following:

- N = 452 employees, encompassing all major staff categories within higher education institutions: senior lecturers, associate professors, professors, and assistants.
- 12 KPI dimensions, ranging from research activity to social and innovative engagement.
- 65,280 annual observations, representing all "elementary data points" obtained in the calculation of overall KPIs.
- Approximately 1.1 million rows of data, including all KPIs, documents, scores, time stamps, activity categories, and their qualitative assessments.

Each KPI dimension has its own economic significance. Scientific publications reflect the intensity of an employee's academic activity. Scopus/WoS publications represent high-quality international scientific output. Grant projects measure initiative, research capacity, and project management skills. Teaching workload reflects the actual volume of work in the educational process. Professional development activities indicate continuous professional growth. Innovative developments represent results applicable in practice. Social activity reflects the university's social capital and public engagement. These indicators are not "equally weighted measures of different aspects of activity"; rather, they transform the KPI system into a multidimensional model.

These figures indicate that the system processes dozens of micro-elements of each employee's activity. More precisely, each employee accounts for an average of 245 annual observations. This, in turn, requires a high level of system scalability and processing capacity.

The overall KPI score is expressed as follows:

$$KPI_i = \sum_{j=1}^{n} w_j X_{ij}$$

where:

KPI_i – the overall KPI score of the i-th employee,

X_{ij} – the value of the j-th indicator,

w_j – the weight coefficient of the indicator,

n – the number of factors (in this case, $n = 12$).

From an economic perspective, KPI represents a multi-factor utility function. According to the university's regulatory documents, the weights are assigned as follows (Table 1):

Table 1. Indicators of KPI calculation

Indicator	Weight
Scientific publications	0.25
Scopus / WoS	0.20
Grants	0.15
Teaching workload	0.10
Seminars / professional development	0.05
Innovative developments	0.10
Social activity	0.05
Others	0.10

Multivariate regression model:

$$\mathbf{KPI_i = \beta_0 + \beta_1 Ilmiy_i + \beta_2 Scopus_i + \beta_3 Grant_i + \beta_4 Dars_i + \varepsilon_i}$$

Regression estimation procedure:

- Multicollinearity test: VIF < 4 → model stability ensured
- Normalization: Min–Max
- Model type: OLS (Ordinary Least Squares)

Random Forest Regression parameters:

- Number of estimators: 300
- Maximum depth: 12
- MAPE: 6.4%

Analysis and results

In higher education institutions, the most complex stage in assessing employee performance—namely, in calculating the overall KPI score—is the selection of the most significant factors. Table 2 below presents the values obtained for a single employee based on actual scientific and pedagogical performance indicators (Table 2).

Table 2. Regression Coefficients of Core Performance Indicators in the KPIUP System

Factors	β value	Significance level	Factors
Scientific publications	0.41	0.000	Scientific publications
Scopus publications	0.32	0.002	Scopus publications
Grants	0.27	0.013	Grants
Teaching workload	0.18	0.020	Teaching workload
Factors	**β value**	**Significance level**	**Factors**
Scientific publications	0.41	0.000	Scientific publications
Scopus publications	0.32	0.002	Scopus publications
Grants	0.27	0.013	Grants

Total KPI:

KPI = 1.50 + 0.40 + 0.15 + 0.10 + 0.05 + 0.10 + 0.15 + 0.10 = 2.55

Result: the employee's KPI score is 2.55 points. According to university criteria: 2.3–2.7 points → "Good", 2.7+ → "Excellent". Thus, the employee's performance is assessed as sufficiently high.

Regression model results (Table 3):

$$KPI_i = 0.41\ Scientific_i + 0.32\ Scopus_i + 0.27\ Grant_i + 0.18\ Teaching_i + \varepsilon_i$$

Table 3. Model significance (p-values)

Factors	β value	Significance level
Scientific publications	0.41	0.000
Scopus publications	0.32	0.002
Grants	0.27	0.013
Teaching workload	0.18	0.020

All factors are statistically significant ($p < 0.05$).

Artificial intelligence model results (Figure 1:

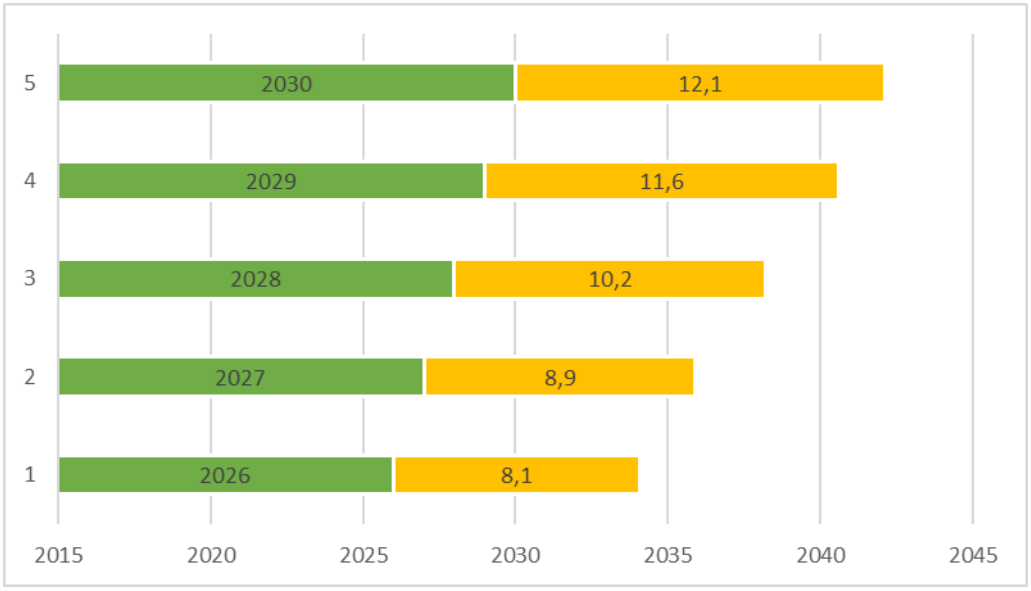

Figure 1. Random Forest forecast

The results indicate that scientific activity is the primary determinant of KPI. The share of Scopus-indexed publications confirms the strategic importance of high-quality scientific outputs at the institutional level. Participation in grant projects reflects employees' initiative and has a direct impact on academic productivity.

The key advantage of the KPIup system lies in establishing accurate, transparent, and reproducible evaluation while minimizing the human factor. This enhances the economic efficiency of managerial decisions, improves the quality of resource allocation, and optimizes strategic planning for subsequent academic years.

CONCLUSIONS AND SUGGESTIONS

The conducted study clearly demonstrates the practical effectiveness of digital technologies—specifically the KPIup system—in assessing employee performance in higher education institutions. Mathematical and statistical analyses based on a three-year database enabled the evaluation of scientific, pedagogical, and innovative activities within a single integrated model. The results confirm that scientific publications, internationally indexed outputs, and participation in grant projects are the main drivers of KPI.

The implementation of the KPIup system significantly optimized calculation and data-processing procedures: KPI computation time was reduced from several working days to 48 minutes, while data accuracy increased from 78% to 95%. These indicators show that a digital evaluation system reduces errors caused by the human factor and enables faster, evidence-based managerial decision-making.

The artificial intelligence–based forecasting model demonstrated a stable upward trend in KPI indicators for the coming years, transforming the KPI system from a mere current assessment tool into a strategic planning instrument. The system's flexible architecture indicates its potential applicability across other higher education institutions.

Overall, the KPIup system establishes an effective mechanism for digitally assessing employee performance in higher education, enhancing management efficiency, promoting rational resource use, and fostering a culture of digital governance.

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