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Artificial Intelligence Drives Optimization and Precision Governance of University Teaching Management Decisions

Wei Tao [1*]

[1]School of Mathematical Science and Application, Nanjing Normal University Taizhou College ,Taizhou, 225300, China

Corresponding Email address list：

Wei Tao, School of Mathematical Science and Application, Nanjing Normal University Taizhou College ,Taizhou, 225300, China Email: taow8111@163.com

Abstract

Background: Artificial intelligence (AI) offers new opportunities to optimize teaching management and enable precision governance through predictive analytics, intelligent optimization, and decision-support systems.

Objective: This study aimed to examine how AI drives the optimization and precision governance of university teaching management decisions, focusing on decision efficiency, resource allocation, teaching quality responsiveness, differentiated governance, and transparency.

Methods: A mixed-methods research design was employed, integrating quantitative AI-based modeling with qualitative governance analysis. Multi-source institutional data, including teaching administration records, learning analytics, teaching evaluation data, and policy documents, were analyzed over a three-year period. Machine learning models were applied for prediction tasks, optimization algorithms were used for resource allocation, and natural language processing was employed to analyze qualitative feedback. Semi-structured interviews with teaching management personnel complemented quantitative findings.

Results: AI-driven teaching management significantly reduced decision cycle time and administrative workload, improved classroom utilization and faculty workload balance, and enhanced predictive accuracy for key governance outcomes. Teaching quality issues were identified more rapidly, corrective interventions increased, and overall teaching evaluation scores improved. Importantly, AI enabled differentiated, data-driven governance across departments and student subgroups while increasing decision transparency, consistency, and stakeholder trust.

Conclusion: Artificial intelligence substantially enhances the optimization and precision of university teaching management decisions. By supporting proactive, differentiated, and transparent governance, AI serves as a critical enabler of evidence-based and adaptive teaching management. Responsible implementation, supported by ethical safeguards and human-in-the-loop governance, is essential to fully realize its transformative potential in higher education.

Keywords: **Artificial Intelligence, Optimization, Precision, Teaching Management Decisions**

Introduction

Universities are complex organizations that integrate teaching, research, administration, and social service functions within increasingly dynamic and data-intensive environments. In recent decades, higher education systems worldwide have faced unprecedented challenges, including massification of enrollment, diversification of student populations, intensified competition for resources, accountability pressures, rapid technological change, and growing expectations for educational quality and equity. Traditional university teaching management models—largely reliant on experience-based decision-making, static regulations, and fragmented information systems—are increasingly insufficient to address the complexity, uncertainty, and real-time responsiveness required in contemporary higher education governance[1-3]. Against this backdrop, **Artificial Intelligence (AI)** has emerged as a transformative force capable of reshaping how universities optimize teaching management and achieve precision governance. Teaching management decision-making in universities encompasses a broad range of activities, including curriculum planning, faculty workload allocation, student assessment systems, academic scheduling, quality assurance, and continuous improvement of teaching and learning processes[4-6]. These decisions are inherently multi-dimensional, involving heterogeneous stakeholders, competing objectives, and large volumes of structured and unstructured data. Conventional management approaches often struggle to integrate these data streams effectively, resulting in delayed feedback, suboptimal resource allocation, and limited personalization in teaching governance. As higher education systems move toward evidence-based and learner-centered paradigms, there is a growing need for intelligent decision-support mechanisms that can process complex data, identify hidden patterns, and provide actionable insights with high precision[7].

Artificial Intelligence, encompassing machine learning, deep learning, natural language processing, and intelligent optimization algorithms, offers powerful tools to address these challenges. By enabling automated data integration, predictive analytics, and adaptive decision-making, AI has the potential to significantly enhance the scientific rationality, efficiency, and transparency of university teaching management. Unlike traditional information systems that primarily support descriptive reporting, AI-driven systems can shift governance from retrospective analysis to predictive and prescriptive decision-making, thereby supporting proactive interventions and continuous optimization[8-11].

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One of the most significant contributions of AI to university teaching management lies in its capacity to support precision governance. Precision governance refers to a governance model that emphasizes accuracy, personalization, timeliness, and differentiated management based on granular data analysis[12]. In the context of university teaching, this means moving beyond one-size-fits-all policies toward targeted strategies that respond to the specific needs of students, instructors, disciplines, and institutional contexts[13]. AI technologies can analyze learning behavior data, teaching evaluation records, curriculum outcomes, and institutional performance indicators at multiple levels, enabling administrators to identify at-risk students, detect teaching quality deviations, and optimize curriculum structures with unprecedented accuracy[14]. Furthermore, AI enables the optimization of teaching management decisions by enhancing resource allocation and operational efficiency. Universities operate under increasing budgetary constraints while facing growing demands for teaching innovation and quality assurance. AI-based optimization models can support data-driven decisions regarding class scheduling, classroom utilization, faculty deployment, and course offerings, reducing inefficiencies and minimizing conflicts between competing objectives[15-17]. By simulating alternative scenarios and evaluating their outcomes, AI systems can assist decision-makers in selecting governance strategies that balance educational quality, equity, and cost-effectiveness.

Another critical dimension of AI-driven teaching management optimization is its role in improving teaching quality assurance and continuous improvement mechanisms. Traditional evaluation systems often rely heavily on periodic surveys and manual reviews, which may suffer from subjectivity, low response rates, and delayed feedback[18-20]. AI can enhance these processes by integrating multiple data sources—such as student learning analytics, teaching interaction logs, textual feedback, and peer evaluation data—and applying advanced analytical techniques to generate comprehensive, real-time assessments of teaching effectiveness. This not only supports more objective and nuanced evaluations but also enables timely feedback loops that foster reflective teaching practices and evidence-based professional development.

In addition, AI contributes to the transformation of governance structures by promoting greater transparency and accountability in teaching management decisions. Algorithmic decision-support systems can document data inputs, analytical processes, and decision rationales, thereby reducing information asymmetry and enhancing trust among stakeholders. When appropriately designed and governed, AI systems can support participatory governance by providing accessible insights to administrators, faculty members, and policymakers, facilitating collaborative decision-making grounded in shared evidence[21]. Despite its transformative potential, the integration of AI into university teaching management also raises important challenges and risks. Issues related to data privacy, algorithmic bias, interpretability, and ethical governance must be carefully addressed to ensure that AI-driven decision-making aligns with educational values and institutional missions. Moreover, the effectiveness of AI systems depends not only on technological sophistication but also on organizational readiness, governance frameworks, and the capacity of decision-makers to interpret and act upon AI-generated insights. Therefore, the application of AI in teaching management should be understood as a socio-technical transformation rather than a purely technical upgrade[22].

Within this context, it is essential to systematically examine how AI drives the optimization and precision governance of university teaching management decisions. Existing studies often focus on isolated applications—such as learning analytics or intelligent tutoring systems—while less attention has been paid to AI's integrative role in institutional-level governance and decision-making[23-25]. A comprehensive perspective that connects AI technologies with governance theory, management science, and educational practice is needed to fully understand the mechanisms through which AI reshapes teaching management and to identify pathways for sustainable and responsible implementation[26].

This study aims to address this gap by exploring the conceptual foundations, functional mechanisms, and practical implications of AI-driven optimization and precision governance in university teaching management. By analyzing how AI supports data integration, decision optimization, and targeted governance interventions, this research seeks to provide a systematic framework for understanding the evolving role of AI in higher education governance. Ultimately, the study contributes to the broader discourse on digital transformation in education by elucidating how AI can enhance the effectiveness, fairness, and adaptability of university teaching management in an increasingly complex and data-rich environment.

Methodology

Study Design

This study adopts a mixed-methods research design integrating quantitative data modeling with qualitative policy and governance analysis to systematically examine how artificial intelligence drives optimization and precision governance in university teaching management decision-making. A mixed-methods approach is appropriate given the dual nature of the research problem, which involves both measurable operational outcomes (e.g., decision efficiency, allocation optimization, predictive accuracy) and governance-related processes (e.g., policy responsiveness, managerial transparency, and decision

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rationality). The methodological framework combines data-driven modeling, system simulation, and expert-informed qualitative analysis to ensure both analytical rigor and contextual validity.

Study Setting and Data Sources

The study was conducted using multi-source institutional data from a comprehensive university teaching management system over a three-year period. Data sources included:

1. **Teaching administration data**, such as course scheduling records, faculty workload allocations, classroom utilization logs, and curriculum structures.
2. **Learning analytics data**, including student enrollment trends, course completion rates, assessment outcomes, and learning behavior indicators derived from learning management systems.
3. **Teaching quality evaluation data**, encompassing student feedback, peer review summaries, and teaching supervision reports.
4. **Policy and governance documents**, such as teaching regulations, academic policies, and strategic planning reports relevant to decision-making processes.
5. **Semi-structured expert interviews**, conducted with university administrators, academic leaders, and teaching management personnel to capture governance perspectives and contextual insights.

All data were anonymized prior to analysis to ensure confidentiality and compliance with institutional data governance policies.

Artificial Intelligence Framework and Decision Models

An AI-driven teaching management decision framework was constructed to support optimization and precision governance objectives. The framework consisted of three functional layers: data processing, analytical modeling, and decision support.

At the **data processing layer**, structured and unstructured data were integrated using data cleaning, normalization, and feature extraction techniques. Natural language processing was applied to textual evaluation data to extract sentiment and thematic indicators related to teaching quality and management effectiveness.

At the **analytical modeling layer**, machine learning algorithms were employed to support predictive and optimization tasks. Supervised learning models were used to predict key teaching management outcomes, such as course demand fluctuations, student performance risk, and faculty workload imbalance. Unsupervised clustering techniques were applied to identify patterns and heterogeneity across departments, courses, and student groups, thereby supporting differentiated governance strategies. Optimization algorithms were implemented to simulate alternative decision scenarios for course scheduling, resource allocation, and staffing arrangements, with objective functions designed to balance efficiency, equity, and quality indicators.

At the **decision support layer**, AI outputs were translated into interpretable decision recommendations through dashboards and rule-based guidance modules. This layer emphasized explainability to ensure that administrators could understand and evaluate AI-assisted recommendations before implementation.

Precision Governance Indicators and Outcome Measures

To evaluate the effectiveness of AI-driven optimization and precision governance, a structured indicator system was developed based on governance theory and teaching management objectives. Key outcome dimensions included:

- **Decision efficiency**, measured by reductions in decision cycle time and administrative workload.
- **Resource allocation optimization**, assessed through improvements in classroom utilization rates, faculty workload balance indices, and scheduling conflict reductions.
- **Teaching quality responsiveness**, evaluated by changes in teaching evaluation scores and the timeliness of corrective interventions.
- **Governance precision**, operationalized as the degree of differentiated decision-making across student groups, disciplines, and teaching units based on data-driven insights.
- **Decision consistency and transparency**, assessed through alignment between AI recommendations, implemented decisions, and documented policy rationales.

Quantitative indicators were standardized to allow cross-dimensional comparison and longitudinal analysis.

Qualitative Analysis and Governance Interpretation

To complement quantitative modeling, qualitative analysis was conducted using expert interviews and policy document review. Semi-structured interviews explored perceptions of AI-assisted decision-making, changes in governance practices, perceived benefits, and implementation challenges. Interview transcripts were analyzed using thematic coding to identify recurring patterns related to precision governance, decision accountability, and organizational adaptation.

Policy documents were analyzed to examine how AI insights were incorporated into formal decision-making procedures and whether governance mechanisms evolved toward greater data-driven precision. Triangulation between qualitative findings and quantitative results was used to enhance the robustness and interpretability of conclusions.

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Analytical Procedures and Validation

Statistical and modeling analyses were conducted using standard analytical software environments. Model performance was evaluated using appropriate accuracy, stability, and error metrics, and sensitivity analyses were performed to assess robustness under varying assumptions. For optimization models, scenario comparison analyses were conducted to evaluate trade-offs among competing governance objectives. Qualitative credibility was enhanced through peer debriefing and iterative validation with domain experts. The integration of quantitative and qualitative findings followed a convergence model, enabling cross-verification and comprehensive interpretation.

Ethical Considerations

Ethical considerations were integral to the methodological design. Data usage adhered to institutional data protection regulations, and access was restricted to authorized research personnel. Algorithmic bias and fairness were explicitly monitored by examining model performance across different student and faculty subgroups. The study emphasized human-in-the-loop decision-making to ensure that AI served as a decision support tool rather than an autonomous authority, aligning technological innovation with educational values and governance responsibility.

Results

Overview of AI-Driven Teaching Management Outcomes

The implementation of the artificial intelligence–driven teaching management decision framework produced significant improvements across multiple dimensions of university governance. Quantitative analyses demonstrated enhanced decision efficiency, optimized resource allocation, improved teaching quality responsiveness, and increased governance precision. Qualitative findings further corroborated these outcomes by revealing shifts toward data-driven, transparent, and differentiated decision-making practices. The results are presented across six thematic areas corresponding to the study's analytical framework.

Decision Efficiency Improvements

Table 1 presents a comparison of key decision efficiency indicators before and after the implementation of the AI-driven decision-support system.

Table 1. Changes in Teaching Management Decision Efficiency

Indicator	Pre-AI Period	Post-AI Period	Percentage Change
Average decision cycle time (days)	14.6	8.2	−43.8%
Manual administrative workload (hours/month)	312	185	−40.7%
Revisions per decision cycle	2.4	1.3	−45.8%
Emergency decision interventions (%)	18.5	9.2	−50.3%

As shown in Table 1, AI-assisted governance substantially reduced decision cycle time and administrative workload. The reduction in emergency interventions indicates that predictive analytics enabled more proactive management, minimizing reactive and ad hoc decisions. These findings demonstrate that AI not only accelerated decision-making but also improved its anticipatory capacity.

Optimization of Teaching Resource Allocation

Resource allocation efficiency was a central objective of AI-driven optimization. **Table 2** summarizes changes in key resource utilization metrics.

Table 2. Teaching Resource Allocation Optimization Outcomes

Indicator	Baseline	AI-Optimized	Improvement
Classroom utilization rate (%)	68.3	82.7	+14.4
Faculty workload variance index	0.42	0.26	−38.1%
Scheduling conflicts per semester	127	51	−59.8%
Course capacity mismatch rate (%)	21.6	11.2	−48.1%

AI-driven optimization algorithms significantly improved classroom utilization and reduced faculty workload imbalance. The sharp decline in scheduling conflicts reflects the effectiveness of scenario-based optimization models. These results indicate that AI enabled more equitable and efficient allocation of teaching resources, aligning institutional capacity with actual teaching demand.

Predictive Accuracy of Teaching Management Models

The performance of machine learning models in predicting key teaching management outcomes is presented in **Table 3**.

Table 3. Predictive Model Performance for Teaching Management Outcomes

Outcome Variable	Model Type	Accuracy / AUC	Precision	Recall
Course enrollment demand	Gradient boosting	0.89	0.87	0.85
Student academic risk	Random forest	0.86	0.84	0.82
Teaching quality deviation	Support vector machine	0.83	0.81	0.79
Faculty workload imbalance	Neural network	0.88	0.86	0.84

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The predictive models achieved consistently high performance across multiple governance-relevant outcomes. Particularly strong results were observed for enrollment demand and workload imbalance prediction, enabling early adjustments in course offerings and staffing plans. These findings confirm the technical robustness of the AI framework and its suitability for operational governance applications.

Teaching Quality Responsiveness and Feedback Loops

AI integration substantially enhanced the responsiveness of teaching quality management. **Table 4** compares teaching quality intervention metrics before and after AI implementation.

Table 4. Teaching Quality Management Responsiveness

Indicator	Pre-AI	Post-AI	Change
Time to identify quality issues (weeks)	6.8	2.9	−57.4%
Corrective actions initiated per semester	24	47	+95.8%
Average teaching evaluation score	4.01	4.28	+6.7%
Negative feedback recurrence rate (%)	31.4	18.9	−39.8%

The reduced detection time demonstrates the value of real-time analytics and natural language processing of feedback data. The increase in corrective actions, coupled with improved evaluation scores and lower recurrence of negative feedback, suggests that AI-supported interventions were both timely and effective, contributing to continuous teaching quality improvement.

Precision Governance and Differentiated Decision-Making

A core contribution of AI was its ability to support differentiated governance strategies. **Table 5** illustrates governance precision indicators across teaching units.

Table 5. Precision Governance Indicators Across Teaching Units

Governance Dimension	Traditional Model	AI-Driven Model
Department-level differentiated policies (%)	22.5	61.3
Student subgroup–specific interventions (%)	18.9	54.6
Discipline-tailored curriculum adjustments (%)	25.4	63.1
Uniform policy reliance (%)	74.2	36.5

The AI-driven model markedly increased the proportion of differentiated decisions while reducing reliance on uniform policies. This shift reflects a transition toward precision governance, where decisions are tailored based on granular data rather than generalized assumptions. These findings align with the theoretical premise that AI enables more responsive and context-sensitive governance.

Governance Transparency and Decision Consistency

Finally, the impact of AI on governance transparency and consistency is presented in **Table 6**.

Table 6. Governance Transparency and Decision Consistency Outcomes

Indicator	Pre-AI	Post-AI
Documented decision rationale rate (%)	46.8	88.2
Alignment between recommendations and decisions (%)	52.3	81.6
Stakeholder trust score (5-point scale)	3.2	4.1
Appeals related to teaching decisions (%)	14.7	6.5

AI-supported decision logs and explainable recommendation modules significantly enhanced transparency. The improved alignment between recommendations and final decisions indicates more consistent governance practices. Increased stakeholder trust and reduced appeals further suggest that AI-driven precision governance contributed to perceived fairness and legitimacy.

Discussion

This study provides systematic empirical evidence that artificial intelligence (AI) can substantially enhance the optimization and precision governance of university teaching management decisions. By integrating predictive analytics, optimization modeling, and explainable decision-support mechanisms, the AI-driven framework demonstrated measurable improvements in decision efficiency, resource allocation, teaching quality responsiveness, governance precision, and transparency[13-16]. These findings extend existing discussions on digital transformation in higher education by moving beyond instructional-level applications of AI and empirically validating its governance-level value.

AI as a Catalyst for Decision Optimization in Teaching Management

One of the most salient findings of this study is the significant improvement in decision efficiency following AI integration. The reduction in decision cycle time and administrative workload indicates that AI effectively addresses long-standing inefficiencies associated with manual, experience-based governance models. Traditional teaching management decisions

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often involve iterative coordination among multiple departments, reliance on static historical data, and delayed feedback mechanisms. The AI-driven framework mitigated these limitations by enabling real-time data integration and predictive modeling, allowing decision-makers to anticipate issues rather than react to them[17].Importantly, efficiency gains did not come at the expense of decision quality. On the contrary, the observed reduction in decision revisions and emergency interventions suggests that AI-supported decisions were more robust and better aligned with institutional realities[18]. This finding supports the argument that AI enhances not only the speed but also the rationality of governance decisions, reinforcing its role as an enabler of evidence-based management in higher education.

Resource Allocation and the Resolution of Structural Imbalances

The results demonstrate that AI-driven optimization significantly improved the allocation of teaching resources, including classrooms, faculty workloads, and course capacities. Universities frequently struggle with structural mismatches between supply and demand, leading to underutilized facilities, faculty overload in some units, and inefficiencies in course scheduling. The substantial reduction in scheduling conflicts and workload variance observed in this study highlights AI's capacity to reconcile competing constraints through multi-objective optimization[20-22]. From a governance perspective, these outcomes are particularly important. Resource allocation decisions are often sources of internal tension and perceived inequity within universities. By relying on transparent, data-driven optimization models, AI can reduce subjective bias and increase the perceived fairness of decisions. This aligns with broader governance principles emphasizing equity, accountability, and rational justification in public and institutional decision-making.

Predictive Analytics and Proactive Governance

The strong performance of predictive models across multiple teaching management outcomes underscores the strategic value of AI for proactive governance. Accurate prediction of course demand, student academic risk, teaching quality deviations, and workload imbalance enables administrators to intervene early, allocate resources dynamically, and design targeted support mechanisms. This predictive capability represents a fundamental shift from reactive governance toward anticipatory and adaptive management[23-26]. The implications of this shift are substantial. Proactive governance reduces the likelihood of crisis-driven decisions, enhances institutional resilience, and supports continuous improvement. Moreover, predictive insights allow universities to align teaching management decisions more closely with strategic objectives, such as improving student success, enhancing teaching quality, and optimizing resource utilization under budgetary constraints.

Teaching Quality Responsiveness and Continuous Improvement

The findings related to teaching quality responsiveness provide compelling evidence that AI can strengthen quality assurance systems. The marked reduction in the time required to identify teaching quality issues reflects the effectiveness of integrating learning analytics and natural language processing into evaluation processes[9-11]. Traditional teaching evaluations are often retrospective and episodic, limiting their usefulness for timely improvement. AI-enabled real-time analytics, by contrast, support continuous monitoring and rapid feedback loops. The increase in corrective actions, coupled with improved evaluation scores and reduced recurrence of negative feedback, suggests that AI-supported interventions were not merely more frequent but also more effective[27-29]. This reinforces the view that AI can function as a powerful tool for fostering reflective teaching practices and supporting professional development. However, it is important to emphasize that these benefits depend on the integration of AI insights into human decision-making processes, rather than their automatic enforcement.

Precision Governance and Differentiated Decision-Making

A central theoretical contribution of this study lies in its empirical validation of AI-enabled precision governance in university teaching management. The substantial increase in differentiated policies and subgroup-specific interventions demonstrates that AI facilitates a departure from uniform, one-size-fits-all governance models. By revealing heterogeneity across departments, disciplines, and student populations, AI enables administrators to tailor decisions to specific contexts and needs[30]. This transition toward precision governance has important implications for educational equity and effectiveness. Differentiated governance allows institutions to allocate resources and design interventions where they are most needed, thereby improving outcomes without unnecessary expenditure. At the same time, precision governance challenges traditional bureaucratic norms and requires new managerial competencies, including data literacy and interpretive capacity among decision-makers.

Transparency, Trust, and Governance Legitimacy

The observed improvements in governance transparency and decision consistency highlight an often-overlooked dimension of AI adoption in higher education. The increased documentation of decision rationales and alignment between AI recommendations and final decisions suggest that AI can strengthen procedural transparency. This, in turn, contributes to higher stakeholder trust and reduced appeals related to teaching management decisions. These findings counter common concerns that AI-driven governance may undermine transparency or accountability. When designed with explainability and human oversight, AI systems can enhance rather than erode governance legitimacy. However, this outcome is contingent

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on careful system design, clear governance frameworks, and explicit ethical guidelines governing data use and algorithmic decision support.

Organizational and Ethical Implications

While the results are largely positive, they also underscore the importance of viewing AI adoption as a socio-technical transformation. The effectiveness of AI-driven teaching management depends not only on algorithmic performance but also on organizational readiness, data governance structures, and institutional culture. Resistance to change, limited data quality, and insufficient interpretive capacity among administrators can constrain the benefits of AI. Ethical considerations remain paramount. Issues related to data privacy, algorithmic bias, and fairness must be continuously monitored, particularly when AI-driven decisions affect students and faculty in differentiated ways. The study's emphasis on human-in-the-loop decision-making reflects a governance model in which AI augments, rather than replaces, human judgment. This approach is essential for aligning technological innovation with the normative values of higher education.

Theoretical and Practical Contributions

Theoretically, this study extends governance and management literature by empirically linking AI technologies with the concept of precision governance in higher education. It demonstrates how AI operationalizes governance principles such as efficiency, equity, transparency, and responsiveness through concrete decision-support mechanisms. Practically, the findings provide actionable insights for university leaders and policymakers seeking to implement AI-driven teaching management systems.

Limitations and Future Research Directions

Several limitations should be acknowledged. The study was conducted within a single institutional context, which may limit generalizability. Future research should examine multi-institutional and cross-national settings to assess contextual variability. Additionally, longer-term studies are needed to evaluate the sustainability of AI-driven governance outcomes and their impact on educational quality over time. Further research should also explore faculty and student perceptions in greater depth to better understand the social implications of precision governance.

Conclusion

In summary, the findings demonstrate that artificial intelligence can play a transformative role in optimizing and refining university teaching management decisions. By enhancing efficiency, enabling predictive and differentiated governance, and strengthening transparency, AI serves as a powerful enabler of precision governance in higher education. When implemented responsibly and embedded within robust governance frameworks, AI has the potential to support more adaptive, equitable, and evidence-based teaching management systems in an increasingly complex educational landscape.

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