Enhancing Teaching Management And Instructional Coordination Through AI-Enabled Multi-Agent Collaboration In Higher Education

Chunhua Du[1*], Qingpo Liu[1], Wenjie Ji[2], and Xiaohui Zhang[1]

[1] Zhejiang A&F University
[2] College of Economics and Management, Nanjing Agricultural University
[*] Corresponding author. E-mail: dch@zafu.edu.cn

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Artificial Intelligence (AI) technology is driving a profound educational transformation, shifting from a supplementary instructional tool toward a strategic enabler of teaching management and instructional coordination. In traditional educational settings, teachers shoulder extensive responsibilities, which creates growing challenges in balancing instructional quality with increasing managerial and administrative demands. A critical issue is how AI can be leveraged to reduce teaching management burdens while improving the efficiency and coordination of instructional processes. To address this issue, this study investigates an AI-enabled multi-agent collaborative approach to support teaching management across the instructional workflow. The coordinated operation of multiple pedagogical AI teaching assistant supports core management functions, including lesson planning, assessment design, grading, learning progress monitoring, and instructional feedback coordination. The study is based on a real-world pilot implementation in a university setting and adopts a descriptive evaluation framework drawing on system usage data and faculty and student feedback. Results from nearly one year of application indicate that AI-supported teaching management can reduce lesson preparation time by approximately 70%, improve grading efficiency by about 90%, and enable rapid generation of multiple exam paper versions. These findings suggest that AI-enabled multi-agent collaboration can serve as an effective support mechanism for more efficient and coordinated teaching management in higher education.

Keywords: Educational Transformation; Multi-Agent Collaboration; Instructional Management; Teaching Governance; Artificial Intelligence

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1. Introduction

The rapid advancement of Artificial Intelligence (AI) has catalyzed profound changes in how higher education systems are organized, managed, and delivered. As universities increasingly adopt digital and data-informed practices, AI has emerged not only as a tool for instructional enhancement but also as a strategic driver reshaping teaching management, instructional coordination, and academic governance. Recent scholarship highlights the growing role of AI in supporting large-scale instructional management processes and enabling more adaptive and efficient approaches to teaching management that are responsive to learner needs. [1–3]. These developments coincide with persistent challenges in traditional teaching management structures. Instructors must navigate expanding class sizes, diverse learner needs, and rising expectations for individualized instruction while simultaneously managing heavy administrative obligations such as lesson planning, assignment creation, grading, reporting, and monitoring student progress. These time-intensive, fragmented tasks restrict educators' capacity to engage in interactive pedagogy, provide timely feedback, and pursue instructional innovation.

Against this backdrop, AI technologies—ranging from intelligent tutoring systems and multimodal generative models to learning analytics and automated assessment engines—have demonstrated substantial potential to support and reconfigure teaching management. Advances in machine learning and natural language processing have expanded AI's functionality from isolated instructional tools to integrated components of educational management ecosystems. Research indicates that AI now assists decision-making across the entire instructional lifecycle, including design, delivery, assessment, and evaluation [4]. Large language models and AI teaching assistant increasingly serve dual roles: supporting student learning while simultaneously assisting instructors with managerial tasks such as content generation, assignment management, learner monitoring, and communication [5]. Empirical studies further show that AI can automate evaluation, streamline feedback cycles, coordinate learning activities, and reduce workflow redundancy, thereby improving instructional efficiency and enabling personalized learning at scale [6, 7].

These developments also illuminate persistent limitations within traditional teaching models. Manual preparation, grading, and progress tracking impose substantial cognitive and administrative burdens on teachers, hindering their ability to adapt instruction responsively or monitor large cohorts effectively. The difficulty of delivering personalized learning at scale remains a central challenge, as conventional structures lack the data-driven insight necessary to identify and support diverse learner trajectories [8]. This challenge is particularly acute in domains such as language learning and STEM education, where timely, task-specific feedback and continuous diagnostic assessment are essential [9–11]. AI-enabled tools offer pathways to address these limitations by automating repetitive tasks, providing real-time analytics, generating tailored learning materials, and facilitating differentiated instruction. Studies demonstrate that AI-supported feedback systems, VR-based adaptive learning environments, and generative AI assistants can enhance both instructional management and student learning processes [12–14]. At the institutional level, AI is increasingly recognized as a mechanism for strengthening academic governance and improving coordination across teaching units. AI-driven analytics support curriculum refinement, workload balancing, early-warning interventions, and longitudinal monitoring of instructional quality [15]. Ethical and human-centered AI frameworks further emphasize the importance of ensuring transparency, fairness, and responsible data use in teaching management [16]. Collectively, these developments position AI not merely as a technology for enhancing classroom instruction but as a catalyst for transforming the broader management of teaching activities in higher education.

Building on these trends, this study examines how AI-enabled multi-agent collaboration can enhance teaching management by optimizing instructional workflows, supporting routine managerial tasks, and strengthening data-informed teaching governance. In this context, "multi-agent collaboration" refers not merely to the presence of multiple AI components, but to a coordinated teaching management mechanism in which AI teaching assistants assume complementary roles across the instructional workflow. This collaboration is realized through a structured division of labor and workflow-based coordination among agents responsible for tasks such as lesson planning, assessment support, grading, learning progress monitoring, and instructional feedback coordination. Rather than focusing on system development, this work emphasizes how such coordinated operation among AI teaching assistants can help instructors reallocate time from administrative labor to pedagogical engagement while providing administrators with actionable insights for monitoring instructional effectiveness and guiding academic interventions. By conceptualizing AI as a managerial partner embedded within the teaching process, this study contributes to ongoing educational reform and advances the understanding of how AI-driven systems can promote more efficient, responsive, and student-centered teaching management in higher education.

To clarify the research focus and provide a clear analytical structure for the Methods and Results sections, this study is guided by the following research questions:

- RQ1: How can AI-enabled multi-agent collaboration be used to support and coordinate key teaching management tasks across the instructional workflow in higher education?
- RQ2: To what extent does the adoption of an AI-supported multi-agent approach improve teaching management efficiency, particularly in terms of lesson preparation, assessment, and grading processes?
- RQ3: How do faculty and students perceive the managerial value of AI-enabled multi-agent support in enhancing instructional coordination and teaching management practices?

While existing research on AI in education has largely focused on AI-assisted instructional tools that support content delivery and student learning, comparatively less attention has been paid to AI-supported teaching management processes that coordinate, monitor, and govern instructional activities. The research questions outlined above address this gap by focusing on teaching management as a complex, workflow-driven practice embedded in everyday instructional operations. Addressing such questions requires not only conceptual analysis, but also an operational approach capable of capturing how management tasks are coordinated, executed, and evaluated in real educational settings. A system-based implementation therefore provides a practical means to examine how AI-enabled multi-agent collaboration can be integrated into routine teaching management workflows, allowing management mechanisms to be observed, applied, and assessed in context. Accordingly, this study adopts a system-supported, real-world pilot approach as the methodological foundation for investigating AI-supported teaching management rather than isolated instructional assistance.

2. Materials and methods

This section outlines the research approach, system design, and evaluation methods used in the development and application of the AI-driven collaborative teaching platform. The methodology includes a description of the platform's architecture, the data collection process, and the evaluation framework used to assess the effectiveness of the system in enhancing teaching and learning.

2.1. Data Collection

Data collection was conducted over a one-year pilot implementation of the platform at a University. To establish an accurate understanding of the system's deployment scale, multiple datasets were incorporated. As illustrated in Fig. 1, the platform supported a total of 101 courses, 56 teachers, 87 teaching classes, and 58 academic majors, serving 1,599 students across different disciplines. These data provide an overview of the platform's operational context and user coverage during the evaluation period. Moreover, anonymized student performance data—including assessment scores, participation in interactive learning activities, and progression along personalized learning pathways—were collected to analyze learning behaviors and outcomes. Platform usage logs were also extracted, capturing the frequency and types of AI-driven functions accessed by teachers and students. Together, these datasets enabled a comprehensive analysis of how different features of the platform contributed to teaching efficiency, learner engagement, and instructional effectiveness.

2.2. System Design

The platform is designed to address long-standing management challenges across the entire teaching process by enabling multi-modal information perception, intelligent reasoning, and data-informed decision-making. These capabilities form a closed-loop management model of "Perception–Decision–Execution," allowing the system to support key instructional workflows rather than functioning merely as a technological tool. Built upon a MaaS (Model-as-a-Service) foundation and a multi-agent collaborative mechanism, the platform integrates more than 50 intelligent teaching agents that operate across pre-class preparation, in-class instruction, and post-class evaluation. Two core subsystems—the AI Teaching Assistant and AI Learning Assistant—collectively support teaching management by reducing administrative workload, coordinating routine instructional tasks, and enhancing personalized student support (see Fig. 1).

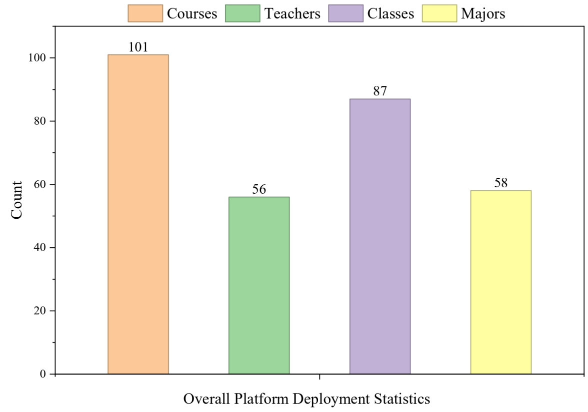

Fig. 1. Overall Platform Deployment Statistics

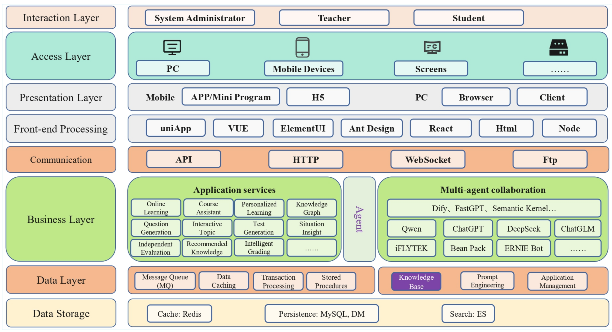

Fig. 2. UP Teaching Platform System Architecture

To ensure effective teaching management and seamless integration of AI-driven support, the platform operates through several functional layers, including interaction, access control, communication, service processing, and data management layers. The interaction layer delivers a unified interface for teachers and students, while the access and communication layers ensure secure and real-time connectivity. The service and data layers coordinate intelligent task execution, manage instructional resources, and support analytics-driven decision-making. Together, these layers enable a stable and scalable environment for multi-agent collaboration, reinforcing the platform's role in optimizing instructional management.

Ai-driven components The heart of the system is its integration of advanced AI technologies that power key educational features such as content generation, automated grading, and personalized learning. The AI-driven components rely heavily on large-scale models and algorithms that enable seamless integration across teaching tasks.

Ai for lesson planning and content generation The platform uses advanced LLMs like GPT-3, DeepSeek, and Tongyi Qianwen for automating lesson content generation. Teachers can input relevant keywords or upload materials, and the system intelligently generates a variety of questions across different formats, including multiple-choice, short answer, and essay-based questions. These models utilize Natural Language Processing (NLP) techniques, which allow the platform to understand context and generate pedagogically relevant content. Technologies like PyTorch and TensorFlow are used to train and fine-tune these models, ensuring accurate and dynamic content creation.

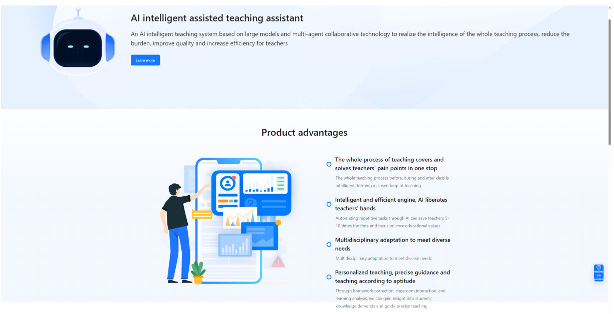

Fig. 3. Overview of the AI Teaching Assistant module on the UPUP Class platform

Automated grading system The platform automates grading for both objective and subjective assessments. For objective questions, the system uses traditional rule-based algorithms for instant scoring. For subjective responses such as essays or open-ended answers, the system leverages NLP algorithms like BERT and RoBERTa to analyze text-based answers, providing scores based on content relevance, logical flow, and accuracy. Additionally, the system uses multi-level semantic parsing models to ensure accuracy in grading subjective responses. For example, in language comprehension tasks, the system checks for understanding of core themes, emotions, and reasoning, and adjusts the score according to predefined educational standards.

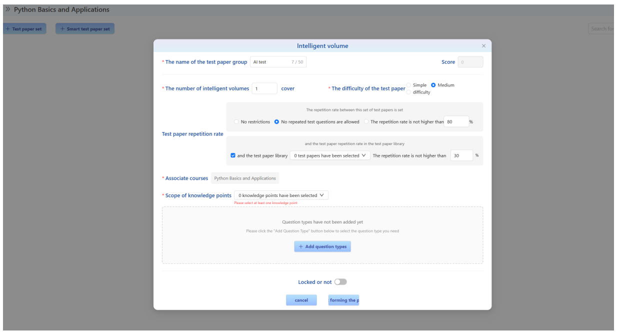

Fig. 4. Intelligent Test Paper Assembly interface

assessment generation supports standardized and efficient exam management within teaching workflows.

Personalized Learning Paths: Personalized learning support is provided through adaptive recommendation mechanisms that adjust learning materials and practice activities based on student performance data. This function supports teaching management by facilitating differentiated instruction and continuous monitoring of learner progress, As shown in Fig. 5.

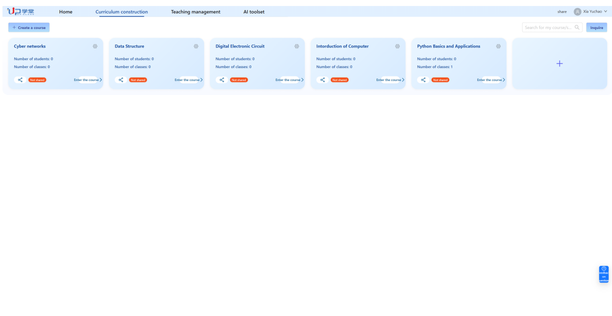

Fig. 5. Course Management dashboard of the UPUP Class platform. The dashboard highlights how aggregated course and learner data provide instructors with management-level visibility for monitoring progress and coordinating instructional activities

Real-Time Feedback and Analytics: The platform provides real-time feedback and learning analytics that summarize student progress, participation patterns, and performance trends. These analytics serve as a decision-support mechanism for instructors and administrators, enabling timely instructional adjustments and data-informed teaching management, As shown in Fig. 6.

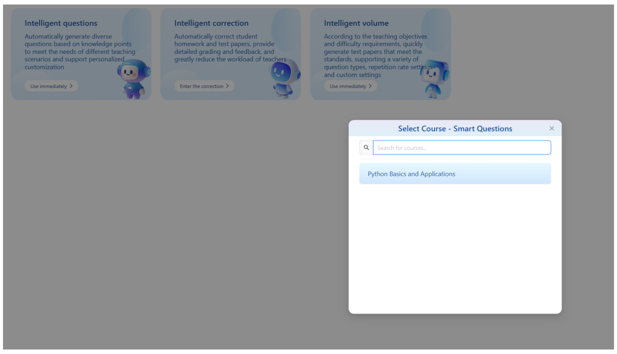

Fig. 6. Intelligent Test Paper Assembly interface. The figure demonstrates the role of AI-supported assessment tools in reducing administrative workload and improving coordination across teaching management processes

2.3. Security and Privacy Considerations

Given the sensitive nature of student data, the platform incorporates a comprehensive security framework designed to ensure privacy, integrity, and controlled access to information. All data stored within the system, as well as data transmitted between client and server, is protected using AES-256 encryption, providing industry-standard cryptographic safeguards. To further strengthen data governance, the platform implements a Role-Based Access Control (RBAC) mechanism, allowing only authorized users-such as students, teachers, or administrators-to access specific categories of information aligned with their institutional responsibilities. In addition, an ElasticSearch-driven audit trail records all user operations across the system, enabling continuous monitoring and supporting retrospective analysis in the event of suspicious activities or security assessments. Furthermore, the overall design adheres to internationally recognized data protection standards, including GDPR and FERPA, ensuring that student records are managed in a compliant, transparent, and secure manner. These combined measures create a rigorous security environment that safeguards user privacy while maintaining the reliability and accountability of the platform.

2.4. Integration with External Tools

The platform supports seamless integration with popular Learning Management Systems (LMS) such as Moodle and Canvas via RESTful APIs. It also integrates with video conferencing tools like Zoom and Microsoft Teams to facilitate live teaching and interaction, ensuring the platform is adaptable to existing institutional infrastructures.

2.5. Scalability and Performance

To support high concurrency and scalability, the platform uses cloud computing on AWS, utilizing elastic compute and storage resources to handle spikes in demand. The backend is designed for high availability, with load balancing managed by Nginx and auto-scaling capabilities via Docker and Kubernetes. Additionally, Redis is used for caching frequently accessed data, ensuring quick retrieval and minimizing latency, while CDNs (Content Delivery Networks) improve content delivery performance globally.

2.6. Evaluation Framework

To evaluate the effectiveness of the platform, key performance indicators (KPIs) were established. Teacher efficiency and teaching quality were treated as two related but conceptually distinct constructs. Teacher efficiency refers to the extent to which routine managerial and administrative tasks can be completed with reduced time and effort, and was measured by estimating the time saved in performing activities such as grading and lesson preparation. Teachers were asked to report the time spent on these tasks before and after using the platform. Teaching quality, in contrast, concerns the effectiveness of instructional practices and learning support, and was assessed through a combination of teacher surveys and student performance indicators, focusing on perceived instructional effectiveness and student engagement. Student learning outcomes were analyzed using the platform's assessment tools by comparing exam performance and overall learning outcomes between students who used the platform and those who did not. User satisfaction was measured separately, with both teachers and students providing feedback on ease of use, system reliability, and the perceived value of AI tools in supporting teaching and learning. Descriptive statistics were applied to survey responses, interview data, and performance records. Pre- and post-platform implementation data were compared to examine reported changes in teacher workload, teaching quality, and student learning outcomes. All before-after comparisons were therefore based on within-subject or within-course contrasts, which helps improve internal validity while remaining consistent with the descriptive evaluation design of the study.

2.7. Ethical Considerations

Ethical concerns regarding data privacy and AI's role in education were addressed by ensuring that all student data was anonymized and securely stored. Learning analytics dashboards and reporting functions were designed to present aggregated and anonymized indicators, preventing the identification of individual students while still supporting instructional decision-making. Informed consent was obtained from all participants (both teachers and students), and the platform adhered to ethical guidelines for AI usage in education. For automated grading and recommendation functions, human-in-the-loop mechanisms were retained, allowing instructors to review, adjust, or override AI-generated outputs before they were applied in instructional contexts. The platform was designed to support, not replace, human educators, ensuring that AI was used to enhance, rather than diminish, teacher-student interactions.

3. Results and discussion

Table 1 summarizes the overall usage statistics collected during the one-year pilot implementation. These data reflect not only the scale of adoption but also the extent to which the AI-enabled AI teaching assistant supported teaching management tasks across departments. A total of 1,599 students and 56 instructors participated, covering 101 courses and 87 teaching classes across 58 majors. All usage statistics and subsequent before–after comparisons reported in this section are based on the same instructors and courses across preand post-adoption periods, rather than on comparisons across different cohorts. Over the pilot period, the system generated 15,169 AI-assisted questions, published 436 assignments, auto-graded 5,280 submissions, and automatically assembled 291 exam papers. These figures illustrate how AI-driven collaborative agents were actively integrated into routine instructional workflows, providing large-scale support for teaching management and instructional coordination.

The platform's deployment trajectory further demonstrates its institutional relevance over the one-year pilot period. As shown in Fig. 7, system use exhibited a clear temporal evolution across early, middle, and later phases of deployment. During the early phase (April-August 2024), adoption remained relatively gradual, which coincided with the summer vacation period and limited teaching activities. A pronounced increase in user adoption occurred in September 2024, following the start of the academic semester, marking the platform's initial large-scale integration into teaching management practices. Subsequent growth during

February-April 2025 similarly aligned with the spring semester, while a temporary slowdown around the winter vacation period was followed by renewed expansion in September-October 2025, when a new academic year began. By the later phase of the pilot, monthly new users reached nearly 220 in April 2025 and exceeded 400 in October 2025, indicating broader institutional uptake and more routine use of the platform across courses and academic units. This temporal pattern suggests that system use evolved from exploratory adoption to more stable and sustained integration, reflecting both the influence of academic calendars, including summer and winter breaks, and a gradual institutional shift toward data-informed, AI-enabled teaching governance.

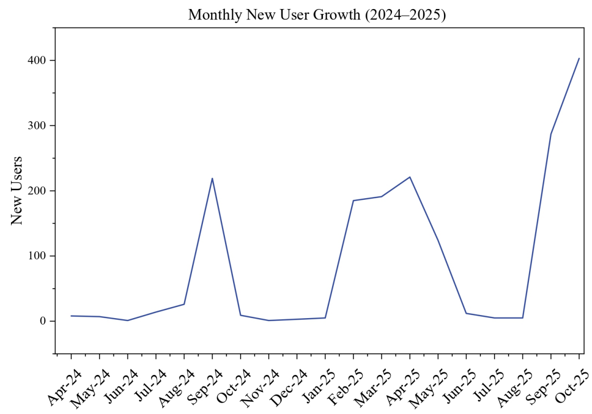

Fig. 7. Monthly New User Growth (2024-2025)

3.1. Teaching Management Efficiency

A primary goal of introducing AI-enabled multi-agent collaboration was to alleviate the managerial and administrative burdens traditionally placed on instructors. Survey responses indicate notable changes in teaching management efficiency following platform adoption. Teachers reported an average reduction of approximately 70% in lesson preparation time due to automated content generation and structured instructional suggestions. Moreover, the multi-agent grading mechanism-responsible for auto-scoring assignments and generating feedback-was associated with a reported reduction of about 90% in grading time for objective tasks. Teachers noted that the system's ability to automatically generate multiple exam versions in under ten minutes was perceived as reducing assessment preparation workload. The time saved allowed instructors to devote more effort to core teaching tasks-including student mentoring, reviewing instructional strategies, and organizing experiential activities-thereby supporting teaching precision and overall instructional quality. These observations suggest that the AI-enabled collaborative framework can contribute to the optimization of key teaching workflows and support more sustainable teaching management practices.

3.2. Student Performance and Engagement

The adoption of AI-assisted teaching management also contributed to measurable improvements in student learning

Table 1. System Usage Statistics

Student Numbers	AI-generated Questions	Assignments Published	Assignments Auto-graded	Papers Auto-assembled
1599	15169	436	5280	291

outcomes. Students who engaged with personalized learning pathways created by the multi-agent analytics system achieved exam scores approximately 10% higher than those not using these features. This suggests that AI-supported instructional management-particularly real-time diagnosis of learning gaps and targeted remediation-directly benefits student achievement. Student engagement also increased significantly. Interactive activities mediated by intelligent feedback agents resulted in a 20% increase in classroom participation. Students expressed that real-time analytics and progress tracking allowed them to better understand their learning status and adjust study strategies accordingly. These improvements highlight that effective teaching management supported by AI can foster a more active, data-informed, and responsive learning environment.

3.3. User Perceptions of Managerial Value

High levels of satisfaction were reported by both instructors and students. Over 85% of instructors indicated that the AI-supported system improved their teaching quality by enabling clearer insight into student performance trends and reducing the need for manual data analysis. Teachers particularly valued the system's capacity to consolidate learning information into actionable dashboards, supporting timely instructional decision-making. Similarly, students expressed appreciation for personalized recommendations, structured feedback, and transparent progress monitoring. They perceived these features as mechanisms that clarified expectations, strengthened self-regulation, and reduced uncertainty in learning tasks. From a management perspective, these responses indicate that AI-enabled AI teaching assistant enhance not only individual teaching activities but also the broader governance of learning processes.

3.4. Implications for Teaching Management Practice

The pilot results suggest that AI-enabled multi-agent collaboration holds substantial promise for transforming teaching management in higher education. First, by automating high-load administrative tasks, AI frees instructors from repetitive processes and reallocates their time toward student-centered teaching. Second, the system's real-time analytics improve the precision and timeliness of instructional decisions-an essential component of effective teaching management. Third, the centralized coordination of teaching tasks (assignment distribution, grading, assessment creation, student monitoring) demonstrates how AI can serve as an operational backbone for modern teaching management systems. The findings also indicate that multi-agent collaboration enhances organizational coherence in instructional management. Instead of fragmented teacher-led processes, AI agents collectively support a continuous management cycle: content creation, implementation, evaluation, and improvement. This aligns with emerging models of digital governance in higher education, where data-driven coordination plays a central role in institutional effectiveness. Together, these results demonstrate that AI-enabled multi-agent teaching systems do more than enhance instruction-they reshape the managerial structures that underpin teaching, driving a shift toward more efficient, data-informed, and learner-centered educational environments.

From an educational management perspective, the contribution of this study lies not in the technical sophistication of the AI system itself, but in how AI-enabled coordination mechanisms reshape the organization and governance of teaching processes. By embedding AI teaching assistants into routine instructional workflows, the proposed approach illustrates how management tasks such as planning, assessment coordination, monitoring, and feedback can be systematically supported at scale. This management-oriented framing helps bridge the gap between technical system design and educational practice, making the findings relevant not only to system developers but also to educational leaders, program coordinators, and policy makers concerned with instructional governance, workload distribution, and data-informed decision-making in higher education.

3.5. Management-Oriented Recommendations

Based on the results of the pilot implementation, this section proposes three management-oriented recommendations for higher education institutions seeking to integrate AI-enabled multi-agent collaboration into teaching management practices. The recommendations are informed by two complementary sources: empirical observations from the one-year pilot implementation and conceptual insights drawn from established theories in instructional management, data-informed decision-making, and teacher professional development.

3.5.1. *Strengthen Governance Structures and Align AI Integration with Instructional Management Theory*

The effective adoption of AI-enabled teaching management requires strong governance mechanisms grounded in instructional leadership and organizational learning theories. Institutions should integrate AI tools into their strategic development plans and establish cross-functional governance committees to coordinate implementation across administrative, technical, and academic units. From the perspective of instructional management theory, AI systems can serve as mediating tools that support the coordination of teaching tasks, the standardization of workflows, and the monitoring of instructional quality. Universities should therefore develop policies that clarify the use of AI in assessment management, instructional decision-making, and student support, ensuring that AI complements-rather than replaces—pedagogical judgment.

Furthermore, institutional policies should formalize workflow standards for tasks such as AI-assisted assessment generation, grading, and feedback cycles. Such standardization is consistent with principles of distributed leadership and organizational coherence, enabling departments to share best practices, reduce redundancy, and maintain consistency in teaching management. Strengthened governance structures ensure that AI technologies are not adopted in isolation, but embedded within a coherent instructional management framework that supports sustainable innovation.

3.5.2. *Leverage AI-Driven Learning Analytics to Enhance Teaching Quality and Data-Informed Decision-Making*

The integration of AI-driven analytics aligns with the broader shift toward data-driven decision-making (DDDM) in education. Real-time data on student learning trajectories, engagement behaviors, and assessment results provide actionable insights for improving instructional quality. Institutions should incorporate these analytics into routine teaching quality assurance processes such as course evaluation, formative assessment, early-warning systems, and curriculum review.

From the perspective of formative assessment theory, AI-enabled real-time feedback supports continuous, low-stakes assessment practices that help teachers identify learning gaps and adjust instruction accordingly. Similarly, learning analytics can guide personalized support strategies rooted in constructivist and socio-cognitive learning theories, which emphasize the importance of adaptive feedback, scaffolding, and learner agency. At the organizational level, integrating analytics into teaching governance allows universities to make more informed decisions about resource allocation, instructional interventions, and curriculum redesign.

To fully operationalize these benefits, institutions should develop data-use protocols and promote a culture of evidence-based instructional decision-making. This includes providing analytical dashboards to departments, supporting data literacy among faculty, and integrating analytics into teaching review cycles. Such practices align with contemporary models of continuous improvement in higher education.

3.5.3. *Enhance Faculty Capacity and Promote Responsible, Ethical Use of AI in Teaching Management*

Teacher professional development is central to the successful adoption of AI-enabled teaching management. Drawing on adult learning theory and technological pedagogical content knowledge (TPACK), institutions should design training programs that help instructors understand how AI can support pedagogical redesign, assessment practices, and data interpretation. Rather than focusing solely on technical training, professional development should emphasize AI-supported pedagogical decision-making, ethical considerations, and integration strategies that sustain teaching quality.

At the same time, responsible AI use requires robust data governance mechanisms. Institutions must establish clear protocols for data privacy, algorithmic transparency, and bias mitigation consistent with ethical AI frameworks. Educators must also be supported in developing critical data literacy to interpret AI-generated insights appropriately, avoiding over-reliance on automated recommendations. This aligns with principles of human-centered AI in education, which emphasize the role of educators as instructional decision-makers and ethical stewards of technology-mediated learning environments.

4. Conclusions

This study demonstrates that AI-enabled multi-agent collaboration can support teaching management in higher education by streamlining instructional workflows, reducing administrative burdens, and enabling more timely, data-informed decision-making. Results from the one-year pilot implementation indicate reported gains in lesson preparation efficiency, assessment coordination, and real-time monitoring of student learning, which allowed instructors to devote greater attention to pedagogical refinement and student engagement. Students likewise benefited from personalized support mechanisms that were associated with higher participation and improved academic outcomes. These findings suggest that AI-assisted multi-agent systems can function as effective management support tools for coordinating and enhancing teaching processes in higher education. Despite these positive findings, this study has several limitations that should be acknowledged. The reported efficiency gains, such as reductions in lesson preparation time and grading workload, are primarily based on self-reported estimates provided by instructors and descriptive system usage records. As such, these measures may be subject to estimation uncertainty and reporting bias. The one-year pilot was conducted in a real-world institutional setting, where variations in course design, assessment formats, and instructor experience may have influenced the observed magnitude of change. The implementation relies on a specific set of large language models and system configurations, and differences in model capabilities, institutional infrastructure, or data governance practices may affect the transferability of the approach to other settings.

Beyond these findings, the study highlights several implications for the future development of AI-supported teaching management. In particular, further investigation is warranted into the long-term institutional integration of AI tools, their scalability across diverse academic units, and the refinement of AI mechanisms for supporting complex and subjective assessment tasks. Future research should examine how AI-driven management frameworks can be more closely aligned with pedagogical goals, organizational structures, and governance practices in order to maximize their sustainable impact on teaching management and instructional quality in higher education.

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