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An AI-Driven Closed-Loop Framework for Cross-Domain Collaboration Integrating Vocational Education and Economic Management

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ABSTRACT

With the rapid advancement of the digital economy, vocational education and economic management are undergoing fundamental transformation, requiring the elimination of data silos and cross-domain collaboration. To address challenges such as system separation, decision delays, privacy barriers, and limited model interpretability, this study proposes an AI-driven "Perception–Analysis–Action" closed-loop framework. The perception layer integrates multi-source data from learning, market, and financial systems; the analysis layer, based on graph neural networks and reinforcement learning, explores cross-domain relationships; and the action layer achieves real-time personalized learning paths, adaptive budgeting, and risk alerts with federated learning and differential privacy ensuring security. Experiments on 600,000 records show improved accuracy (2–5%), latency reduction (to 19 ms), and better interpretability, validating the framework's role in promoting intelligent and transparent cross-domain collaboration.

KEYWORDS

AI-Driven Collaboration, Cross-Domain Integration, Closed-Loop Architecture, Federated Learning, Vocational Education and Economic Management

INTRODUCTION

As the digital economy enters deeper waters, the operational logic of vocational education and economic management is undergoing a fundamental transformation (Williams, 2021). On one hand, the pace of technological iteration—driven by artificial intelligence (AI), big data, and the Internet of Things—continues to outstrip the speed at which curricula and management frameworks are updated. On the other hand, organizations are facing increasing pressure for real-time and evidence-based decision-making, while traditional experiential or rule-based approaches struggle to handle multidimensional, dynamic, and high-frequency data environments (Gade, 2021; Olayinka, 2021). Meanwhile, with the acceleration of lifelong learning policies and intelligent manufacturing strategies, massive volumes of heterogeneous data are being generated across learning, production, and financial domains, yet efficient cross-domain integration remains a critical challenge (Agrawal & Nargund, 2024; Chen et al., 2024; Rakholia et al., 2024).

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Internationally, many countries have recognized the transformative role of AI in vocational education and economic governance (Goralski & Tan, 2020). Germany's dual system has incorporated intelligent data tracking to align training outcomes with industrial demand; Finland has advanced digital vocational education through AI-enabled learning analytics; and the Organisation for Economic Co-operation and Development (OECD) has established AI governance frameworks that promote transparency, fairness, and accountability in education systems. Despite these global developments, most existing frameworks still treat vocational education and economic management as separate systems and lack a unified architecture for dynamic data sharing and coordinated optimization. This separation often results in decision latency, redundant resource allocation, and fragmented policy implementation.

To address these gaps, this study proposes a novel "perception–analysis–action" closed-loop architecture designed to integrate the dual domains of vocational education and economic management through AI-driven collaboration. The perception layer aggregates signals from learning processes, financial operations, market dynamics, and policy updates. The analysis layer leverages graph neural networks (GNNs) combined with reinforcement learning to explore multi-domain coupling relationships and employs explainable AI to enhance transparency in decision-making. Finally, the action layer produces personalized learning paths, adaptive budgeting plans, and risk alerts in real time (M. Zhang et al., 2020). The framework incorporates federated privacy computing and adaptive control strategies for iterative online optimization, forming a low-latency, high-robustness intelligent ecosystem that simultaneously enhances educational quality and operational efficiency.

Moreover, by employing a dynamic knowledge graph that maps skill components to evolving job requirements, the system identifies capability gaps and adjusts resource allocation autonomously. In doing so, it realizes an AI-enabled, cross-domain collaboration loop that bridges educational and economic objectives, offering both theoretical innovation and practical feasibility. Unlike previous single-domain or static models, this study presents one of the first attempts to construct a dynamic, interpretable, and privacy-preserving collaborative system, contributing to the emerging discourse on intelligent governance in vocational education and economic management.

LITERATURE REVIEW

In recent years, research on AI-assisted vocational education and economic management has been steadily increasing, exhibiting three main characteristics: deepening technology, more segmented application scenarios, and insufficient cross-domain integration (Zary & Zary, 2025). Overall, both domestic and international literature generally agree that intelligent algorithms can improve course adaptability, predict operational risks, and to some extent shorten decision-making cycles; however, teaching and management aspects are still often modeled independently, and the lack of unified semantics across dual-domain data hinders the full realization of collaborative benefits.

Hardy and Liu (2022) proposed a complex connectivity model based on policy networks and data infrastructures, exploring its role in vocational education reform in China. By analyzing the interactions among multi-level policy actors, they revealed how data-driven governance mechanisms promote the transformation and optimization of the vocational education system (Hardy & Liu, 2022). The study by Li et al. (2023) on the construction of industry-education alliances reflects the integration of the industrial chain, innovation chain, talent chain, and education chain, promoting regional economic development and high-quality talent cultivation. These models align with the broader goal of utilizing AI to optimize collaborative frameworks and are expected to enhance the efficiency of vocational training and industry integration (Li et al., 2023).

The application of AI in educational management systems has also received increasing attention. Kumar (2024) proposed an AI-driven administrative process automation model that, by introducing intelligent algorithms, achieves greater efficiency and accuracy in administrative operations, significantly enhancing management efficiency and resource utilization. Similarly, Cai (2020)