Research on the Innovation of China-ASEAN Digital Industry-Education Integration Model from the Perspective of the Belt and Road Initiative

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Abstract: *From the perspective of the Belt and Road Initiative, China and ASEAN countries present an uneven distribution in terms of digital infrastructure and talent reserves, and their endowment differences constitute both structural obstacles to cross-border industry-education integration and a foundation for complementary cooperation. This study proceeds from three levels: theoretical foundation, structural analysis, and model innovation. It reviews the conceptual evolution and trend of spatial-temporal reconstruction of digital industry-education integration, and identifies the three-level integration demands of China and ASEAN. It then analyzes the supply-demand matching mechanism under the embedding of digital technologies, the cross-border data-driven value co-creation process, and the nonlinear relationship between collaboration density and knowledge transfer efficiency. Finally, it proposes the generative logic of distributed communities based on digital platforms, a modular curriculum adaptation model, and an adaptive ecosystem with flexible architecture. The research suggests that the direction of innovation lies in shifting from linear collaboration to networked symbiosis, with algorithmic trust replacing geographical proximity.*

Keywords: *Belt and Road Initiative; China-ASEAN; digital industry-education integration; model innovation; cross-border collaboration; modular curriculum; flexible architecture*

Introduction

The digital economy deeply penetrates the global industrial chain and the education system. China and ASEAN countries, due to their different stages of digital development, generate complementary demands, which endows the innovation of the cross-border digital industry-education integration model with academic value and practical necessity. Traditional industry-education integration relies on geographical proximity and institutional homology, making it difficult to address cross-regional unbalanced scenarios. China possesses a leading advantage in the field of digital infrastructure, while ASEAN presents a broad internal gradient. This unbalanced state requires a redesign of the matching mechanism between educational supply and industrial demand. Existing studies mostly focus on bilateral project-based cooperation and lack a systematic analysis of the cross-border multi-layer structure as well as a model innovation path that combines theoretical rigor with operational adaptability. This study starts from the theoretical foundation of digital industry-education integration, analyzes the matching mechanism, resource-sharing network, and collaboration efficiency, and constructs a distributed community, a modular adaptation model, and an adaptive ecosystem, so as to fill the theoretical gap in model innovation.

1. Theoretical Foundation and Regional Adaptation Logic of Digital Industry-Education Integration

1.1 Conceptual Evolution and Core Dimensions of Digital Industry-Education Integration

The concept of digital industry-education integration originates from the deep penetration of information technology into traditional models of collaboration between education and industry. Early industry-education integration mainly relied on school-enterprise collaboration within physical space, where the efficiency of resource transfer and the update cycle of knowledge were constrained by geographical distance and organizational boundaries. With the iteration of digital technologies, data elements have become a new medium connecting the educational supply side and the industrial demand

side, pushing industry-education integration from a linear alignment relationship toward a networked collaborative ecosystem. The core features of digital industry-education integration manifest in three dimensions: first, the immediacy and ubiquity of resource sharing, as digital platforms eliminate the spatial and temporal constraints of knowledge transfer; second, the dynamic mapping of competency demands, as industrial technological changes can be fed back to teaching modules in real time through data flows; third, the multi-actor participation in value co-creation, as educational institutions and industrial organizations form a symbiotic evolutionary relationship within digital space.

A deeper analysis of the core dimensions of digital industry-education integration requires an examination from three levels: structure, process, and outcome. At the structural level, the emphasis is placed on the degree of interconnectivity of digital infrastructure, including data interface standards, knowledge graph construction, and the scalability of collaborative platforms. At the process level, the focus is on the matching mechanism between educational content and industrial demand, involving the dynamic reorganization of course modules, the semantic alignment of skill tags, and the data tracking of learning trajectories. At the outcome level, the attention is directed toward the adaptive capacity of the integrated ecosystem, measuring the system's self-adjustment efficiency in response to technological iterations and changes in market demand. These dimensions together constitute a theoretical analytical framework for digital industry-education integration, providing a foundational tool for model innovation in cross-border scenarios[1-3].

1.2 Spatial-Temporal Reconstruction of Cross-Border Industry-Education Integration from the Perspective of the Belt and Road Initiative

The geographical scope covered by the Belt and Road Framework spans multiple development stages and regions with varying levels of digital infrastructure construction, and this characteristic imposes a requirement for the reconstruction of the spatial logic of traditional industry-education integration. Cross-border industry-education integration is no longer confined to project-based collaboration between bilateral institutions; instead, it evolves into a distributed network with multi-node interconnection. Digital technologies, by compressing the time delay of information transmission and reducing the transaction costs of cross-border collaboration, provide operable technical conditions for the cross-border flow of educational resources. At the same time, differences in institutional environments, language systems, and industrial standards across regions constitute structural obstacles that cross-border industry-education integration must overcome. The essence of spatial-temporal reconstruction lies in transforming physical distance into manageable digital distance, achieving an effective connection between cross-border educational supply and industrial demand through standardized data protocols and modularized knowledge encapsulation.

In the cross-border context of the Belt and Road Initiative, the spatial-temporal reconstruction of industry-education integration presents three typical trends. First, the decentralized distribution of collaboration nodes occurs, as the traditional industry-education collaboration model centered on geographical hubs is replaced by a multi-center flattened network. Second, the compression and extension of the time dimension coexist, with real-time interactive technologies shortening response cycles while asynchronous learning platforms expand the time window for knowledge absorption. Third, the blurring of spatial boundaries takes place, as the introduction of virtual simulation environments and remote experiment platforms allows cross-border industry-education activities to be conducted without physical premises. These trends collectively reshape the operational logic of cross-border industry-education integration, requiring relevant actors to redefine their role positioning and resource exchange methods within the network.

1.3 Identification of Digital Endowment Differences and Integration Demands between China and ASEAN

China and ASEAN countries present significant endowment differences in terms of digital infrastructure, digital talent reserves, and the level of industrial digitalization. China holds a leading position in high-speed broadband coverage, data center scale, and digital payment systems, while ASEAN exhibits a large internal gradient, with countries such as Singapore and Malaysia having relatively high levels of digitalization, whereas Myanmar, Laos, and others remain in the early stages of digital infrastructure construction. This unbalanced state constitutes both an obstacle to cross-border digital industry-education integration and a foundation for complementary cooperation. The identification of endowment differences requires a quantitative assessment from three dimensions: hardware infrastructure, software application ecosystem, and human resource stock, so as to clarify the

relative positions of each party in the digital capability spectrum and the types of exchangeable resources.

Based on the analysis of endowment differences, the complementary demands between China and ASEAN in the field of digital industry-education integration can be summarized into three levels. The first level is the basic demand, which involves the cross-border flow of general training resources for digital skills and standardized curriculum systems. The second level is the matching demand, as different industrial development stages of ASEAN countries correspond to differentiated digital talent specifications, requiring the precise supply of customized educational modules. The third level is the collaborative innovation demand, which targets emerging technology fields such as the intelligent Internet of Things and edge computing, where both parties can achieve knowledge co-creation and capacity co-building through joint research and development platforms. The identification of these three types of demands provides directional guidance for designing adaptive integration models in subsequent steps, facilitating the construction of a tiered and categorized framework for cross-border digital industry-education collaboration[4-6].

2. Multi-Layer Structure Analysis of China-ASEAN Digital Industry-Education Integration

2.1 Matching Mechanism between Educational Supply and Industrial Demand under the Embedding of Digital Technologies

The embedding of digital technologies changes the traditional matching logic between educational supply and industrial demand. In the stage before the introduction of digital tools, the skill structure output by the education system often exhibits a time lag and structural mismatch with the actual demands of the industrial sector, mainly due to the excessively long information transmission chain and the unstable feedback cycle. Digital technologies, by constructing real-time data collection and processing channels, enable technological changes, job competency requirements, and emerging skill gaps on the industrial side to be mapped into the curriculum design and competency development programs on the educational supply side in a near-real-time manner. The core of this matching mechanism lies in a data-driven closed-loop feedback system, in which industrial demands are converted into quantifiable skill tags and knowledge units, while educational supply achieves dynamic responses to these tags through a modular curriculum system.

Further analysis of the structural characteristics of this matching mechanism reveals that its operation depends on three key links. First, the demand identification link occurs, in which natural language processing and semantic analysis technologies extract a structured competency demand map from industrial recruitment information, technical documents, and project reports. Second, the supply transformation link takes place, in which educational institutions conduct a gap analysis on existing course content based on the demand map, identify coverage gaps and redundant modules, and adjust the allocation of teaching resources accordingly. Third, the matching verification link is implemented, in which learner behavioral data and employment tracking are used to evaluate matching accuracy and form the basis for iterative optimization. This closed-loop mechanism faces challenges such as language differences, inconsistent standard systems, and heterogeneous data interfaces in the China-ASEAN cross-border context, but its basic operational logic remains applicable across regions.

2.2 Cross-Border Data Flow-Driven Resource Sharing and Value Co-Creation in Industry-Education Integration

Cross-border data flow constitutes the foundational support for digital industry-education resource sharing between China and ASEAN. In the traditional model of industry-education integration, the cross-border exchange of educational resources and industrial resources is limited by the mobility of physical carriers and the information barriers of organizational boundaries. Data, as a non-rival resource, features low replication costs, high transmission speed, and minimal depreciation during use, thus demonstrating unique circulation advantages in cross-border scenarios. By establishing standardized data exchange protocols and a mutually trusted data governance framework, educational institutions and industrial organizations in China and ASEAN can achieve cross-domain sharing of curriculum resources, experimental datasets, virtual simulation tools, and skill assessment models. This sharing not only reduces the cost of duplicate development but also improves resource utilization efficiency and the speed of knowledge diffusion[7].

Value co-creation constitutes another core output driven by cross-border data flow. Unlike

unidirectional resource transfer, value co-creation emphasizes that participating actors jointly generate new knowledge assets and competency combinations during the process of data interaction. Specifically, while sharing basic resources, all parties from China and ASEAN can make differentiated contributions based on their respective industrial characteristics and educational advantages. For example, one party provides basic algorithm course modules, the other party supplements industry application case data, and the two parties jointly develop training content adapted to specific industrial scenarios. This process relies on the bidirectional feedback mechanism formed by cross-border data flow, in which data not only carries the resources themselves but also conveys information about usage effects, adaptation deviations, and improvement needs. Through continuous data exchange and joint analysis, all parties can iteratively optimize resource forms, thereby forming a value-added chain characterized by cross-border collaboration.

2.3 Collaboration Density and Knowledge Transfer Efficiency in a Multi-Actor Network

The China-ASEAN digital industry-education integration involves the collaborative interaction of multiple actors, including educational institutions, industrial organizations, technology platforms, and industry associations. The operational efficiency of this network structure depends on the collaboration density among the actors, that is, the frequency and intensity of effective information exchange and joint actions per unit of time. The level of collaboration density is constrained by each actor's digital access capability, level of interoperability, and the maturity of shared cognitive frameworks. In a high-density collaboration network, the connection paths among actors are short and redundancy is low, allowing demand information and solutions to be matched through fewer transmission links, thereby improving the response speed and adaptability of the entire system. Conversely, a low-density collaboration network is prone to information silos and idle resources, leading industry-education integration to fall into a state of local optimization but overall inefficiency.

There is a nonlinear relationship between knowledge transfer efficiency and collaboration density. Within a certain threshold range, an increase in collaboration density helps shorten the path of knowledge migration from the industrial frontier to the education system and accelerates the externalization and structuring process of tacit knowledge. However, when the collaboration density exceeds a certain critical point, excessive information exchange may lead to cognitive overload and rising coordination costs, which in turn inhibits knowledge transfer efficiency. Therefore, in the design of the China-ASEAN cross-border industry-education integration network, it is necessary to identify the optimal range of collaboration density. This identification can be achieved by analyzing the closeness of knowledge correlations among actors, the signal-to-noise ratio of information transmission, and the complexity of task dependency structures. At the same time, introducing a layered collaboration mechanism — separating high-frequency operational coordination from low-frequency strategic coordination — helps control interaction costs while maintaining the necessary collaboration density, thereby sustaining a high level of knowledge transfer efficiency.

3. Innovation Paths for the China-ASEAN Digital Industry-Education Integration Model

3.1 The Generative Logic of a Distributed Industry-Education Integration Community Based on Digital Platforms

Digital platforms reconstruct the formation path of the industry-education integration community between China and ASEAN. Traditional community forms rely on geographical proximity and institutional homology, and their generation requires long-term trust accumulation and face-to-face interaction. Digital platforms, through standardized interface protocols, traceable contribution recording mechanisms, and modular functional components, enable educational institutions and industrial organizations from different regions to quickly establish collaborative relationships under conditions lacking a historical cooperation base. The core feature of a distributed community lies in its decentralized node connection mode, where each actor can serve as both a resource provider and a user, and platform algorithms automatically match potential collaboration partners based on demand characteristics and capability tags, thereby reducing the cost of community formation and coordination difficulty[8].

Further examination of the generative mechanism of the distributed community reveals three driving forces. First, the connection driving force occurs, as digital platforms eliminate technical barriers and semantic differences among actors through unified identity authentication and data

exchange standards. Second, the trust substitution mechanism takes place, in which technological tools such as blockchains record each actor's contribution behaviors and performance records, forming an immutable reputation archive and partially replacing traditional interpersonal trust with algorithmic trust. Third, the value capture mechanism is implemented, as platforms design contribution quantification and benefit distribution rules, enabling participating actors to clearly foresee the relationship between their inputs and outputs. The synergistic effect of these three mechanisms allows the China-ASEAN cross-border industry-education integration community to form and maintain operation within a relatively short period, with its stability depending on the fairness of platform rules and the fault tolerance of the system.

3.2 Design of an Adaptive Model for Modular Curriculum and Dynamic Competency Development

The modular curriculum system serves as an effective tool for addressing the diversity and variability of demands in the China-ASEAN cross-border industry-education integration. A traditional linear curriculum structure struggles to accommodate the differentiated requirements of different countries and industries regarding digital skill specifications. The modular design decomposes the knowledge system into independently combinable learning units, with each unit corresponding to clear competency objectives and evaluation standards. In the China-ASEAN context, the modular curriculum embeds a cross-border adaptation layer responsible for identifying common modules and differentiated modules within the industrial demand maps of different regions. The common modules enable cross-border sharing and reuse, while the differentiated modules allow each participating party to make customized adjustments based on local industrial characteristics, thereby granting flexibility to adapt to diverse scenarios while maintaining the internal consistency of the knowledge system[9].

The adaptive model for dynamic competency development serves as the control logic for the operation of the modular curriculum system. The core of this model lies in establishing a mapping function between changes in competency demands and the reorganization of curriculum modules. Specifically, through continuous monitoring of trends in skill demand changes across various industrial sectors in China and ASEAN, the model automatically calculates the gap vector between the current curriculum combination and the target competency state, and accordingly generates module adjustment plans. The adjustment plan includes three types of operations: module replacement, which replaces obsolete knowledge with new content; module supplementation, which fills blank areas in the competency map; and module reorganization, which changes the learning sequence and dependency relationships among modules. The data foundation for this adaptation process comes from real-time skill demand signals from the industrial side and the analysis of learner behavioral trajectories. The operational accuracy of the model depends on the noise level of demand signals and the granularity rationality of module partitioning, both of which require parameter calibration in cross-border scenarios.

3.3 Adaptive Evolution and Flexible Architecture of the Cross-Border Industry-Education Integration Ecosystem

The cross-border industry-education integration ecosystem presents adaptive evolution characteristics within the China-ASEAN context. This ecosystem consists of multiple elements, including educational actors, industrial actors, technology intermediaries, and resource repositories, and the nonlinear interactions among these elements generate the overall behavior of the system. Adaptive evolution means that the system can automatically adjust its structural parameters and operating rules in response to environmental changes and internal state feedback without relying on external instructions. In the China-ASEAN cross-border scenario, when the demand for a certain type of digital skill decreases, the invocation frequency of relevant curriculum modules automatically declines, and the weight of resource allocation shifts toward emerging demand areas. When a cross-border data channel becomes congested, the system automatically switches to an alternative transmission path or adjusts the data compression ratio. This evolutionary capability originates from the feedback loops and learning algorithms deployed within the system[10].

Flexible architecture serves as the structural foundation supporting the above adaptive evolution. The flexible architecture incorporates three design principles. First, redundant design is adopted, where key functional components are deployed with multiple instances so that the failure of a single node does not affect the overall service capability. Second, loose coupling is established, meaning that subsystems interact through standardized interfaces rather than tight binding, facilitating local upgrades and replacements. Third, an expandable boundary is provided, as the system reserves access ports for

new types of actors and new types of resources to accommodate emerging industrial demands or educational forms within the China-ASEAN region. Under the flexible architecture, the cross-border industry-education integration ecosystem can withstand a certain degree of disturbances—such as data flow interruptions, sudden demand changes, or resource supply fluctuations — and return to an acceptable operating state after the disturbance is eliminated. The speed and accuracy of this recovery process depend on the system's monitoring granularity and the sensitivity design of its response mechanisms.

Conclusion

This study focuses on the innovation of the China-ASEAN digital industry-education integration model from the perspective of the Belt and Road Initiative, and it constructs a systematic analytical framework covering theoretical evolution, structural characteristics, and path design. The study clarifies the core features of digital industry-education integration in three dimensions: the immediacy of resource sharing, the dynamic mapping of competency demands, and the value co-creation of multiple actors. It also reveals the trends of decentralization, time window expansion, and spatial boundary blurring in the spatial-temporal reconstruction of cross-border scenarios. The study analyzes the closed-loop matching mechanism, the bidirectional value co-creation process, and the nonlinear relationship between collaboration density and knowledge transfer efficiency. On this basis, it proposes the generative logic of a distributed community based on digital platforms, an adaptive model of modular curriculum, and the principles of flexible architecture. Future research can focus on the quantitative calibration of collaboration density thresholds, the implementation schemes of distributed ledger technology in reputation mechanisms, and the potential application of edge computing and federated learning as adaptive regulators. In addition, multi-agent simulation can be used to explore the disturbance response boundaries of the flexible architecture.

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