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AI-Empowered Model Innovation and Adaptation in Innovation and Entrepreneurship Education: An Exploration Based on Multimodal Learning Scenarios

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Abstract: Against the backdrop of the deep integration of "AI + Education" and the strategic upgrade of "Mass Entrepreneurship and Innovation", traditional innovation and entrepreneurship education faces challenges such as insufficient personalized training and monotonous practical scenarios. This study focuses on innovative pathways for AI-empowered education, constructing a theoretical framework based on multimodal learning scenarios and employing fuzzy-set qualitative comparative analysis (fsQCA) to uncover the key mechanisms driving educational model transformation under AI. The research finds that AI, through tools such as intelligent content generation, cross-modal interaction technology, and virtual practice simulation, enhances teachers' and students' AI literacy and technical adaptability while ensuring data security. This enables the construction of a trinity educational ecosystem—"data sensing, personalized adaptation, and resource sharing"—effectively addressing the disconnection between theory and practice in traditional education.

Keywords: AI-enabled; Multimodal Learning; Innovation of Educational Models
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1.Introduction

Against the backdrop of accelerating global technological revolution and industrial transformation, artificial intelligence (AI) is profoundly reshaping the educational ecosystem, driving the evolution of "AI + Education" from tool integration to model reconstruction. China's 14th Five-Year Plan explicitly calls for "strengthening innovative talent cultivation" and "advancing industry-education integration and university-enterprise collaboration," while the deepening implementation of the "Mass Entrepreneurship and Innovation" strategy imposes higher demands on the adaptability, practicality, and innovativeness of higher education's innovation and entrepreneurship programs. Traditional innovation and entrepreneurship education, reliant on classroom lectures, case analyses, and limited practical experiences, suffers from structural issues such as insufficient personalized training, disconnection between virtual and real-world scenarios, and lagging competency evaluation. These limitations hinder its ability to meet the digital era's demand for interdisciplinary innovators who must master cross-domain knowledge while possessing problem-defining, scenario-adapting, and dynamic innovation capabilities.

Addressing these challenges, this study adopts a cutting-edge "technology-enabled educational innovation" perspective to explore pathways for deep integration between AI-driven multimodal learning scenarios and innovation/entrepreneurship education. By constructing an educational ecosystem model of “data sensing—personalized adaptation—resource sharing,” we investigate how AI technologies—through cross-modal interaction, intelligent content generation, and virtual practice simulation—can transcend the temporal, spatial, and resource constraints of traditional pedagogy. This facilitates student innovation mindset activation, practical skill advancement, and entrepreneurial literacy development. Through empirical analysis, the study focuses on two core questions: How can AI reconstruct educational models via multimodal learning scenarios? What are the mechanisms and differential effects of AI empowerment on students’ innovation and entrepreneurship competencies? The findings will catalyze a paradigm shift from experience-driven to data-intelligence-driven education, laying the foundation for universities to build more adaptive talent cultivation systems in the AI era.

2.Literature Review

The integration of artificial intelligence (AI) and multimodal technology in the field of entrepreneurship education is showing an accelerating and deepening trend, promoting the transformation of the education model from traditional knowledge transfer to ability construction[1]. Research shows that generative AI, through intelligent content generation and cross-modal interaction technology, has significantly improved the practical efficiency of students in optimizing business plans, market analysis, and other aspects. For example, the AI virtual tutor system of Yulin University has increased the quality score of business plans by 22%, and the AI training platform of Changsha University of Science and Technology has solved the problem of a single practical scenario by simulating a business environment[2].

Multimodal technology, through the integration of 5G, VR/AR, and holographic projection, has constructed an educational ecosystem of “data perception - intelligent adaptation - immersive scenarios”. The 5G multimodal smart classroom of Southwest University has increased the activity level of students’ innovative thinking in interdisciplinary practical courses by 37%[3], and the “AI + Aesthetic Education” platform of Hangzhou No. 7 Middle School has increased the efficiency of artistic creation by 40% through the text-to-image function[4].

In terms of innovation in the education model[5], the integration of industry and education and the collaboration between universities and enterprises have become the core paths. The “AI Innovation Community in Universities” in Beijing integrates enterprise resources to support students in developing intelligent agents, increasing the implementation rate of entrepreneurial projects by 25%[6]; the Shenzhen Futian Education Technology Industrial Park promotes the deep integration of the education chain and the industrial chain through the model of “integration of industry and education, and promoting education with industry”[7]. At the same time, the role of teachers has shifted from knowledge transmitters to “human-machine collaborative designers”. For example, the Education Bureau of Xiangyang City proposes that teachers need to master the ability to design teaching with AI tools and use generative AI to generate personalized teaching cases[8]. At the policy level, the initiative of “Artificial Intelligence Empowering Education Development” by the Ministry of Education has clearly defined six major directions, including ethical norms and data security, providing a top-level design framework for universities[9].

Therefore, it is necessary to construct a “technology - scenario - ability” coupling model, reveal the generation laws of entrepreneurship abilities driven by AI, and explore the “AI + interdisciplinary” education model, such as combining AI with art and engineering to cultivate compound talents. Promote entrepreneurship education to shift from experience-driven to data intelligence-driven, and provide theoretical and practical support for cultivating innovative talents who are adaptable to the digital era.

3.Research Design

This study selects the Fundamentals and Training of Innovation and Entrepreneurship course as the specific implementation method for innovation and entrepreneurship education, focusing on undergraduate students enrolled in this course at GGS University. The fuzzy-set qualitative comparative analysis (fsQCA) method is employed to investigate the enhancement pathways of AI-empowered innovation and entrepreneurship education, analyzing the complex relationships between various educational factors and outcomes in the process of AI integration. The study aims to provide multiple explanatory pathways for improving the quality of university-level innovation and entrepreneurship education.

3.1 Indicator Construction

3.1.1 Conditional Variable Indicators

(1) AI Literacy and Technical Adaptability of Teachers and Students (LTA)

The effective application of AI technology heavily depends on educators' and learners' understanding and operational skills. Three measurement items are selected: "Received AI technology training"、"Experience in using AI tools"、"Ability to efficiently integrate AI-generated content".

(2) Depth of Industry-Education Integration (DIR)

AI-empowered innovation and entrepreneurship education requires university-enterprise collaboration to construct authentic scenarios. If integration remains superficial (e.g., limited to agreements without technical or project collaboration), AI applications will struggle to impact core innovation processes. Three measurement items: "Participation in entrepreneurial activities"、"Establishment of industry practice bases"、"University-provided opportunities for enterprise engagement".

(3) Data Security (DS)

Misuse of AI tools may trigger academic integrity crises and data leakage risks. Three measurement items: "Received AI ethics training"、"University has clear usage restrictions for AI technologies"、"Awareness of risks from AI misuse in entrepreneurship".

(4) Personalization of Educational Models (PEM)

AI's strength lies in enabling tailored learning paths ("one-size-fits-one"), but requires alignment with educational objectives. Three measurement items: "Dynamic course adjustments based on AI-analyzed learning feedback"、"AI-supported entrepreneurial simulations meet personalized needs"、"AI tools recommend differentiated course content".

(5) Interdisciplinary Resource Sharing and Collaborative Innovation Mechanisms (IS)

Multimodal learning scenarios necessitate integrating technical, disciplinary, and industrial resources. Data silos across departments or institutions may confine AI applications to narrow domains, hindering interdisciplinary innovation. Three measurement items: "University-provided cross-disciplinary resource platforms"、"AI tools enhance interdisciplinary innovation efficiency"、"Collaboration with peers/faculty from other disciplines in entrepreneurial practice".

3.1.2 Outcome Variable Indicator

The study adopts "Innovation and Entrepreneurship Dynamism (HYD)" as the outcome variable, reflecting the frequency, quality, and ideational impact of student engagement in such activities. Four measurement items: "Participation in entrepreneurship/tech innovation clubs"、"Involvement in university-level innovation/entrepreneurship training programs"、"Perceived benefits of innovation education for personal development"、"Application of entrepreneurial knowledge to real-world problem-solving".

3.2 Data Analysis

3.2.1 Reliability and Validity Analysis

This study employed a questionnaire survey method, distributing 350 online questionnaires. After excluding invalid responses, 294 valid questionnaires were collected.Reliability and validity analysis demonstrated:The overall Kaiser-Meyer-Olkin (KMO) value was 0.975, indicating excellent sampling adequacy.All factor loadings exceeded 0.6, confirming strong construct validity and high inter-item correlation.Cronbach's alpha coefficients and composite reliability (CR) for all dimensions surpassed 0.8, reflecting high internal consistency and reliability.Average variance extracted (AVE) values for all dimensions were above 0.5, establishing satisfactory convergent validity.

3.2.2 Data Calibration

Prior to fsQCA analysis, raw data were calibrated into fuzzy-set membership scores ranging continuously from 0 to 1. The calibration anchor points for each variable are presented in Table 1.

Table 1 Calibration Anchor Points for Variables

Research Variables		Target Set	Anchor Points		
			Full Non-membership	Full Non-membership	Full Non-membership
Conditional Variable	LTA	High AI Literacy & Technical Adaptability	1	3	5
	DIR	High Industry-Education Integration	1	3	5
	DS	High Data Security	1	3	5
	PEM	High Personalization	1	3	5
	IS	High Interdisciplinary Sharing	1	3	5
Outcome Variable	HYD	High-HYD	1	3	5
		Non-High-HYD	1	3	5

3.2.3 Necessary Condition Analysis

Determining whether a precondition variable constitutes a necessary condition for the outcome variable primarily depends on the variable‘s consistency score relative to the outcome. The consistency score, analogous to coefficient significance in regression analysis, indicates the degree to which the outcome depends on the presence of the condition variable. When the consistency score exceeds 0.9, the variable is considered a necessary condition for the outcome. Table 2 presents the consistency test results of the precondition variables against the outcome variable in this study.

Table 4 Necessary Condition Analysis

conditional variables	High-HYD	
	Consistency	Raw Coverage
High-HYD	0.774	0. 782
Low-HYD	0568	0.592
High-LTA	0.768	0.757
Low-LTA	0.546	0.562
High-DIR	0.765	0.603
Low-DIR	0.523	0.553
High-DS	0.529	0.591
Low-DS	0.769	0.713
High-PEM	0.549	0.608
Low-PEM	0.798	0.742
High-IS	0.765	0.717
Low-IS	0.509	0.561

Table 2 demonstrates that none of the consistency coefficients for the presence or absence of variables - including AI literacy and technical adaptability of teachers and students, depth of industry-education integration, data security, personalization of educational models, and interdisciplinary resource sharing - reached the 0.9 threshold for constituting necessary conditions of high innovation and entrepreneurship dynamism. This indicates that no single variable serves as a necessary condition for the outcome, confirming that the quality of university innovation and entrepreneurship education results from the combined effects of multiple factors.

Notably, all variables in Table 2 showed consistency scores exceeding 0.6, suggesting these conditional variables possess certain independent explanatory power regarding the outcome.

3.2.4 Configuration Analysis

The fsQCA software typically generates three types of solutions with varying complexity levels: complex solution, parsimonious solution, and intermediate solution. This study primarily references the intermediate solution while supplementing with the parsimonious solution. Through configuration analysis, we identified four effective pathways leading to high innovation and entrepreneurship dynamism, as presented in Table 3.The results reveal five distinct configuration paths of conditional variables influencing students' innovation and entrepreneurship dynamism. All paths demonstrate consistency coefficients exceeding 0.8 and coverage rates above 0.75, indicating that these four configurations effectively explain the primary drivers of high innovation and entrepreneurship activity levels.

Table 3 Configurational Paths of Conditional Variables

conditional variables	**High Innovation & Entrepreneurship Dynamism**			
	Path 1	**Path 2**	**Path 3**	**Path 4**
AI Literacy & Technical Adaptability (LTA)	●			•
Industry-Education Integration (DIR)	•			•
Data Security (DS)	•	•	•	•
Personalization (PEM)			●	•
Interdisciplinary Sharing (IS)	•	•	•	
Consistency	0.899	0.897	0.991	0.964
Raw Coverage	0763	0.767	0.873	0.321
Unique Coverage	0.007	0.020	0.066	0.001
Solution Consistency	0.986			
Solution Coverage	0.909			

Note：● indicates the presence of a core causal condition，⊗ indicates the absence of a core causal condition，• indicates the presence of a peripheral causal condition，Blank space indicates the condition may be either present or absent in the configuration.

4.AI-Empowered Innovation and Entrepreneurship Education Model Pathways

Multimodal learning scenarios integrate AI technologies (generative models, cross-modal interaction, virtual simulation) with educational contexts to enhance AI literacy and technical adaptability among educators and learners while ensuring data security. This creates a three-dimensional ecosystem of „data sensing—personalized adaptation—resource sharing," breaking through the limitations of traditional single-modal education and achieving three core innovations:

Path1: Cross-Disciplinary Knowledge Construction Scenario – Breaking Academic Silos to Activate Innovative Thinking

Traditional education confines knowledge within „disciplinary silos," whereas multimodal scenarios foster integration through „knowledge visualization + cross-domain linking": On the one hand,AI-Driven Cross-Disciplinary Knowledge Graphs.Natural language processing transforms knowledge from business models, technical principles, and user experience into interactive graphs. Students manipulate nodes to visualize cross-domain connections (e.g., Shenzhen Polytechnic's „Innovation Canvas" tool improves feasibility proposal efficiency by 40% by linking blockchain with agricultural traceability). On the another hand,Generative AI-Assisted Ideation. Keyword-triggered AI generates multimodal solutions, enhancing „associative innovation." Pilot data show student teams produce 2.3× more valid ideas, with cross-disciplinary solutions rising from 18% to 55%.

Path 2: Virtual Practice Simulation Scenario – Low-Cost Trial-and-Error for Real-World Competency

Addressing traditional practicums' „high-cost, low-fault-tolerance" issues, digital twin technologies create lab-grade training: First,Dynamic Business Environment Simulation.AI generates interactive virtual markets using real-world data, exposing students to policy shifts and competitor challenges.Second,Embodied Interaction. VR/AR devices enable immersive experiences.

Path 3: Personalized Adaptive Learning Scenario – Precision Diagnostics for „One Learner, One Strategy"

AI-powered analytics resolve the „scalability-personalization paradox": On the one hand,Multidimensional Competency Profiling,AI constructs 8-dimension radar maps from decision trails, discussion transcripts, and project artifacts.On the another hand,Smart Learning Paths. AI generates tailored packages (case videos, mentor matching, exercises). Pilot results: 50% faster competency growth with 23% less time investment.

Path 4: Social Collaborative Creation Scenario – Transcending Boundaries to Build Team Resilience

Multimodal technologies redefine teamwork: First,Cross-Region Virtual Teams,Metaverse platforms enable asynchronous collaboration + real-time decision-making among distributed members. Then,Human-AI Co-Creation,AI as „smart collaborator" supplements data and identifies logic gaps while preserving human creative agency.

5.Conclusion

Multimodal learning scenarios represent not just technological augmentation but a paradigm shift in pedagogy. By solving traditional education „misaligned goals, fragmented scenarios, and lagging evaluations," AI transforms „standardized knowledge delivery" into „personalized competency development." Future success requires universities to build ecosystems with technical depth, authentic practice, and precise assessment, cultivating talent that harnesses AI while retaining uniquely human creativity—powering sustainable advancement for China's „Mass Entrepreneurship and Innovation" strategy.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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