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Artificial Intelligence Enabled Model for Cultivating Interdisciplinary Innovation Competence in Higher Education

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Abstract: The rapid development of artificial intelligence is driving the transformation of higher education paradigms toward intelligence, integration, and innovation. As a core indicator for cultivating interdisciplinary talents, interdisciplinary innovation competence requires the establishment of an educational model that aligns with the learning characteristics and competency demands of the AI era. Based on innovation competence development theory, interdisciplinary integration theory, and educational digital transformation theory, this study proposes a pathway mechanism for AI-empowered interdisciplinary innovation competence cultivation in higher education. Accordingly, an AI enabled interdisciplinary innovation competence cultivation model with "discipline-oriented, innovation practice, and outcome evaluation" is constructed. The results indicate that this model enables AI to significantly enhance students' interdisciplinary design thinking, complex problem-solving ability, and quality of innovative expression, while improving learning initiative and collaboration depth, boosting teaching efficiency, and facilitating the formation of a multi-agent collaborative teaching and learning mechanism among humans and machines. The research provides theoretical support and practical reference for the reconstruction of innovation-oriented interdisciplinary talent cultivation models and intelligent teaching reform in higher education.

Keywords: artificial intelligence; interdisciplinary education; innovation competence cultivation; multi-agent collaborative mechanism

1. Research Background and Problem Statement

Since the 21st century, the global scientific and technological revolution and industrial transformation have continued to deepen, and the deep integration of artificial intelligence and higher education has become an important trend in educational reform [1]. Especially since 2022, generative artificial intelligence technology, represented by ChatGPT, has made breakthrough progress in text generation, image creation, code writing, and knowledge reasoning, providing new opportunities for intelligent knowledge support, precise learning analysis, and innovation-ability enhancement in higher education [2]. GAI is rapidly promoting the transformation of higher education paradigms from knowledge transmission to intelligent interaction, from discipline-centered to competency-oriented, and from teacher-led to human-machine collaborative co-education [3].

Meanwhile, in response to the urgent demand of the economy and society for compound and innovative talents, the Ministry of Education has successively emphasized that interdisciplinary integration and innovation competence cultivation have become

important directions in higher education talent training. The document of White Paper on China's Smart Education by Ministry of Education People's Republic of China clearly points out that artificial intelligence should be deeply integrated with professional education to enhance students' comprehensive technical ability and innovative practical ability. However, in the current process of cultivating interdisciplinary innovative talents in universities, there are still many challenges: the curriculum system is still mainly based on single-discipline knowledge, teaching methods lack innovation, the evaluation system for students' innovation ability is not yet improved, and AI technology mostly remains at the level of auxiliary tools rather than deeply empowering education [4].

Therefore, based on the innovation competence cultivation theory, interdisciplinary integration theory, and educational digital transformation theory, this paper proposes a model for artificial-intelligence-enabled cultivation of interdisciplinary innovation competence. The study aims to explore the functional mechanism of generative artificial intelligence in interdisciplinary innovation education in universities, construct an innovation-competence cultivation path suitable for the AI era, promote the shift of higher-education talent training from a knowledge-structure-oriented approach to an innovation-competence-oriented approach, and provide theoretical support and practical reference for interdisciplinary education reform.

2. Research Content and Key Issues

Existing research focuses primarily on enhancing discipline-specific professional competence, while limited attention is given to interdisciplinary innovation competence from the perspective of AI empowerment. This study begins with the functional mechanism of artificial intelligence, explores the formation pathway of innovation competence, and extends the theoretical applicability to interdisciplinary education [5]. Therefore, a model of "discipline orientation- innovation practice - outcome evaluation" is constructed to address the lack of systematic theoretical support for AI-integrated innovative teaching pathways [6].

Traditional AI education research often considers AI as an auxiliary tool, whereas this study views AI as an active cognitive agent, promoting the shift from "AI as a tool" to "AI as a collaborative learning partner" [7]. Based on this perspective, an AI-driven human-machine multi-agent collaborative teaching and learning mechanism is proposed, offering a new theoretical explanation for digitally supported interdisciplinary competence development [8].

On the one hand, under traditional teaching models, interdisciplinary curricula often struggle to achieve knowledge integration and innovation transfer, leading to limited improvement in students' complex problem-solving and systemic thinking abilities [9]. On the other hand, existing applications of generative AI in education mostly remain at the exploratory stage, lacking deep alignment with curriculum design, teaching strategies, and competence development objectives (Table 1).

Table 1. Main Innovations of This Study.

Research Direction	Current Challenges	Breakthroughs of This Study
AI in Education	AI is mostly used as a tool, lacking intelligent and collaborative teaching models	Constructs an AI-supported collaborative teaching-learning model
Interdisciplinary Teaching	Multiple disciplines often coexist without deep integration	Integrates disciplinary content based on competence-oriented instructional design
Innovation Competence Development	Innovation training is mainly limited to project-based practice	Introduces Generative AI to enhance solution creation and innovative thinking

The present study primarily addresses three key issues: Firstly, the analysis of the needs for AI-enabled cultivation of interdisciplinary innovation competence in higher

education; secondly, the construction of the pathway mechanism and the proposal of the "discipline orientation-innovation practice-outcome evaluation" model; and thirdly, the evaluation of teaching effectiveness and optimization strategies. Through educational needs analysis and the integration of relevant theories, this study proposes an artificial intelligence-empowered model for cultivating interdisciplinary innovation competence, and subsequently develops a teaching design approach that is aligned with the requirements of interdisciplinary innovation competence development.

3. Concept Definition and Theoretical Foundation

3.1. Concept Definition

Generative Artificial Intelligence (GAI) refers to a new type of artificial intelligence system that realizes content generation and intelligent reasoning through technologies such as deep learning, large language models, and neural networks. Unlike traditional AI, its core capability lies in understanding, generating, optimizing, and interacting, enabling quasi-cognitive collaboration with users in scenarios such as text generation, programming assistance, visual design, and solution optimization [4]. In educational contexts, GAI can provide: (1) content generation support-assisting in experimental task design, curriculum development, and solution planning; (2) intelligent feedback-analyzing learning processes and offering adaptive recommendations [10]; (3) cognitive enhancement-facilitating reasoning and structural analysis; (4) innovation stimulation-expanding creative thinking and supporting solution formation; and (5) knowledge transfer-promoting interdisciplinary linkages and scenario-based application (Table 2) [2].

Table 2. Evolution of Education Empowerment Models.

Evolution Stage	Educational Paradigm	Role of AI
Traditional Stage	Teacher-led	None
Digital Education Stage	Human-machine-assisted teaching	Tool based
Intelligent Education Stage	Data driven learning	Supportive
AI 2.0 Stage	Human AI collaborative learning	Cognitive partner

AI 1.0 was centered on convolutional neural networks applied to computer vision and natural language understanding, where machines began surpassing humans in specific tasks. Following the release of China's New Generation Artificial Intelligence Development Plan. AI was positioned as a key driver of industrial transformation. AI 2.0 represents a major leap, overcoming single-domain limitations and enabling cross-domain intelligence through large-scale model training on massive, unlabeled data. In this era, big data intelligence, collective intelligence, cross-media intelligence, hybrid human AI augmented intelligence, and autonomous intelligent systems have become fundamental theoretical and technological supports, widely applied in various sectors such as manufacturing, healthcare, and education [11].

3.2. Theoretical Foundation

Innovation competence refers to an individual's ability to propose creative solutions to complex problems by integrating cross-disciplinary knowledge and methodologies. In interdisciplinary education, innovation competence includes: (1) knowledge construction, (2) problem identification and redefinition, (3) development of innovative solutions, and (4) implementation and expression of innovation. According to innovation competence cultivation theory, competence develops progressively from knowledge accumulation to contextual transfer and ultimately to innovation formation and realization [12]. In this study, the mechanism for cultivating innovation competence is optimized based on the enhancement effects of GAI, as shown in Table 3.

Table 3. AI Enabled Innovation Competence Cultivation Mechanism.

Innovation Cultivation Stage	Traditional Approach	GAI-Enabled Approach
Knowledge Acquisition	Teacher led instruction	AI based multi-source knowledge generation
Thinking Stimulation	Discussion driven	AI assisted divergent thinking
Solution Optimization	Instructor guided	AI supported collaborative design and iteration
Innovation Presentation	Static output	AI enhanced expression

Interdisciplinary integration theory posits that effective problem-solving in complex environments requires the integration of multiple knowledge systems across different academic disciplines. Higher education has evolved from "multi-disciplinary coexistence" to "deep integration," emphasizing problem-based and practice-driven learning. Traditionally, interdisciplinary integration relies primarily on teacher-led instruction, whereas under GAI-enabled learning, AI can generate high-level analytical perspectives based on prompts, facilitate concept bridging, and support interdisciplinary synthesis. Meanwhile, digital education transformation theory emphasizes transitioning from "informatization" to "intelligent, systemic, and ecological development," restructuring educational models and enhancing competence through technological support.

3.3. Mechanism Analysis of AI-Enabled Cultivation of Interdisciplinary Innovation Competence

Based on the above theoretical foundations, it is argued that GAI empowers the cultivation of interdisciplinary innovation competence through four mechanisms:

(1) Innovation Facilitation Mechanism: GAI stimulates creativity and accelerates design-oriented innovation processes by supporting solution planning, module structuring, and optimization.

(2) Knowledge Integration Mechanism: By generating solutions from diverse disciplinary perspectives, GAI promotes cross-field knowledge network development.

(3) Intelligent Feedback Mechanism: Through real-time feedback, GAI assists students in refining their ideas, improving learning effectiveness and solution quality.

(4) Cognitive Augmentation Mechanism: By structuring complex problems using large language models, GAI provides high-level reasoning pathways and supports the shift from knowledge processing to innovation construction.

4. AI Enabled Interdisciplinary Innovation Competence Development Model

With the advent of the artificial intelligence era, societal demands for complex problem-solving, cross-domain integration, and system design capabilities have significantly increased. Traditional single-discipline teaching models in universities have gradually revealed limitations, including insufficient innovation drive, barriers to knowledge transfer, and weakened practical competence. Policies on interdisciplinary education emphasize "cross-disciplinary integration, innovative talent cultivation, and the involvement of intelligent technologies," requiring the talent development paradigm to shift from "knowledge-structure-oriented" to "innovation-competence-oriented." However, in current interdisciplinary talent cultivation, universities face challenges such as students struggling to transfer knowledge across domains and lacking innovation and practical skills [5]. The introduction of generative artificial intelligence enables students to obtain real-time intelligent enhancement in tasks such as solution development, case analysis, reasoning validation, and innovative expression, providing a new technology-driven approach for cultivating interdisciplinary innovation competence. Therefore, implementing a GAI-enabled innovation education model for interdisciplinary learning is both necessary and feasible. This study proposes an AI enabled interdisciplinary innovation competence development model, as illustrated in Figure 1.
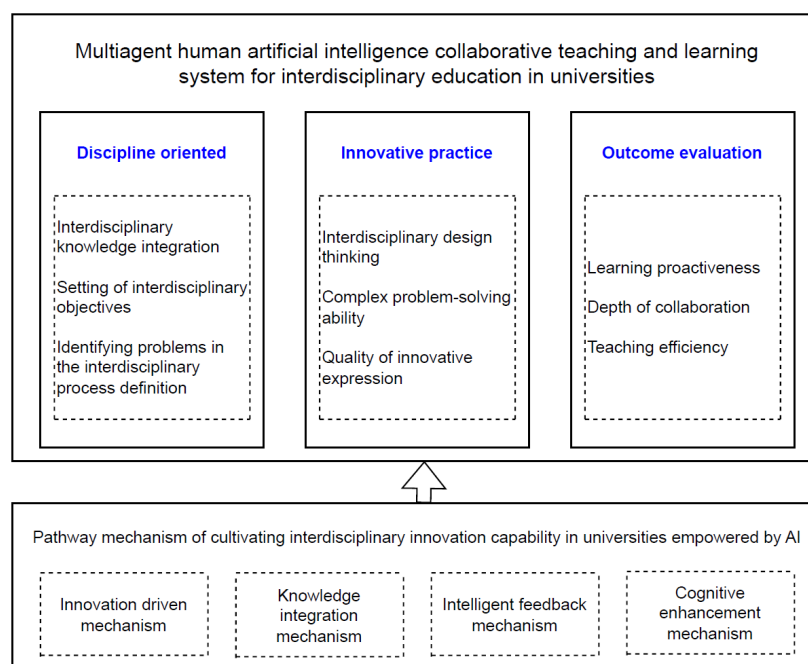
Figure 1. AI Enabled Interdisciplinary Innovation Competence Development Model.

In this model, a human and AI multiagent collaborative teaching and learning mechanism runs throughout the entire process. AI functions as a cognitive partner, teachers act as facilitators, and students are positioned as the primary drivers of innovative learning, collectively forming a collaborative interaction mechanism among humans and intelligent systems. The model consists of three stages, representing the empowerment pathway of GAI in interdisciplinary innovation competence cultivation in higher education. In the discipline-orientation stage, based on clarifying interdisciplinary tasks and defining knowledge integration directions, AI assists in course resource integration and task design.

In the innovation practice stage, AI facilitates co-design, multi-step reasoning, prompt engineering, and innovative expression, supporting interdisciplinary project-based learning and solution development. In the outcome evaluation stage, AI supports formative assessment and data-driven feedback, evaluating innovation outputs, learning behavior, and collaborative performance [2]. By integrating generative AI into the instructional process, collaborative multi-agent learning involving humans and AI is fostered, leading to enhanced interdisciplinary design thinking, complex problem-solving, and innovative expression among students.

The proposed model is universal and can be applied to interdisciplinary programs across engineering, medicine, management, and education. It breaks through traditional teacher-centered instructional approaches and promotes a multi-agent collaborative model in which AI actively supports learning, teachers guide instructional direction, and students take ownership of learning. The findings of this study provide practical guidance for AI-driven innovation competence cultivation in universities.

5. Conclusion

Interdisciplinary learning emphasizes integrative understanding across multiple knowledge domains, cross-boundary thinking alignment, and practice-oriented problem-driven learning. Its core lies in whether students can combine methodologies from different disciplines to generate innovative solutions. The key to generative artificial intelligence empowering the cultivation of interdisciplinary innovation competence lies in opening knowledge channels across disciplines and promoting the evolution of

educational models from knowledge-supported to innovation-driven. Based on an analysis of the demand for innovative talent cultivation in the AI era, this study systematically examined the mechanism through which generative AI enables interdisciplinary innovation competence development and clarified the core value of GAI in knowledge support, cognitive enhancement, intelligent feedback, and innovation promotion. The findings indicate that traditional teaching models face significant bottlenecks in interdisciplinary knowledge integration and innovation capability formation, whereas generative AI, as an intelligent cognitive facilitator, contributes to overcoming these limitations. The mechanism analysis provides a theoretical basis for model construction and logical support for subsequent practical validation in teaching.

Drawing on AI-era educational demand analysis and a multi-theoretical integration perspective, this study reveals the intrinsic mechanism of GAI-enabled cultivation of interdisciplinary innovation competence in higher education. The results demonstrate that GAI is not merely an instructional support tool but an intelligent participant in the formation of innovative cognition. It plays a fundamental role in optimizing the innovation competence development pathway, facilitating interdisciplinary integration, and establishing human-AI multi-agent collaborative mechanisms. The proposed "discipline orientation-innovation practice-outcome evaluation" model for GAI-enabled interdisciplinary innovation competence cultivation is grounded in disciplinary logic, incorporates GAI as a core cognitive enhancement tool, employs innovation-driven tasks as the learning catalyst, and relies on collaborative evaluation mechanisms as the quality assurance framework. This model supports a comprehensive human-AI multi-agent collaborative teaching-learning mechanism throughout the process. It demonstrates both theoretical and practical transferability, supports interdisciplinary courses and project-based teaching, promotes the evolution of student competencies, teaching methodologies, and curriculum structures, and can be adapted to a wide range of interdisciplinary academic programs in higher education.

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