A Study on the Connotation and Dimensional Structure of Postgraduate Innovation Ability in the Context of Artificial Intelligence

Lei Wang*, Shiyi Sun, Chunlan Qin
School of Business, Guilin University of Electronic Technology, Guilin, Guangxi, China
**Corresponding Author*

Abstract: In the context of the rapid development of artificial intelligence, the connotation and cultivation methods of postgraduate innovation ability are undergoing profound changes. The traditional framework of innovation ability emphasizes "knowledge memorization + problem-solving" ability, which is no longer compatible with the new look of the current era of data-driven, human-machine collaboration and interdisciplinary multi-dimensional artificial intelligence. In the academic thinking, this study believes that innovation ability is not a "professional skill" but a "comprehensive quality". The impact of generative artificial intelligence on the cultivation of innovation ability is a multi-dimensional and complex mechanism that requires the integration of multiple theories for explanation. It also emphasizes that the cultivation of innovation ability cannot be separated from the idea of collaboration among multiple stakeholders such as the government, universities, and society. Based on literature review and analysis, expert interviews, questionnaire surveys, and case studies, this paper redefines the new connotation and structural framework of postgraduate innovation ability, constructing a multi-dimensional innovation ability framework encompassing digital literacy, technological thinking, and teamwork. This framework emphasizes digital literacy as the foundation, technological thinking as the core, and teamwork as the support, while also integrating critical thinking, ethical concepts, and interdisciplinary integration skills. It fully aligns with the new standards for high-level talent in the era of artificial intelligence. This research can provide a theoretical basis and practical pathways for optimizing postgraduate training programs, reforming teaching methods, and innovating mentor guidance mechanisms.

Keywords: Artificial Intelligence; Postgraduate; Innovation Ability; Multi-Dimensional

1. Introduction

Countries and regions around the world highly recognize the enormous potential of artificial intelligence technology in higher education. Its transformative power is driving comprehensive and profound improvements in education systems, particularly bringing new hope and opportunities to developing countries to improve education quality, optimize learning environments, and promote educational equity. The Ministry of Education's "Outline for Building a Strong Education Nation (2024-2035)" explicitly proposes to "promote the deep integration of artificial intelligence and education," and the third anniversary deployment meeting of the National Smart Education Platform further elevated "artificial intelligence empowering all elements of education" to a national strategy [1]. The "Development Plan for Professional Degree Postgraduate Education (2020-2025)" emphasizes the need to " promote the establishment of 'customized talent training programs' for employers, closely aligning talent training with employment needs" [2]. From 2017 to 2022, a series of important requirements concerning national innovation development were gradually proposed. In 2017, "accelerating the construction of an innovative country". was put forward as a key national development objective. In 2021, further emphasis was placed on the core position of innovation in the overall modernization of my country and to deeply implement the strategies of invigorating the country through science and education, strengthening the country through talent, and

innovation-driven development. In 2022, the strategic requirements were explicitly put forward to "comprehensively improve the quality of independent talent cultivation and focusing on cultivating top-notch innovative talents" and "postgraduate education plays an important role in cultivating innovative talents, improving innovation capabilities, serving economic and social development, and promoting the modernization of the national governance system and governance capabilities". Graduate students are the reserve force for national scientific research and innovation, and a key force for future innovation and technological development. Scientific research and innovation ability is a core competitiveness and vital force for scientific and academic progress that a graduate student should possess. Cultivating students' innovative ability is an essential requirement of graduate education. Therefore, cultivating and enhancing the scientific research and innovation ability of graduate students is a new standard and requirement put forward by national strategy for graduate education.

Currently, the cultivation system for postgraduate innovation ability faces numerous problems and challenges. The existing framework for innovation ability does not fully reflect the new demands of the AI era, making the definition of postgraduate innovation ability ambiguous. Most studies still use "knowledge memorization + problem solving" as the core criterion for judging ability. This traditional model ignores a series of new abilities that postgraduates should master in the context of AI. Insufficient interdisciplinary integration further exacerbates the ambiguity in the definition of innovation ability. Faced with complex and diverse problems, knowledge from a single discipline is no longer sufficient, while interdisciplinary knowledge integration and collaborative ability have become important factors driving innovation [3]. However, in reality, barriers between different disciplines still exist in the current education system, which to some extent restricts the comprehensive growth of graduate students' innovative ability and makes it difficult for the connotation of innovative ability to meet the diversified needs of talent in the new era [4]. To address the above issues, this paper delves into the paradigm shift in innovation in the era of artificial intelligence. It establishes cutting-edge dynamics through systematic literature analysis, widely consults interdisciplinary experts to obtain their insights, and conducts a questionnaire survey to understand the actual situation. Simultaneously, it analyzes practical paths in depth through typical case studies, comprehensively exploring and defining the specific manifestations and new connotations of postgraduate innovation capabilities in the AI era. Based on this, a new multi-dimensional framework for innovation capabilities is constructed, and a scientific and operable evaluation system is provided, significantly improving the innovation level of postgraduates, meeting the new era's demand for high-level, interdisciplinary innovative talents, providing solid theoretical support and practical guidance for subsequent teaching practice reforms, and providing solid data support and theoretical evidence for optimizing the training mechanism and innovative education model.

This research has important theoretical and practical significance. From a theoretical perspective, in the context of the artificial intelligence era, it broadens the understanding of traditional innovative ability, systematically constructs the constituent dimensions and connotations of graduate students' innovative ability, fills the gaps in existing theories regarding the understanding of emerging elements such as digital literacy and human-computer collaboration, makes the connotation definition of graduate students' innovative ability clearer, and provides core support for forming a theoretical framework for graduate students' innovative ability adapted to the artificial intelligence era. From a practical perspective, the research serves the strategic needs of national innovation-driven development and the cultivation of new-quality talents. A multi-dimensional framework and evaluation system for innovation ability provides clear guidance for optimizing university training programs, reforming curriculum systems, and improving teaching models. It cultivates students' critical thinking, interdisciplinary integration skills, and human-machine collaborative innovation capabilities, thereby effectively improving the quality of postgraduate training and supplying the nation with top-notch innovative talents.

2. Research Review

2.1 The Connotation of Innovation Ability

Scientifically defining innovation ability is a

prerequisite for carrying out the work of cultivating and evaluating innovative talents. With the interdisciplinary and global development of postgraduate education, innovation ability, as one of the core training objectives, has gradually become a focus of academic attention. Researchers, relying on their own research perspectives and methods, have different definitions of the connotation of postgraduate innovation ability, and a unified understanding has not yet been formed.

Since the 1990s, cultivating and developing high-quality creative talents has become an important goal of education and teaching in countries around the world, and also one of the main research areas. For example, the 21st Century Skills Framework explicitly identifies innovation ability as one of the 4C skills. Since Guilford proposed focusing on innovation ability in 1950, different researchers have conducted a large number of theoretical and empirical studies on innovation ability from different research perspectives, such as defining innovation ability from the perspectives of products, processes, personality, and environment [5].

Generally speaking, Lin Chongde et al. believe that innovation ability is the intellectual quality of producing a novel, unique, socially valuable, or personally valuable product by utilizing all known information according to a certain purpose.

Regarding the classification of innovative abilities, innovative abilities were divided into two categories: implicit abilities and explicit abilities [6]. The former involves innovative knowledge, innovative personality, innovative motivation, and innovative thinking, while the latter is presented in terms of the quantity and quality of innovative achievements such as academic papers and invention patents. This classification highlights that innovative ability includes both individual characteristics and can also be presented as the final innovative achievement. Specifically, Postgraduate innovative ability is based on innovative knowledge and skills, guided by innovative consciousness, and achieved through the integration of innovative thinking and innovative personality in theoretical learning and scientific research practice, thereby achieving an innovative transformation in cognition and behavior, and ultimately producing novel and applicable results [7]. Its core components include four parts: innovative knowledge and skills, innovative thinking, innovative personality, and innovative achievements. It can be seen from this that the theory emphasizes the unity of internal factors and behavioral results.

Zhang [8] emphasized the systematic nature of innovation ability, dividing it into four elements: innovative vision, innovative awareness, innovative thinking, and innovative spirit. They also integrated knowledge innovation ability and practical innovation ability into the two dimensions, highlighting the overall and practical characteristics of innovation ability from a macro perspective. Zhu [9] proposed a "three-dimensional, six-element" model based on academic innovation, including three dimensions: psychological, knowledge, and social ability, as well as six core elements: insightful imagination, comprehensive intersection, knowledge system, reflective criticism, academic autonomy, and collaborative sharing. This model emphasizes the psychological, cognitive, and social interaction characteristics of innovation ability, highlighting its complexity and multidimensionality. In the integration of the connotation of postgraduate innovation ability, the focus has been placed on the ability to discover, analyze, propose, and solve problems in scientific research activities [10]. Li [11] proposed from the perspective of the training mechanism, with knowledge, innovative awareness, and innovative thinking as the core, emphasizing the roles of postgraduates, supervisors, and schools in the development of ability. These studies show from various perspectives that innovation ability reflects an individual's intrinsic qualities and is also influenced by the system and educational environment. Postgraduate innovation ability is a complex and comprehensive ability. Because different disciplines define it differently, innovation ability also involves multidisciplinary research perspectives. Innovation ability not only relies on knowledge and skills, but also achieves cognitive and behavioral innovation through the interaction of innovative thinking and innovative personality under the guidance of innovative consciousness [12]. It also involves interdisciplinary integration ability, collaborative innovation ability, knowledge application ability, and multi-faceted communication ability, while being influenced by mental ability, knowledge accumulation, motivation, personality, and environmental factors. Additionally, the multidimensional connotation of postgraduate

innovation ability was explored from the perspectives of psychology, economics, education, sociology, and cultural studies, with emphasis placed on the conceptual distinction between innovation and ability [13].

Postgraduate innovation ability, as a multi-dimensional and dynamically evolving ability system, involves the accumulation of knowledge and skills, thinking methods, personality traits, and the guidance of innovative awareness. It presents innovation in cognition and behavior, and ultimately realizes knowledge creation and application through academic papers, patents, and other achievement types. The research conducted by different scholars has provided a rich theoretical foundation for defining its structure and connotation. However, in the context of the artificial intelligence era, it is still necessary to further expand the connotation of digital literacy, human-machine collaboration and interdisciplinary multi-dimensional innovation ability to meet the new era's demand for cultivating high-level innovative talents.

2.2 Current Status of Research on Postgraduate Innovation Ability

Based on the clarification of the connotation of postgraduate innovation ability, the academic community has gradually expanded its research direction from single scientific research results to a systematic evaluation of the innovation process, comprehensive quality, and multi-dimensional abilities. The evaluation research of postgraduate innovation ability shows an evolution from "academic innovation ability" to "composite innovation ability," that is, from examining only single scientific research results to gradually developing into a comprehensive evaluation system that takes into account knowledge and skills, innovative thinking, personality traits, collaborative ability, and interdisciplinary integration ability. Zhou et al. [14] systematically reviewed the literature and summarized the evaluation indicators of postgraduate innovation ability. They constructed a multi-dimensional indicator system that includes innovation awareness, innovation knowledge, innovation methods, innovation achievements and innovation personality, and emphasized the importance of interdisciplinary integration and innovation platform support for enhancing postgraduate innovation ability. This study reveals that a single-discipline perspective cannot fully reflect innovative practices. Interdisciplinary evaluation models should be combined with platform resource utilization to more accurately measure the diversity and complexity of the innovation process. Based on this, Pan and Gu [15], combining literature review and empirical questionnaires, found that the degree of interdisciplinary collaboration can significantly broaden graduate students' innovative horizons. In the era of artificial intelligence, interdisciplinary collaboration and knowledge integration are of significant importance for cultivating innovative abilities. Further focusing on the systematic nature of evaluation methods, research based on the analytic hierarchy process and bibliometrics, found that existing research still lacks comprehensiveness and dynamism [13]. They suggested combining multi-source perspectives with dynamic evaluation methods and introducing artificial intelligence and big data technologies in future research to achieve tracking of the entire process of graduate students' innovative ability development. This view echoes the extant research: a comprehensive review of the literature on innovative ability evaluation over the past decade, summarized and refined five core dimensions, and pointed out that with the assistance of artificial intelligence, process-oriented evaluation can more accurately reflect the development trajectory of graduate students' innovative abilities [7]. It is evident that artificial intelligence not only provides technological tools but also sets higher standards for the scientific validity and operability of the innovation capability evaluation index system. Regarding platform support and educational resources, analysis conducted through the supporting role of collaborative innovation platforms in postgraduate innovation capabilities through literature review, questionnaire surveys, and expert interviews [16]. They found a positive correlation between platform usage frequency and innovation awareness and practice, while also pointing out that uneven distribution of platform resources and insufficient innovation capabilities of mentors are the main constraints. This indicates that in the stage of constructing an innovation capability framework in the era of artificial intelligence, a comprehensive consideration should be given to the allocation of educational resources, the quality of mentor guidance, and

the efficiency of technological platform application. A systematic elaboration on the innovation capability structure model was further developed, summarizing influencing factors such as institutional incentives, research opportunities, educational environment, and policy support [17]. They emphasized that institutional and cultural support plays a crucial role in enhancing postgraduate innovation capabilities, while also calling on educators and policymakers to participate in the systematic design of the innovation capability training system to enhance postgraduates' intrinsic motivation, cognitive structure, and innovative cultural atmosphere, and further strengthen the guiding role of teachers in innovation education [18].

It is worth noting that the addition of artificial intelligence technology provides new opportunities and challenges for cultivating postgraduate innovation capabilities. Zhou and Zhao [4] pointed out that generative artificial intelligence can significantly improve the efficiency of postgraduate innovation capability cultivation, and students' AI usage ability, data security awareness, and interdisciplinary writing experience are listed as important factors affecting innovation capabilities. Cluster analysis of relevant literature using CiteSpace to conduct cluster analysis on relevant literature and found that "AI-collaborative innovation" has become a research hotspot and helps to promote the formation of a new model for cultivating postgraduate innovation ability [19]. Studies on innovation capability framework for the intelligent era demonstrate that innovative personality and critical thinking form the foundation, digital learning ability provides the guarantee, computational thinking and design thinking are essential skills for realizing innovative ideas in the intelligent era, and human-machine collaboration is an important support for solving the human-machine problem faced in the intelligent era [5].

The current state of research on the evaluation of postgraduate innovation ability shows a development trend from being guided by single research achievements to multi-dimensional ability evaluation, supported by interdisciplinary and collaborative platforms, expanding capabilities in the AI era, and dynamic process-oriented evaluation. This trend not only enriches the theoretical foundation of innovation ability evaluation, but also provides relevant practical evidence for creating a multi-dimensional ability framework including digital literacy, technological thinking, and teamwork, laying a solid foundation for the reconstruction of innovation ability dimensions and the design of evaluation systems in the era of artificial intelligence.

2.3 Research Review

In summary, existing research has formed a certain theoretical foundation in defining the connotation, structure, and evaluation methods of postgraduate innovation ability. Research generally agrees that innovation ability is not a single component, but a multi-dimensional comprehensive ability system composed of knowledge and skills, innovative awareness, innovative thinking, innovative personality, and innovative achievements. In terms of evaluation research, the academic community is gradually shifting from a single achievement-oriented approach to a process-oriented, multi-dimensional, and interdisciplinary integration-oriented approach, emphasizing the dynamic and systematic nature of innovation ability. At the same time, environmental factors such as collaborative innovation platforms, interdisciplinary resource support, and educational system incentives are generally considered important external conditions affecting the improvement of postgraduate innovation ability. Furthermore, with the intervention of artificial intelligence technology, researchers have begun to focus on the impact of AI on training methods for innovative abilities, learning behaviors, and the innovation ecosystem, forming a new research focus on "AI-assisted cultivation of innovative abilities," providing technical and theoretical support for expanding the content of innovative ability evaluation.

Current research still has significant shortcomings. Regarding the connotation of innovation ability, although most studies have defined it in terms of knowledge, thinking, and personality traits, they remain within the traditional model predating artificial intelligence. They lack attention to important new capability elements added in the AI era, such as digital literacy, human-machine collaboration, algorithmic logic understanding, and cross-disciplinary integration capabilities. The new connotation of innovation ability has not yet been systematically identified or presented in a

structured manner. In terms of refining the dimensions of capability composition, existing research relies more on theoretical deduction or expert experience, lacking empirical support in real-world research scenarios, interdisciplinary team collaboration situations, and AI-assisted innovation practices. This results in limited operability of the capability framework in practical application. Regarding the construction of evaluation systems, current research is still mainly based on static and outcome evaluations, lacking models that dynamically track and evaluate the growth path of innovation ability, performance at each stage, and the evolution of ability during AI intervention. While some studies have focused on the positive impact of AI tools on cultivating innovation capabilities, questions such as "how to truly embed AI capabilities into the framework of graduate students' innovation capabilities," "how to couple AI usage capabilities with academic ethics, innovative thinking, and scientific research expression systems," and "how to introduce AI tools to enhance graduate students' innovation capabilities" remain unanalyzed.

Addressing the above research gaps: Against the backdrop of the paradigm shift in innovation in the era of artificial intelligence, this study uses systematic literature analysis, expert interviews, questionnaires, and typical case studies to further clarify the significance of postgraduate innovation capabilities. It constructs a multi-dimensional innovation capability structure model that includes digital literacy, technological thinking, teamwork, human-machine co-creation ability, and interdisciplinary integration ability. Furthermore, it proposes a systematic, dynamic, and operable evaluation system, providing theoretical support and practical suggestions for cultivating postgraduate innovative talents in the new era.

3. Analysis of the Dimensions of Postgraduate Innovation Ability

3.1 Changes Brought to Innovation Ability by Artificial Intelligence

In contemporary society, the arrival of the artificial intelligence era has opened up a broader space for the cultivation of postgraduate innovation ability, and has also extended and expanded the connotation of postgraduate innovation ability. Traditional innovation ability mainly relies on one's own knowledge accumulation, logical deduction and practical experience, while in the artificial intelligence era, innovation activities show more prominent characteristics such as data-driven, human-machine collaboration and interdisciplinary integration. In the intelligent era, using intelligent technology to cultivate innovative talents is the primary function of innovation culture and an important factor affecting the overall innovation level of my country. Innovation ability is a recognized indicator for evaluating innovative talents. Therefore, creating digital representations and intelligent applications of innovation ability and promoting the cultivation of innovative talents has become the core issue at present.

As artificial intelligence is increasingly deeply embedded in human cognitive practices, it is gradually evolving into a cognitive extender, forming a deeply coupled collaborative cognitive system with individuals, changing the structure of human thinking and the boundaries of innovation ability. The relationship between artificial intelligence and humans is no longer a linear one of tool and user, but rather forms an inseparable collaborative cognitive unit, becoming a new cognitive paradigm different from traditional automated tools [19]. Artificial intelligence expands the scope of human perception and memory, enabling humans to discover problems and innovate in a larger spatiotemporal dimension. The participation of artificial intelligence greatly improves the efficiency and objective analysis ability of creative activities. It can quickly generate alternative solutions, simulate multiple scenarios and evaluate the results, thus enhancing the effectiveness of human decision-making. This does not mean that artificial intelligence will replace humans as decision-makers or creators. The goal of human-intelligence coupling is to better align technology with human creative intentions and enhance creative capabilities. In terms of knowledge acquisition and processing, AI technology greatly accelerates the speed at which graduate students absorb and process large amounts of information, thereby enhancing the efficiency and level of their knowledge reserves. In cultivating innovative thinking, AI provides graduate students with auxiliary tools such as creative inspiration and problem analysis through machine learning and data mining. In practical skills simulation training, AI enables hands-on practice without physical limitations

through platforms such as virtual laboratories [20]. Furthermore, in the problem-solving process, AI systems provide graduate students with decision-making support and assistance through data analysis and pattern recognition, helping them find the best solutions when dealing with complex problems. Regarding improving learning capabilities, AI technology recommends suitable learning paths and resources based on the individual needs and progress of graduate students, effectively promoting the growth of learning efficiency [21].

In the context of artificial intelligence, the cultivation of graduate students' innovation capabilities still faces challenges. Over-reliance on AI's content generation functions can weaken graduate students' problem awareness, critical thinking, and knowledge processing abilities, making innovation activities tend to be "tool-driven" rather than "subject-generated," thus affecting the improvement of graduate students' independent research capabilities and innovation capabilities [4]. In conclusion, improving innovation capabilities in the AI era must avoid "substitution dependence". The era of artificial intelligence does not weaken the innovative ability of graduate students, but rather reshapes its connotation and structure, giving new forms and requirements to traditional elements such as innovative knowledge, innovative awareness, and innovative thinking.

3.2 Reconstruction of the Dimensions of Graduate Students' Innovative Ability

In the context of the deep integration of artificial intelligence into graduate students' scientific research and learning, the innovative ability of graduate students is no longer a single-dimensional ability, nor is it composed of the traditional "knowledge memorization + problem solving," but rather an innovative ability framework composed of multiple dimensions such as digital literacy, technical thinking, and teamwork.

Digital literacy, in the context of artificial intelligence, refers to the comprehensive ability of graduate students to understand, apply, and evaluate mathematical techniques and AI tools. In the digital age, the acquisition of learning resources, the improvement of learning methods, and the innovation of learning environments are all closely linked to mathematical techniques and AI. Students with high mathematical literacy can conveniently access a large number of learning resources with the help of mathematical techniques and AI tools, and achieve self-improvement, knowledge management, and the presentation of learning outcomes through online AI platforms. Graduate students use digital technology to promote interdisciplinary research and practice, thereby enhancing their innovative thinking and problem-solving abilities. Digital literacy has a significant impact on the innovative abilities of undergraduates. The level of digital literacy directly affects whether graduate students can effectively use AI tools to create higher-level innovative thinking and ultimately achieve more groundbreaking research results.

Technical thinking refers to the ability of graduate students to use computational logic and model structures to analyze problems, transform systems thinking, engineering methods, and computational thinking into scientific research innovation, and formulate effective problem-solving abilities, including decomposition, pattern recognition, abstraction, and algorithm design. This is crucial for utilizing artificial intelligence tools in the research workflow [21]. Therefore, technical thinking emphasizes abstracting problems and using algorithms to complete logical deduction and structured innovation, which is the core of improving human-machine co-creation capabilities.

Teamwork refers to the ability of graduate students to effectively communicate, share knowledge, appropriately allocate tasks, and jointly achieve results in a collaborative environment with multiple stakeholders, all working towards a common research goal. Unlike traditional teamwork that simply emphasizes interpersonal cooperation, teamwork in the era of artificial intelligence places greater emphasis on collaborative innovation involving both humans and AI. Graduate students in a team not only need to collaborate but also need to consider AI tools as part of the team during the innovation process. They should be able to select appropriate AI tools according to task requirements and conduct research together, relying on the complementary advantages of humans and machines to enhance the team's innovation capabilities and the quality of its results. Team collaborative innovation capability is the ability to achieve human-AI collaboration, cross-knowledge system integration, and

co-creation of innovative practices based on the support of artificial intelligence technology.

Building on the three core dimensions introduced earlier, namely digital intelligence literacy, technical thinking and team collaboration, this study further develops a corresponding evaluation indicator system. Through a hierarchical structure of primary and secondary indicators, the framework specifies the key competency elements demonstrated by graduate students in AI-supported learning, research and collaborative processes, thereby forming a multidimensional evaluation system that can comprehensively reflect their innovation capability. The detailed indicator system is presented in Table 1.

Table 1. Graduate Student Innovation Capability Evaluation Framework

Primary Indicator	Secondary Indicator	Indicator Description
1. Digital Literacy	1.1Ability to Use Digital Tools	Proficient in using Python, data analysis tools, and generative AI (such as ChatGPT, deepseek, etc.)
	1.2Information Retrieval Ability	Able to use academic databases, search engines, and knowledge graph platforms to obtain literature and organize and annotate information.
	1.3AI Application Capabilities	Able to effectively use AI to improve efficiency in literature review, modeling analysis, and visualization, and effectively judge the correctness and limitations of AI tool output.
	1.4Digital Thinking and Innovation	Able to decompose complex problems, consider how to solve them through algorithms, models, automation, etc., learn digital tools and methods from different fields across disciplines, and use digital tools to discover new research directions.
	1.5Digital Practice and Output	Able to utilize online courses, AI-powered online education, and other resources for personalized and continuous learning, producing more innovative research results compared to traditional methods (such as using new algorithms, models, and other new approaches).
2.Technological Thinking	2.1 Systems Thinking Ability	Able to systematically decompose complex problems, identify valuable content from data and literature, and propose systematic research solutions.
	2.2 Algorithm and Model Thinking	Able to construct algorithmic steps for solving problems and utilize deep learning models or simulation models to explore research problems
	2.3Technical Application Ability	Applying AI to the scientific research process, such as model optimization, simulation, and prediction, and transforming theory into feasible systems or research frameworks.
3.Team Collaboration	3.1Interpersonal Collaboration Ability	Able to clearly articulate research tasks, progress, and problems, communicate effectively with team members, and divide tasks and collaboratively promote output based on project requirements.
	3.2 Human-Machine Collaboration Ability	Able to select appropriate AI tools (text generation, data processing, etc.) based on task requirements, leveraging AI to stimulate new ideas and perspectives.
	3.3Hybrid Collaboration Ability	Able to communicate effectively between human members and AI tools, translating team requirements, tasks, and problems into AI-processable instructions, and summarizing and

In the process of cultivating innovation ability, it is necessary to strengthen digital literacy, deepen technical thinking, and enhance awareness of human-machine collaborative innovation. These three dimensions are interconnected and together construct a new multi-dimensional structural model that adapts to the research activities of graduate students in the era of artificial intelligence, thereby driving graduate students to enhance their innovation ability in the era of artificial intelligence and strengthen their competitiveness in academic research and career development.

4. Conclusion

Cultivating innovative talents is the only way to build a strong education nation. Against the backdrop of rapid development in artificial intelligence, this study systematically explores the new connotations and multi-dimensional structural framework of postgraduate students' innovative abilities. This research argues that innovative ability is not a "professional skill" but rather a "comprehensive quality". It preliminarily establishes a multi-dimensional framework for innovative abilities encompassing digital literacy, technological thinking, and teamwork, and also provides a scientific and feasible evaluation system. The various dimensions are interconnected, effectively improving postgraduate students' innovative abilities, meeting the new expectations of the new era for high-level, interdisciplinary innovative talents, providing a solid theoretical foundation and practical guidance for subsequent teaching practice reforms, and offering effective data support and theoretical evidence for optimizing training mechanisms and innovating education models.

This study defines the new connotation of graduate students' innovative ability in the era of artificial intelligence from a systemic perspective. Graduate students' innovative ability is no longer the traditional paradigm of "knowledge memorization + problem solving". It is a new connotation of comprehensive quality in which, in a data-driven, human-machine collaborative innovation environment, students use AI tools, mathematical techniques, technical thinking, and interdisciplinary knowledge to discover, analyze, and overcome complex problems, thereby enhancing their own creativity. This framework does not negate the elements of traditional innovative ability, but rather integrates and enhances them with the current new context of the artificial intelligence era, more appropriately conforming to the comprehensive standards for graduate students' innovative ability in the contemporary context.

This study also has some limitations and shortcomings. This study primarily uses theoretical derivation and bibliometric analysis to define the connotation and structural framework of innovation ability. However, the multi-dimensional framework of graduate students' innovation ability has not been verified in real-world research scenarios. Regarding the collaborative ability of human-machine collaborative innovation, it remains at the conceptual level, requiring further exploration of its behavioral manifestations and specific implementation paths. Within the multi-dimensional framework of innovation ability, a model of the interrelationships between the various dimensions has not yet been constructed, hindering a deeper understanding of the framework as a whole.

The multi-dimensional framework of innovation ability proposed in this paper needs further empirical testing and analysis in real-world teaching scenarios and research activities driven by generative artificial intelligence technology. The impact of generative artificial intelligence on the cultivation of innovation ability manifests as a complex multi-dimensional mechanism, requiring explanation using multiple theories. It is necessary to clarify the manifestations and development stages of each dimension of innovation ability elements before constructing an implementable evaluation index system and training model for innovation ability, thereby increasing the practical guiding value of this study's structural framework.

Acknowledgement

This study is supported by the Innovation Project of Guangxi Graduate Education (Project No.: JGY2025161).

References

[1] UNESCO Center for Innovation in Higher Education. Artificial Intelligence Reshapes the Global Higher Education Landscape. China Scholar, 2025(3): 7-12.

[2] Hu Zhen-tao, Jin Yong, Zhou Lin, et al. Research on the Training Model for AI Professional Degree Postgraduates Under Deep Industry-Academia-Research-Application Integration. Modern Educational Equipment in China, 2025(5): 132-134.

[3] Zhang Yongmei, Du Zhirong, Guo Ao, et al. Artificial Intelligence-Empowered Evaluation of Graduate Innovation Capabilities. Software Guide, 2025, 24(4): 184-190.

[4] Zhou Wenhui, Zhao Jinmin. The Value and Challenges of ChatGPT in Cultivating Graduate Students' Innovation Capabilities. Higher Education Management, 2024, 18(2): 42-52.

[5] Li Jihong, Zhuang Rongxia, Nian Zhiying,

et al. Cultivating Innovation Capabilities for Human-Machine Collaboration: A Discussion on Creative Talent Needs in the Intelligent Era. Chinese Journal of Educational Technology, 2021(7): 36-42, 61.

[6] Lü Hongyan. The Essence and Enhancement Pathways of Doctoral Students' Innovation Capabilities. Jiangsu Higher Education, 2013(5): 101-102.

[7] Wang Hongcai, Sun Jiapeng. Research Status and Prospects of Evaluating Graduate Students' Innovation Capabilities in China. Research on Graduate Education, 2022(6): 1-7.

[8] Zhang Xianlu. Aesthetic Education Pathways for Cultivating Graduate Students' Innovation Capabilities: Using Beauty to Reveal Truth. Research on Graduate Education, 2024(4): 37-43.

[9] Zhu Xudong. On the Fundamental Connotation of Academic Innovation Capacity Among University Faculty. Comparative Education Research, 2011, 33(7): 1-6.

[10] Chen Xinzhong, Li Zhongyun, Hu Rui. Three Fundamental Issues in Evaluating Graduate Students' Innovation Capabilities. Degree and Graduate Education, 2010(1): 10-13.

[11] Li Hui. Factors Influencing and Cultivation Mechanisms for Graduate Students' Innovation Capabilities in Ethnic Universities. Journal of Northwest Minzu University (Philosophy and Social Sciences Edition), 2017(4): 161-167.

[12] Zhao Yanling, Wang Junhui, Bo Xiaoming, et al. Research on the Formation Mechanism and Cultivation Model of Graduate Students' Academic Innovation Capabilities. Education Theory and Practice, 2022, 42(33): 8-11.

[13] Xu Jihong, Guo Shiming, Hong Tao, et al. Construction of an Evaluation Index System for Postgraduate Innovation Capabilities from a Multidisciplinary Perspective. Research on Postgraduate Education, 2016(3): 67-71.

[14] Zhou Yuqing, Huang Huan, Fu Hongfei. Leading the Reform and Development of Graduate Education Through "Double First-Class" Initiative: A Review of the High-Level Forum on "Double First-Class" Construction. Research on Graduate Education, 2016(3): 1-6.

[15] Pan Bingru, Gu Jianmin. The Impact of Advisor Guidance Factors on Graduate Students' Innovation Capabilities: A Comparative Analysis Across Disciplinary Categories. Degree and Postgraduate Education, 2022(4): 52-60.

[16] Zhou Zhengzhu, Li Yaoyao. Research on the Current Status and Improvement Strategies for Cultivating Graduate Students' Innovative Abilities in a Collaborative Innovation Environment. Creative Education Studies, 2021, 9: 330.

[17] He Shoukui. Training Paths of Innovation Ability for Professional Degree Graduate Students Based on SEM. Higher Education of Architecture, 2020, 29(2), 72-80.

[18] Wang Jiajie, Li Tianyi, Ding Tian, et al. Research on Identifying Fake Reviews in Online Medical Communities Based on Synthetic Data from Large Language Models. Theory and Practice of Intelligence, 2025.

[19] Chen Yebin, Cao Jing. Literature Analysis on Cultivating Graduate Students' Innovative Abilities Using CiteSpace. Operations Research and Fuzziology, 2025, 15: 238.

[20] Deng Wu, Zhao Huimin, Xu Junjie, et al. Case-Project Driven Teaching Method for Cultivating Graduate Students in Artificial Intelligence. Journal of Higher Education, 2024, 10(28): 50-53, 58.

[21] Xiong F, Yu X, Leong H W, et al. AI-driven research ecosystem: unifying human-AI collaboration models and new research thinking paradigms. Journal of Educational Technology and Innovation, 2025, 7(1): 71-75.

