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How to Cultivate Digital Engineering Management Talents: A Case on the ”Digital Intelligence Innovation and Management” Engineering Doctoral Program

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1 Introduction

In the current context of the world's comprehensive promotion of digital transformation, improving the digital literacy and skills of talents is the top priority of quality education in higher education[1]. In 2022, China released the world's first higher education digitalization strategy report, "Infinite Possibilities—Report on the Digital Development of World Higher Education", which pointed out that the rapid development of intelligent technology is accompanied by high social demand for digital literacy of talents, but the current education system has not yet adapted to this change, and some higher education institutions are not yet in a position to adjust the layout of disciplines and specialties in a timely manner in order to meet the challenges brought by artificial intelligence [2]. The "2024 Digital Talent White Paper" released by China shows that the demand for digital managers in enterprises accounts for up to 70% [3]. Relevant surveys also show that in 2025, China's talent gap involving digital engineering construction and digital engineering management will reach more than 5 million [4]. How to cultivate high-quality talents who can adapt to the digital intelligence transformation and development has become one of the key issues that urgently need to be solved in the current engineering education reform.

Currently, with the increasing integration of artificial intelligence and digital technology into the entire process of education development, the traditional education model is facing a series of new challenges [5]. The "shortcomings" of school education in terms of educational content, methods, and systems have resulted in many "mismatches" between the innovative talents it cultivates and the needs of digital transformation [6]. Therefore, the rapid development of digital intelligence technology requires a systematic change in the engineering management personnel training system. In summary, this study adopted a single-case study methodology, taking the "Digital Intelligence Innovation and Management" Engineering Doctoral Program carried out by Z University as the research object; based on the concept of "Convergence Education", we systematically deconstructed the program across three dimensions: knowledge integration, technology integration and domain integration. Consequently, We summarized the talent cultivation model and experience of Z University, with a view to providing insights for the cultivation of high-level digital engineering management talents in the digital intelligence transformation era.

2 Literature Review

2.1 Training Mode and Path of Digital Engineering Management Talents

In the era of digital intelligence, professional talents need to adapt to the requirements of industrial digital transformation, for which data resources as the key element, and they must have the ability to solve problems in a "data-driven" manner [7]. Therefore, mastering and flexibly applying digital intelligence technologies such as generative artificial intelligence, big data, and cloud computing for theoretical analysis and practical creation has become a new requirement for cultivating high-level composite innovative talents [8]. Based on this, academia has explored and formulated new talent cultivation plans from multiple perspectives. Zhang Tingting et al. selected five representative "digital intelligence talent" training programs and extracted the key practices of talent training from the three dimensions of task objectives, education standards, and practice models [9]. Ji Feng et al. proposed a path for cultivating interdisciplinary business talents in the digital intelligence era by optimizing training objectives, improving the training process, and establishing the support system [10]. Wang Zhuli et al. proposed strategies for cultivating five key abilities that talents in the digital intelligence era should have in sub-dimensions [11]. Meanwhile, many universities in China are actively exploring the reform of talent training models for engineering management in the digital intelligence era. In 2019, Hangzhou Dianzi University established the "Digital Engineering Management Experimental Class" to explore the training mode of engineering management talents based on the CDIO concept, and explored a collaborative education mechanism through cooperation between schools and enterprises in the construction of experimental platforms and practice bases [4],[12]. Shandong University of Finance and Economics established a digital engineering management talents training system of "digital platform + engineering technology platform + management platform + economic platform" [13]. Overall, China's universities are actively reforming their educational philosophies and innovating their educational models to cultivate high-quality engineering management talents that are adaptable to the development of the digital intelligence era.

2.2 Theoretical Basis: Convergence Education Philosophy

The Convergence Education is a new educational paradigm driven by the Wicked Problem in the real world. It transcends disciplinary boundaries and promotes the cultivation of high-level talents through the in-depth integration of content systems, tool systems, and thinking modes, giving rise to creative ideas and problem-solving approaches [14]. In 2022, the National Science and Technology Council of the United States released a report specifically on Convergence Education. The report

emphasized that in order to achieve the goals of Convergence Education, stakeholders must build a coherent and complete framework, and encourage the promotion of effective Convergence Education methods [15]. On this basis, some scholars have summarized the three pillars of Convergence Education as knowledge, technology, and domain, and proposed that the integrated ecosystem of Convergence Education demonstrates comprehensive integration and systematic integration of knowledge, technology, and domain through deep integration of content system, tool system, thinking mode, and other levels (as shown in Figure 1) [16].

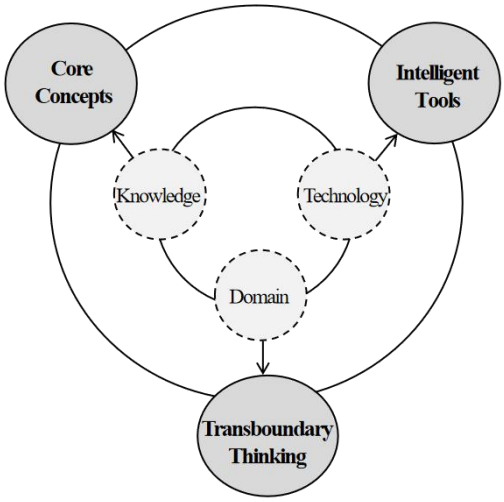

Figure 1 Integrated Ecosystem of Convergence Education

The Convergence Education Philosophy provided a theoretical basis and reference framework for us to systematically deconstruct and analyze the "Digital Intelligence Innovation and Management" Engineering Doctoral Program from three dimensions: "knowledge integration", "technology integration", and "domain integration".

3 Research Design

3.1 Research Methodology

This study adopted a single-case study methodology, obtaining primary data through semi-structured interviews with mentors, students and administrators who participated in the program, and collecting relevant secondary data from internal channels, official websites, and mainstream media.

3.2 Case Selection

This study takes the "Digital Intelligence Innovation and Management" Engineering Doctoral Program established by Z University as the research object for the following

reasons: Firstly, the case fits the research theme. The program aims to cultivate the students' ability to carry out the management of digital intelligence innovation in related engineering fields, responding to the new demand for high-level engineering management talents in the context of digital intelligence. Secondly, the case is novel. The program has begun recruiting and cultivating Doctor of Engineering in the direction of digital intelligence innovation and management in conjunction with a number of engineering faculties from 2023. Thirdly, it is convenient to obtain information. Our research group has long been concerned about the cultivation of engineers and Doctor of Engineering at Z University, and has reliable and stable internal channels to obtain relevant information. In summary, the case selected by this study has certain typicality, representativeness and reliability.

3.3 Data Collection

We obtained data through the following methods: firstly, conducting interviews to obtain first-hand information. On the one hand, since the students' academic records are incorporated into the Polytechnic Institute of Z University upon enrollment, we conducted semi-structured interviews with four administrators of this Institute to understand the particularities of the Doctor of Engineering in terms of teaching philosophy, teaching processes, teaching modes, etc. On the other hand, we also conducted semi-structured interviews with one mentor and one student who are deeply involved in the program to obtain core information (Table 1 shows the information of the interviewees). Secondly, we gathered second-hand information. This study has extensively collected normative documents such as enrollment brochures, training programs, evaluation and assessment rules released by the official websites; at the same time, we extensively collected mainstream media's reports related to the program. The information obtained through multiple channels formed a "triangular validation", which enhances the accuracy and authenticity of the data and ensures the credibility of the research results.

Table 1 Interviewer Information

Colleges	Identity	Quantity
School of Management at Z University	mentor involved in the program	1 person
	student involved in the program	1 person
Polytechnic Institute of Z University	administrators	4 persons

4 Case Analysis

In order to cultivate applied and compound high-level engineering management talents that are urgently needed in key national fields in the era of digital intelligence, the School of Management at Z University targets technical management backbone

personnel and related enterprise management backbone personnel from enterprises, national laboratories, and other institutions undertaking national key special tasks in related fields for enrollment. The School of Management, in collaboration with the College of Civil Engineering and Architecture as well as the School of Mechanical Engineering, jointly recruited and cultivated the Doctor of Engineering in the direction of “Digital Intelligence Innovation and Management” starting in 2023. In 2024, Z University established five additional Engineering Doctoral Programs, including “Digital Intelligence Innovation and Management”. Its enrollment categories include four engineering degree categories: Mechanical Engineering, Civil Engineering and Hydraulic Engineering, Traffic and Transportation, Energy and Power Engineering.

4.1 Knowledge Integration: Giving Rise to the Program’s Characteristic Cultivation Concept

The Convergence Education Philosophy holds that the result of the integration of knowledge systems is the birth of core concepts of disciplines. The School of Management at Z University, relying on the high-level management discipline clusters as well as the science, technology, agriculture and medicine clusters, independently established China’s first second-level interdisciplinary of “Digital Intelligence Innovation and Management” in June 2021. The School of Management, leveraging this second-level interdisciplinary and Z University’s existing engineering doctoral training system, has collaboratively established the “Digital Intelligence Innovation and Management” Engineering Doctoral Program with engineering departments and majors including Mechanical Engineering, Civil Engineering and Hydraulic Engineering, Traffic and Transportation, and Energy and Power Engineering. The program is aligned with the major national engineering management needs under the "Digital China" strategy, and the concept of “cross-discipline” is integrated throughout the entire talent cultivation process. The program aims to cultivate high-level engineering management talents with applied and complex capabilities who possess mastery of “basic theories and knowledge” and the ability of “application of digital intelligence technology + engineering technology innovation and management”. Specifically, the quality structure of the program’s engineering doctoral students is as follows: on the one hand, in terms of knowledge structure, students of the program need to master the basic theories, expertise and research methods of the discipline of Digital Intelligence Innovation and Management, and possess an in-depth understanding of the discipline’s cutting-edge development trends; on the other hand, in terms of the fundamental ability, one should not only master information technologies such as cloud computing, big data processing and analysis, as well as artificial intelligence technologies such as generative AI and machine

learning, but also possess the capabilities for technological innovation and management to solve complex engineering problems based on familiarity with digital intelligence innovation and management practices.

> *Intelligentization is usually accompanied by the interdisciplinary intersection, and the result of this intersection is the imposition of higher demands on talent cultivation (Administrator, B).*

> *Interdisciplinary literacy and awareness are of utmost importance, and we need to cultivate the ability of Doctor of Engineering to leverage knowledge, tools, and resources from other disciplines to address complex engineering problems (Administrator, Z1).*

4.2 Technology Integration: Enhancing the Effectiveness of Educational Tools and Instruments

The Convergence Education Philosophy holds that the integration of the technologies can enhance the effectiveness of tools and means, giving rise to machine intelligence. The School of Management actively integrated the technical resources from advantageous disciplines such as Management, Medicine, and Engineering at Z University, and formally established the “Digital Intelligence Innovation and Management Laboratories” in 2023. The laboratories focus on three main areas: digital intelligent technology, digital intelligent organization, and digital intelligent innovation, which primarily establish four research directions: “Intelligent Technology and Decision-Making Methods”, “Digital Intelligence Technology and Future Work Design”, “Organizational Change Driven by Digital Intelligence Technology”, and “Paths and Policies of Digital Intelligence Technology Innovation”. For an extended period, several research teams have been focusing on the domain of "Digital Intelligence Innovation and Management," conducting research and establishing a solid research foundation. Subsequently, relying on the laboratory as a research platform, they have been awarded a number of major projects from the National Natural Science Foundation of China and the National Social Science Foundation of China. To better serve talent cultivation, both Doctor of Engineering and academic graduate students are deeply involved in the research work of the major key projects, taking responsibility for different types of research tasks based on their respective strengths; among them, Doctor of Engineering usually participate in solving complex engineering technologies or carrying out engineering technological innovations due to their strong theoretical foundation in engineering technology and engineering practical ability.

> *Universities should collaborate with enterprises to seek to undertake national*

research projects, thereby enabling Doctor of Engineering to enhance their competencies through participation in high-impact projects, rather than focusing on low-level papers (Administrator, Z2).

4.3 Domain Integration: Promoting the Formation of Multidimensional Transboundary Thinking

The Convergence Education Philosophy holds that the domain-level integration facilitates the formation of transboundary thinking. The "Digital Intelligence Innovation and Management" Engineering Doctoral Program implements a distinctive talent cultivation pathway of "cross-discipline+cross-industry+cross-border".

4.3.1 Cross-discipline Cultivation

(i) Interdisciplinary Faculty

One aspect is the joint guidance provided by the "School of Management + Engineering Departments" dual mentors. The program implements a dual mentor system with "main mentor + associate mentor" joint guidance. After determining a specific research direction, students will be co-supervised by an interdisciplinary mentor group comprising professors from the School of Management as the main mentor and professors from the faculties or majors of Mechanical Engineering, Civil Engineering and Hydraulic Engineering, Traffic and Transportation, and Energy and Power Engineering as the associate mentor. Furthermore, to enhance the application-oriented nature of the training process, the program mandates that the mentor group includes an expert with extensive engineering practical experience.

The second aspect is that the School of Management has established a multi-level and interdisciplinary mentor team. The School of Management has established three tiers of mentor teams in recent years. The first tier comprises three "Strategic Discipline Teams", each consisting of the School of Management's discipline (direction) leaders, domestic and foreign strategic scientists, and core research backbones. The second tier includes twelve "Characteristic Cross-disciplinary Teams", each focusing on the featured discipline direction and composed of researchers from the School of Management and various disciplines of science, engineering, agriculture, and medicine. The third tier consists of several "Zijin micro-teams", each composed of young top-notch scholars. It is worth noting that the School of Management is currently promoting the "team mentoring model" . Although the main mentor of a student is typically the leader or chief scientist of a first or second tier team, other faculty members in the main mentor's team also provide guidance to the students during the actual training process.

This program adopts a dual-mentor system, meaning that there is one mentor from the School of Management and another from the engineering departments, and mentors are usually the core backbone or leader of a large team (Mentor, L).

Doctor of Engineering cannot be trained on a large scale like masters; rather, they require personalized, one-on-one guidance (Administrator, Z2).

(ii) Interdisciplinary Curriculum System

One aspect is to leverage the cross-discipline to develop distinctive “professional degree courses”. Drawing on the theoretical frontiers in the second-level interdisciplinary of "Digital Intelligence Innovation and Management", the School of Management has established two professional degree courses for this program. These courses are grounded in engineering management theory, providing a comprehensive overview of the second-level interdisciplinary, including its theoretical frontiers and scientific research issues. The course content integrates industry and enterprise development trends, emphasizing the exploration of cutting-edge theories, management practices, research ideas, issues, and methods in the fields of intelligent organization, digital strategy, digital decision-making, digital intelligence innovation, and digital entrepreneurship.

The second aspect is to develop distinctive “professional elective courses” based on industrial demand. The School of Management encourages its faculty members to collaborate with engineering department teachers to develop "cross-disciplinary innovative industrial courses" that address the needs of strategic and future industries, including the low-carbon economy, aerospace economy, integrated circuits, and high-end equipment manufacturing, as well as future industrial development. At present, the School of Management has collaboratively developed five courses with the College of Integrated Circuits, the College of Energy Engineering, the School of Mechanical Engineering, the College of Computer Science and Technology, the College of Civil Engineering and Architecture, and the School of Medicine. These courses primarily target the fields of integrated circuits, low-carbon energy and finance, intelligent manufacturing, and artificial intelligence. Overall, the curriculum system of the “Digital Intelligence Innovation and Management” Engineering Doctoral Program is presented in Table 2.

Table 2 Curriculum System of the Engineering Doctoral Program

Course Type	Course Name	Course Nature
Public Degree Courses	English for Graduate Students	Compulsory
	Chinese Marxism and Contemporary	

	Engineering Management	
Professional Degree Courses	Introduction to Digital Intelligence Innovation and Management	Compulsory
	Frontiers of Digital Intelligence Innovation and Management Theory	
	Advanced Management Research Methods	
	Graduate Student Dissertation Writing Guidance	
Professional Elective Courses	Integrated Circuit Independent Innovation Management	Elective
	Integrated Circuit Technology Entrepreneurship Management	
	Low carbon energy and sustainable finance	
	Intelligent Manufacturing and Management	
	Artificial Intelligence and Industry Applications	
	Or taking courses related to the Doctor of Engineering that already exist in the associate mentor's college	

4.3.2 Cross-industry Cultivation

(i) Employing Enterprise Mentors to Provide Diversified Guidance

To strengthen the application-oriented concept of Doctor of Engineering training, the program continues to deepen the integration of industry and education by employing numerous experts with extensive engineering practice experience, a high level of vocational ability, and strong mentoring skills from top enterprises in national strategic emerging industries. Enterprise mentors are deeply involved in the cross-disciplinary construction of "Digital Intelligence Innovation and Management", the construction of cross-disciplinary teaching projects and the construction of cross-disciplinary innovative industrial courses, and provide multifaceted guidance to the Doctor of Engineering through short-term lectures, academic lectures, and in-depth collaborative research.

(ii) Building High-level Industry-education Integration Platforms Jointly by Schools and Enterprises

On the one hand, leveraging strategic partnerships with Alibaba, Dahua Technology, Hikvision, and Zhejiang Geely Holding Group, the School of Management has established lots of laboratories. The industry-teaching integration platforms provide diverse application scenarios in digital intelligence management and enable students to conduct case studies on the digital intelligence transformation of enterprises and digital intelligence organization management in real engineering management

contexts. On the other hand, the School of Management has collaborated with leading enterprises to develop a number of digital intelligence "large language models" that can facilitate the digital-physical integration. For example, in July 2024, the School of Management and Huawei jointly developed the China's first open-source large language model in the field of finance and accounting-Zhihai Dayu. These large language models provide reliable technical support and cutting-edge application platforms for the cultivation of composite engineering management talents.

> *Currently, we are more inclined to collaborate with well-known enterprises in establishing laboratories, thereby laying the foundation for future research that is closely tied to industrial development (Mentor, L).*

(iii) Conducting In-depth Engineering Practice Research in Industry Enterprises

The dissertation topics of students must closely address major technological innovation and management innovation issues in the research direction of digital intelligence innovation and management. Therefore, to facilitate students in exploring real-world problems and conducting authentic research in industry and enterprise contexts, the program has established a compulsory "professional practice section". The section requires students to engage in professional practice for at least six months, aligned with the research direction of their mentor team and the needs of partner enterprises. Additionally, students must participate as key members in school-enterprise collaborations or enterprise's technology tackling prior to their dissertation defense, and submit two qualified enterprise engineering practice reports. Upon successful completion, students will be awarded credits.

4.3.3 Cross-border Cultivation

The School of Management continues to advance the internationalization training programs of Doctor of Engineering in "Digital Intelligence Innovation and Management" through strategic partnerships with internationally renowned universities, including Massachusetts Institute of Technology, Stanford University, University of Cambridge, City University of Hong Kong, and Singapore Management University. The School of Management plans to sponsor approximately 5 young teachers and doctoral students to visit these prestigious international universities annually, thereby enriching their academic diversity experiences and overseas experiences, and fostering the development of first-class engineering management talents with international perspectives.

4.4 Brief Summary

The program has developed a distinctive talent cultivation model based on the integration of the university's disciplinary advantages and the extensive cooperative network encompassing industry and top international universities, as shown in Figure 2. Meanwhile, major university strategies, such as the "Digital Social Science Convergence Research Program" and the "Interdisciplinary BEST Strategy", have furnished consistent policy and resource backing to guarantee the seamless execution of the program. Currently, the program has achieved preliminary outcomes.

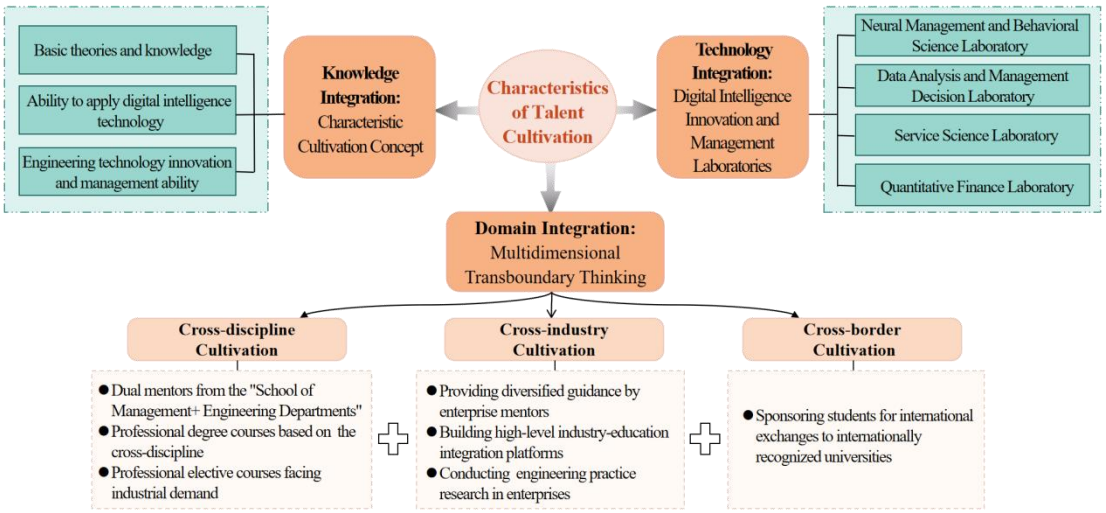

Figure 2 Characteristics of Talent Cultivation of the "Digital Intelligence Innovation and Management" Engineering Doctoral Program

Firstly, a series of research outputs have been derived. Taking the project applications as an example, in 2024, six cross-disciplinary research projects that were approved as major or key projects at the national level, thereby continuously achieving breakthroughs in interdisciplinary research and collaboration. With regard to the construction of supporting laboratories, in December 2024, the "Digital Intelligence Innovation and Management Laboratories" was successfully designated as the "Philosophy and Social Science Laboratory of Zhejiang Province". As for academic research achievements, in recent years, the research teams have been dedicated to compiling a series of books titled "Digital Intelligence Innovation and Management," which aims to contribute to the construction of an autonomous knowledge system for Chinese Management in the digital intelligence era. Currently, three books have been officially published by Science Press.

Secondly, positive feedback has been received from students. Since the inception of the enrollment, this program has garnered widespread attention from high-level talents in related fields. Currently, students express high satisfaction with both the curriculum system and the mentorship model. One student from the construction

industry, after completing the professional degree courses, remarked that the comprehensive curriculum theoretical framework and the insightful guidance from the instructors helped her gain a comprehensive understanding of cutting-edge theories, management practices, and industrial development trends in the fields of intelligent organization, digital strategy, digital decision-making, digital intelligence innovation, and digital entrepreneurship. Moreover, these courses offer significant practical guidance, providing her with a clear direction for the enterprise's future digital reform. As a result, she exclaimed, "These courses surprised me and suddenly enlightened me" (Student, Y).

5 Discussion

The program provides a distinctive talent training program for engineering management, addressing the two crucial questions of "what kind of digital engineering management talents are needed in the era of digital intelligence transformation, and how to cultivate them." Specifically, firstly, the program aims to cultivate high-level engineering management talents who possess mastery of "basic theories and knowledge" and the ability of "application of digital intelligence technology + engineering technology innovation and management". Secondly, the "Digital Intelligence Innovation and Management Laboratories", established through the integration of multiple advantageous disciplinary resources, provide a crucial platform support for students to focus on key issues in the field and conduct research. Finally, the program implemented a distinctive talent cultivation path involving "three types of transboundary" approaches. Specifically, it included the cross-disciplinary co-construction of faculty and curriculum system with multiple advantageous disciplines on campus, the cross-industrial co-construction of industry-education integration platforms with leading enterprises, and the cross-border co-cultivation of internationalized talents with internationally renowned universities.

There are many similarities and differences between this program and the talent cultivation models of top international universities. North America boasts rich experience in cultivating engineering management talents, with MIT's System Design & Management (SDM) program being a typical representative. Upon comparison, numerous similarities and differences emerge between the talent training models of Chinese and North American universities. Specifically, regarding training objectives, both programs emphasize the fostering of interdisciplinary awareness and abilities. However, this program underscores the ability to integrate digital intelligence technologies with engineering management. Conversely, SDM emphasizes the development of systematic thinking and leadership. Regarding curriculum setting, this program focuses on establishing an interdisciplinary curriculum system through the integration of multidisciplinary resources. In contrast, SDM typically employs a

modular curriculum system, emphasizing case studies and practical internships. Regarding industry-university-research cooperation, this program emphasizes strengthening university-enterprise collaborative education through the establishment of industry-education integration platforms, whereas SDM focuses more on strengthening university-enterprise cooperation in internship and project participation. Lastly, both programs emphasize the joint cultivation of talents through international resources.

The program exhibits universal applicability and generalizability, offering valuable insights to other universities in cultivating engineering management talents. Specifically, firstly, universities should conduct in-depth research on the ability requirements for engineering management talents in the era of digital intelligence transformation, formulate training programs that align with the contemporary demands and emphasize the enhancement of "digital intelligence + " capabilities. Secondly, Universities are encouraged to break down disciplinary barriers and establish corresponding interdisciplinary focusing on "digital intelligence innovation and management." Simultaneously, based on the integration of multidisciplinary resources, universities should build interdisciplinary curriculum systems and teaching staff teams. Thirdly, Universities should not only collaborate with leading enterprises to establish laboratories or practice bases but also invite industry experts to jointly design courses and integrate authentic digital intelligence management scenarios and cases into the teaching session. Lastly, universities should elevate the standard of international talent development by introducing high-quality international educational resources, facilitating student exchange programs, and offering international joint training initiatives.

6 Conclusion

This study adopted a single-case study methodology, focusing on the "Digital Intelligence Innovation and Management" Engineering Doctoral Program as the research subject. Drawing on the Convergence Education Philosophy, this study systematically deconstructed the program's characteristics for cultivating digital engineering management talents across three dimensions: knowledge integration, technology integration, and domain integration. The findings reveal that, in order to enhance students' digital and intelligent management capabilities, the program has not only established a high-level interdisciplinary experimental platform but also offered distinctive educational components by leveraging cross-disciplinary, cross-industry, and cross-border resources. Overall, this study has three research contributions. Firstly, this study presented a distinctive training program for high-level digital engineering management talents, enriching the research content related to the cultivation concept, educational tools and instruments, and the cultivation model. Secondly, this case

provide practical and feasible solutions to alleviate the current global shortage of digital engineering management talents. Finally, this study fills the current research gap in the interdisciplinary construction of “Digital Intelligence Innovation and Management”, offering insights to improve the discipline research direction, discipline research system and talent cultivation system.

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