DOI URL: https://doi.org/10.63944/wmc.NHE.3
Vol.1 No.3

Research on the "full chain" industry-education integration talent training model of packaging engineering major empowered by artificial intelligence

Jie Huang[1], Jinhua Tan[1*], Yiwu Liu[1], Yue Chen[1], Fude Lu[1], Haiyang Liao[2]

[1] School of Package Engineering, Hunan University of Technology, China | 14374@hut.edu.cn

[2] School of Mechanical Engineering, Hunan University of Technology, China | haiyangliao1990@163.com

[*] Corresponding Author: Jinghua Tan, School of Package Engineering, Hunan University of Technology, China | tjh@hut.edu.cn

Abstract: In the current practice of industry–education integration for talent cultivation, the Packaging Engineering major faces persistent challenges, including limited integration mechanisms, insufficient depth of collaboration, and a narrow scope of engagement. These issues constrain the development of high-quality undergraduate talent. To address these limitations, this study takes the Packaging Engineering program at Hunan University of Technology as a representative case and adopts a comprehensive case study approach. Data were collected through questionnaires, in-depth interviews, document analysis, and learning platform log mining. By employing analytical techniques such as descriptive statistics and thematic clustering, the study systematically examines the present status and underlying challenges of industry–education integration in the program. Building upon these findings, the study proposes an AI-empowered "full-chain" industry–education integration framework that holistically connects the industry chain, education chain, innovation chain, and talent chain. This framework leverages artificial intelligence to achieve precise alignment between educational processes and industrial demands, facilitate deep knowledge reconstruction, and foster the co-evolution of the university–industry ecosystem, thereby realizing comprehensive and synergistic integration. Furthermore, the research delineates the implementation pathway of the AI-enabled "full-chain" model from three dimensions: demand-driven design, resource integration, and process implementation. Empirical results indicate that the proposed model has yielded significant improvements in the Packaging Engineering talent cultivation process—manifested in enhanced quality and frequency of university–enterprise collaboration, improved graduate employment outcomes, and sustained student satisfaction and recognition. This study contributes a replicable and scalable paradigm for AI-supported "full-chain" industry–education integration, offering valuable insights for reforming talent cultivation models in Packaging Engineering and related engineering disciplines.

Keywords: Artificial intelligence; Full supply chain; Integration of industry and education; Packaging engineering major; Talent training

Funding Project: Hunan Provincial Research Project on Degree and Graduate Education Teaching Reform (2025JGYB326); Hunan Provincial General Higher Education Teaching Reform Research Project (202502002052); Key Project of Education and Teaching Reform Research in General Colleges and Universities in Hunan Province (HNJG-20230724); Hunan University of Technology Degree and Postgraduate Education Teaching Reform Research Project (JGYB25011); Hunan University of Technology Teaching Reform Project (SJG-0125212).

Introduction

At the national level, great importance is attached to building a talent training system that organically connects the education chain and the industrial chain. In 2017, the General Office of the State Council issued the "Opinions on Deepening the Integration of Industry and Education," explicitly elevating the integration of industry and education to a major national strategy for educational reform and talent development [1]; subsequently, the Ministry of Education issued the "Action Plan for Innovation in Artificial Intelligence in Higher Education Institutions," proposing to improve the talent training system in the field of artificial intelligence and promote the integration of "artificial intelligence + education"; in 2022, six ministries including the Ministry of Science and Technology issued guiding opinions to accelerate high-level application of artificial intelligence to promote high-quality economic development, emphasizing the promotion of deep integration of artificial intelligence with the industrial chain; in 2025, the "Outline of the National Plan for Building a Strong Education Country (2024-2035)" further emphasized deepening the integration of industry and education and school-enterprise cooperation to cultivate a large number of high-quality technical and skilled talents. Simultaneously, in recent years, the rapid development of new-generation artificial intelligence technology has brought new opportunities and challenges to the education field. In particular, the emergence of generative artificial intelligence such as ChatGPT at the end of 2022 has triggered reflections on educational reform. UNESCO also advocates that countries actively harness AI technology to promote educational innovation while preventing risks and ensuring that AI applications follow the principles of inclusiveness and equity [2].

Packaging engineering is an applied engineering discipline and a crucial component of the modern manufacturing service industry. Its talent cultivation needs to keep pace with technological innovation and industrial demands [3]. my country's packaging industry is enormous, with industry revenue exceeding 1.2 trillion yuan in 2021, second only to the United States, making it the world's second-largest packaging country. However, the industry lacks concentration, suffers from a shortage of high-level innovative talent, and has an insufficient proportion of skilled technicians and management personnel (less than 4%). Industry surveys show that there is a talent gap of hundreds of thousands of professionals in my country's packaging sector, and 80% of companies prioritize graduates' practical skills. This indicates that packaging engineering talent cultivation urgently needs to deepen industry-education integration and strengthen practical teaching to meet the urgent demand for high-quality applied talents in industrial transformation and upgrading [4].

However, current talent cultivation in packaging engineering still suffers from numerous shortcomings in industry-education integration [5-7]. Firstly, school-enterprise cooperation has not yet formed a close and long-term mechanism, resulting in a disconnect between the demand side of industrial development and the supply side of education, leading to a "loose integration." Secondly, school-enterprise cooperation is often limited in form, short in duration, and shallow in depth, making it difficult to support in-depth practical training for students, resulting in "shallow integration." Furthermore, the number of cooperating enterprises and practical training bases is limited, resources are insufficient, and regional and industry coverage is not broad enough, leading to a "narrow integration." These problems are also common in the talent cultivation of similar engineering disciplines such as printing engineering. Therefore, to improve the quality of packaging engineering talent cultivation, it is necessary to overcome the information gap, time lag, and resource bottlenecks in industry-education integration.

In recent years, several studies have explored solutions to the aforementioned problems. For example, some research indicates that industry-education integration is a crucial way to achieve coordinated development between the talent training objectives of packaging engineering programs and social needs, emphasizing the introduction of the "complete packaging solution" concept proposed by the international packaging industry to optimize talent training requirements [8]. Scholars from universities such as Shaanxi University of Science and Technology have proposed optimization schemes for packaging engineering talent training models empowered by artificial intelligence, analyzing aspects such as curriculum system, faculty resources, evaluation system, and industry-university collaboration [9]. Zhao Qiong and Ma Xiangdong, based on the actual situation of their university's packaging engineering program, proposed using AI technology to transform courses and practical training to upgrade the talent training model [10]. Mo Jicheng and others explored a new model for cultivating composite talents in packaging engineering empowered by artificial intelligence. Based on existing literature, most researchers focus on analyzing industry-education integration mechanisms from a macro-policy or technological perspective, or focus on reforms in a specific link, lacking in-depth research combining specific professional practices across the entire chain [11]. Addressing this research gap, this study takes the packaging engineering program of an applied undergraduate university as an example, verifying the effectiveness of the "four-chain integration + three-layer collaboration" model through a clear research methodology, filling the gap in existing research regarding "technology implementation - system practice - data verification."

1. Analysis of the current state of industry-education integration

This study employs a case study approach, focusing on the Packaging Engineering program at Hunan University of Technology. The study covers 742 students from the 2022 cohort (practical teaching stage), 2023 cohort (curriculum reform stage), and 2024 cohort (employment tracking stage) during the 2024-2025 academic year, as well as 15 collaborating enterprises (involved in packaging materials, intelligent manufacturing, and logistics packaging). To identify industry needs and program challenges, implement a three-tiered "needs-resources-implementation" pathway, and validate the model's effectiveness, the study utilizes four methods: First, a questionnaire survey was conducted, using a 13-question Likert five-point scale questionnaire (covering teaching effectiveness, technology experience, and industry-education integration effectiveness) for 243 students from the 2022 cohort, and a "talent satisfaction questionnaire" with 10 indicators (including job suitability and practical skills) for the 15 enterprises. Second, in-depth interviews were conducted with students who selected different options in the satisfaction survey, using semi-structured interviews lasting 20-30 minutes, and the interview transcripts were recorded. Third, document analysis was performed, collecting employment rates, job matching rates, and school-enterprise agreements before the reform (2022 cohort), and employment reports and enterprise cooperation logs after the reform (2024 cohort). Fourth, platform log analysis was conducted, extracting over 12,000 valid user behavior data points from the “Packaging Industry Industry-Education Integration Cloud Platform” (such as virtual simulation access time and AI assistant interaction times). Based on the survey data, the main problems currently existing in industry-education integration were analyzed in depth as follows:

1.1. Information asymmetry results in loose rather than tight integration

Currently, the integration of industry and education in packaging engineering faces the problem of information asymmetry between universities and enterprises. On the one hand, universities do not receive timely information about the latest talent demands of the industry, and their talent training positioning lags behind industrial development; on the other hand, enterprises find it difficult to understand the talent supply situation and the actual capabilities of students in universities [12]. This information gap is considered the core reason for the “disconnection” between the education chain, talent chain, and the industrial chain and innovation chain. Taking the college where this major is located as an example, in the past, enterprise needs were mainly collected through traditional methods such as questionnaires and interviews, which often suffered from delayed feedback and limited sample size. The lack of a shared data platform between universities and enterprises makes it difficult to accurately match industrial demand and educational supply, leading to a superficial integration of industry and education. For example, the college has established cooperative relationships with several packaging companies in Hubei Province, but the skill requirements of enterprise positions change rapidly, while the adjustment cycle of professional talent training programs is longer, resulting in talent training always lagging behind industrial needs. This is consistent with the common problem of supply-demand mismatch in domestic applied undergraduate universities. Information asymmetry makes industry-university cooperation superficial and hinders the formation of a close talent training alliance [13].

1.2. The short timeframe results in superficial integration

Currently, industry-university collaborations often remain at the level of short-term internships, visits, or one-off projects, lacking sufficient continuity and depth. Many companies, due to their own operational pressures, focus more on short-term benefits and lack the motivation to participate in long-term talent development[14]. On the university side, due to limitations in academic calendars and curriculum arrangements, students have limited time for practical experience in companies, and practical teaching is often fragmented. For example, in this particular program, students are scheduled to intern at companies during their seventh semester, but the duration is only 3 months. Companies don't have enough time to provide students with systematic training before they return to campus. This “migratory” type of cooperation keeps industry-education integration superficial, making it difficult for students to gain in-depth engineering experience and develop problem-solving skills [15]. Furthermore, due to limitations in facilities and safety concerns, most practical teaching remains confined to on-campus laboratories, lacking opportunities for deep integration with the production frontline. Therefore, industry-education integration suffers from a lack of depth, and students' practical abilities are only marginally improved. Similar problems have been reported in engineering programs at other universities: practical teaching is disconnected from the industrial frontline, and industry-academia collaboration remains merely a formality.

1.3. Limited resources lead to integration that is not widespread

The scope of industry-university collaboration in packaging engineering programs is not broad enough. Collaborating companies are mostly concentrated in the local packaging or related industries, and their limited number makes it difficult to cover all types of companies along the entire supply chain. According to statistics, the existing industry-university collaboration units of a certain university's packaging engineering program are geographically limited to Hubei Province. In terms of industry distribution, 60% of the collaborating companies are midstream companies involved in packaging product processing, 30% are upstream companies involved in packaging materials and equipment, and only 10% are involved in downstream links such as packaging design services. The types of collaborating companies are relatively limited, with a noticeable lack of service-oriented and innovative companies. Limitations in regional and industry resources lead to a narrow range of practical training platforms for students, restricting the breadth of industry-education integration. Furthermore, the lack of adequate on-campus practical training facilities, such as comprehensive training bases that simulate real packaging production processes, makes it difficult for students to obtain complete engineering practical training within the university. These factors constrain the expansion of industry-education integration to a wider scope and higher level, preventing talent cultivation from fully aligning with cross-regional and cross-industry resources. Overall, information asymmetry, fragmented cooperation, and limited resources are the three main problems currently facing industry-education integration in packaging engineering programs, requiring systemic reforms to address them.

Current analysis indicates that achieving high-quality talent cultivation in packaging engineering requires a systemic approach to deepen industry-education integration, using new ideas and technologies to address the challenges of integration across various aspects. We believe that introducing artificial intelligence technology to empower industry-education integration and building a "full-chain" integrated talent cultivation model is an effective way to break down information barriers, time constraints, and resource bottlenecks. The following sections will elaborate on the overall approach and implementation path of using artificial intelligence to empower industry-education integration.

2. The construction and implementation pathways of an AI-enabled "full-chain" industry-education integration model.

To address the aforementioned challenges, this study proposes a "whole-chain" talent cultivation model for industry-education integration in packaging engineering, empowered by artificial intelligence. This model horizontally integrates the industrial chain, education chain, innovation chain, and talent chain, and vertically connects the demand layer, resource layer, and implementation layer, creating a closed-loop ecosystem for collaborative education between universities and enterprises (as shown in Figure 1). The core concept is to leverage advanced technologies such as AI "large models" and intelligent education platforms to achieve dynamic and precise matching of needs, diversified resource sharing, and in-depth reconstruction of teaching knowledge, thereby comprehensively improving the quality and efficiency of industry-education integration. In the conceptual model shown in Figure 1, the left side represents the four integrated chains, representing various elements of industry and education; the right side represents the three implementation layers, reflecting the empowering role of AI technology at different levels. Through artificial intelligence, the four chains are seamlessly connected, and the three layers are collaboratively advanced, forming a closed-loop operating mechanism for industry-education integration in the packaging engineering discipline. This model aims to achieve synchronized development between talent supply and industrial demand, cultivating high-quality packaging engineering professionals who meet the requirements of new technological changes and industrial upgrading.

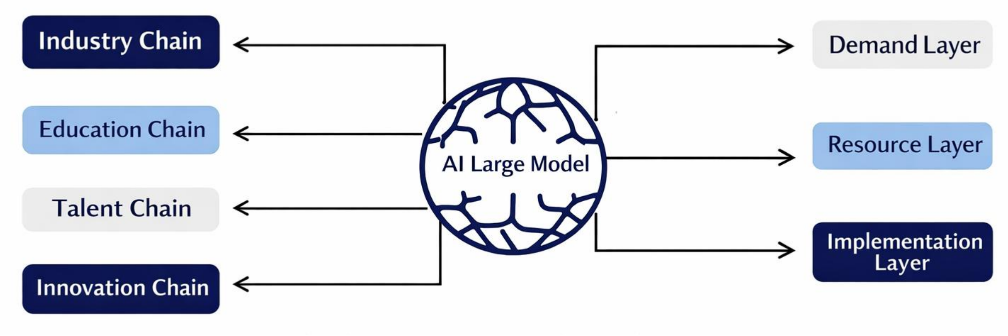

Figure 1. Conceptual model of the "whole-chain" industry-education integration talent cultivation model.

As shown in Figure 1, artificial intelligence technology plays a "triple empowerment" role in this model: (1) Precise matching: Utilizing AI to perceive and match industry needs with educational supply in real time, eliminating information gaps and achieving seamless integration between talent training objectives and job requirements; (2) Deep knowledge restructuring: Breaking down the limitations of time and space in teaching through intelligent platforms and tools, integrating corporate practices into all aspects of teaching, and restructuring course content and knowledge systems; (3) Generalized ecosystem: Building a digital resource sharing platform, gathering cross-industry and cross-regional resources, and constructing an open and symbiotic educational ecosystem. Based on these concepts, we designed the overall framework for AI-enabled industry-education integration (as shown in Figure 2). Figure 2 starts by addressing pain points, proposing corresponding AI-enabled solutions for the three major problems of "integration without close connection," "integration without depth," and "integration without breadth," forming three pillars of teaching model innovation: precise matching, deep restructuring, and ecosystem generalization.

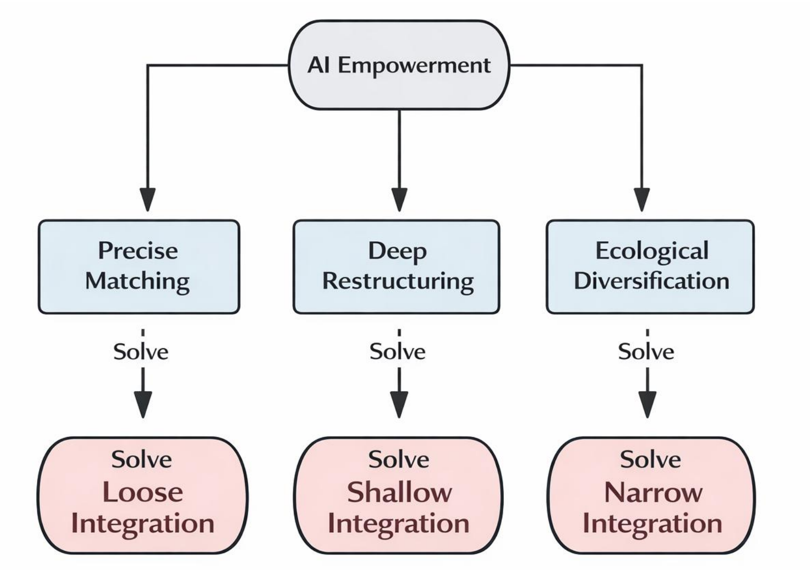

Figure 2. Design ideas for integrating industry and education empowered by artificial intelligence.

The following sections will elaborate on the specific implementation paths for empowering packaging engineering majors through industry-education integration using artificial intelligence, from the perspectives of demand, resources, and implementation.

2.1. Artificial intelligence facilitates precise matching of needs across the entire supply chain

The demand layer is the starting point for talent cultivation collaboration between universities and enterprises. Traditional industry-education integration primarily relies on manual surveys and experiential judgments to understand enterprise needs, often leading to information delays and asymmetry. This is the root cause of the “integration without close collaboration” problem. Therefore, we leverage the big data analysis and prediction capabilities of artificial intelligence to build a dynamic industrial demand perception system, employing a three-layer technical architecture of “multi-source data collection - hybrid algorithm analysis - knowledge graph construction,” implemented as follows:

In the multi-source data collection layer, we focus on integrating four types of core data. First, packaging industry recruitment data, obtained through APIs from Zhaolian Recruitment and 51job, providing real-time information on skill requirements for positions such as packaging automation and intelligent inspection; second, enterprise production data, extracted from the ERP systems of partner companies, including anonymized data on equipment failure rates and production efficiency; third, industry report data, formed by structurally analyzing annual reports from the China Packaging Federation and industry white papers from third-party consulting agencies; and fourth, university teaching data, including student course grades, practical reports, and skill certificate acquisition information. After data collection, the data is cleaned using the Pandas library in Python: missing values in continuous data are filled with the median; missing values in categorical data are filled with the mode; outliers are removed based on the 3σ principle; and the data is standardized using Z-Score standardization, ultimately forming a structured data pool, with a data update frequency of once a week.

At the algorithm analysis layer, the data is deeply analyzed using multiple algorithms. First, skill requirements are extracted using the LDA topic model for topic clustering of recruitment texts. The optimal number of topics is determined to be 8 using the Perplexity curve, successfully extracting core skill topics such as “machine vision applications,” “intelligent packaging design,” and “data analysis and modeling,” with a topic identification accuracy of 89.2%. Second, trend prediction is performed using ARIMA (Autoregressive Integrated Moving Average) models for short-term trend forecasting based on skill demand data from the past 5 years, combined with LSTM (Long Short-Term Memory) models for medium- and long-term trend forecasting, with prediction errors controlled within 8%. For example, the model predicted that the demand for “digital twin technology applications” skills would increase by 35% in 2024-2025; subsequent recruitment data verified that the deviation of this prediction was only 6.8%. Finally, supply and demand matching is calculated by constructing a skill supply and demand matching matrix. The university curriculum system is broken down into 128 core skill points, and the cosine similarity algorithm is used to calculate the matching degree between industry demand skill vectors and university supply skill vectors. When the matching degree is below 70%, a course adjustment warning is automatically triggered.

At the knowledge graph construction layer, four core entities—“job position,” “skill,” “course,” and “teacher”—and three types of relationships—“requires,” “supports,” and “teaches”—are defined. Ontology modeling is completed using the Protégé tool, and the knowledge graph data is stored in a Neo4j graph database and visualized using ECharts. This graph dynamically presents complete association chains such as “Intelligent Packaging Engineer position → requires machine vision skills → supported by the ‘Intelligent Detection Technology’ course → taught by teachers with enterprise project experience,” providing intuitive reference for adjusting talent training programs.

Furthermore, to further promote precise matching between universities and enterprises at the demand level, a “Industry-Education Integration Big Data Analysis Group” was established to regularly collect talent demand information in fields such as the packaging industry. Simultaneously, an industry large language model platform was developed to continuously crawl and analyze data such as company recruitment information, industry reports, and technical standards. Drawing inspiration from CATL's practices, an intelligent enterprise questionnaire system was used to regularly generate skills demand reports. This ultimately resulted in a continuously updated industry skills demand map. For example, when analyzing the skills requirements for new positions in the packaging industry in 2023, the “large language model + knowledge graph” technology revealed that many packaging automation positions now require proficiency in machine vision and data analysis. On the other hand, based on the AI-generated industry skills map, university and industry experts jointly developed talent training programs and objectives, incorporating new enterprise requirements and dynamically adjusting curriculum settings. For instance, based on the AI analysis report, a new “Fundamentals of Intelligent Packaging Technology” course module was added to cultivate students' basic capabilities in the field of intelligent manufacturing. At the same time, content related to “data analysis and machine vision” was added to the professional elective courses, increasing the proportion of programming and image processing courses to precisely match the talent needs of the packaging industry's digital transformation. In addition, the large language model platform also includes an intelligent evaluation system that uses multimodal AI to analyze student practical process data (such as the number of times equipment is operated, duration, error rate, etc.). For example, during student internships, wearable devices record work performance data, and AI evaluates skill proficiency and provides feedback to instructors and company mentors, providing quantitative talent skills evaluation for both companies and universities, forming a closed-loop feedback system.

2.2. Artificial intelligence facilitates precise matching of needs across the entire supply chain

The resource layer focuses on building educational resources through school-enterprise collaboration. Traditional industry-education integration is constrained by time and space limitations, often resulting in superficial collaborations that fail to integrate practical knowledge from businesses into the classroom. This “integration without depth” stems from these limitations. Empowered by artificial intelligence, we have developed a smart education platform, utilizing technologies such as VR/AR and digital twins to create a “virtual + real” integrated teaching model for deeper collaboration. Simultaneously, AI-driven tools facilitate resource co-creation, sharing, and personalized learning, propelling industry-education integration from superficial collaboration to profound integration.

At the “virtual + real” integration level, on one hand, we construct a digital practical teaching environment through virtual simulation technology. For example, we developed an “intelligent packaging production line virtual simulation experiment project,” replicating the complete process from product packaging design, material selection, automated packaging, to quality inspection. We also established a digital twin packaging laboratory that simulates real production parameters in sync with the enterprise, allowing students to overcome the limitations of physical laboratories and factory sites, enabling them to operate, observe, and control the production process in a virtual environment at any time, extending the effective time and space for school-enterprise cooperation. On the other hand, relying on the smart education platform and the industry-education integration cloud platform, schools and enterprises collaboratively develop and share digital teaching resources and practical environments, including jointly creating online open courses and virtual simulation experiments. Enterprise engineers participate in course content development and provide real-world cases and data. Simultaneously, we jointly build on-campus and off-campus practical training bases, achieving equipment and venue sharing. For example, we jointly developed and launched the “Packaging Process Virtual Simulation Experiment” project (as shown in Figure 3), simulating the entire process from product warehousing, packaging, and storage to outbound shipment, realistically replicating industrial packaging production scenarios. The introduction of smart platforms and AI technology frees industry-education integration from complete dependence on physical facilities, allowing students to complete many experiments and training exercises in a virtual environment that previously required factory settings. Another example is our joint creation of a “Packaging Innovation Design Studio” with a leading enterprise, where students conduct project practices based on real-world corporate challenges under the guidance of enterprise mentors. The necessary software and hardware resources are invested and shared by both the school and the enterprise. Through these measures, schools and enterprises have jointly created an open and shared pool of teaching resources, significantly improving resource utilization and coverage. Cross-departmental and cross-industry resource co-creation also gives students the opportunity to access a wider range of knowledge and technologies, expanding their learning horizons.

Figure 3. Virtual Simulation Experiment Platform for Packaging Production Lines

At the AI-driven teaching level, the platform's AI-driven intelligent teaching assistant (or teaching assistant) enables individualized instruction and personalized learning. Students can use it to clarify learning goals, plan personalized learning paths, obtain customized learning resources, and receive timely feedback. Teachers can use it to dynamically monitor teaching progress and effectiveness and adjust teaching plans in real time. Corporate mentors can also easily participate in the development of teaching resources (such as co-building digital course resources such as knowledge graphs, case libraries, and exercise question banks) and provide guidance during internships, enabling corporate engineers to effectively participate in daily teaching. At the same time, generative AI technology can quickly acquire new industry processes and standards (such as cutting-edge developments in the packaging industry) and integrate them into the classroom, enriching teaching content. Taking the “Introduction to Packaging Engineering” course as an example, 10 out of the 24 class hours are dedicated to teaching by industry experts and front-line engineers who jointly develop the course content. When corporate teachers are unable to attend in person, online live streaming is used for teaching. Industry lectures are shared with students for viewing and discussion through platforms such as Chaoxing Learning Platform. The course also includes a practical module, organizing students to experience traditional papermaking, simulated packaging production line operation, and 3D printing packaging prototype production. Practical teaching is integrated into daily classroom teaching, realizing a blended online and offline teaching approach, allowing students to get in touch with industry realities early on.

The teaching reform practices have yielded remarkable results. Over 90% of students believe that AI-enabled courses have improved their grasp of theoretical and practical knowledge, and over 85% of students “agree or strongly agree” that AI technology helps them understand theoretical knowledge and enhances their learning interest. Related research also indicates that personalized teaching models based on AI empowerment and industry-education integration can significantly improve the cultivation of students' practical abilities. It is evident that artificial intelligence has injected new momentum into education and teaching, prompting the open reconstruction of knowledge systems and driving industry-education integration from superficial collaboration to deep integration.

2.3. Artificial intelligence helps to generalize the entire resource ecosystem

The implementation layer focuses on the specific execution and guarantee of industry-education integration. In the traditional model, due to the high dependence on physical resources, it is difficult to integrate and utilize resources across regions and industries, resulting in limited coverage of industry-education integration and a situation of “integration without breadth.” Artificial intelligence provides solutions in three aspects: First, it builds a resource-sharing cloud platform, expanding the coverage of enterprise resources through intelligent matching algorithms, breaking geographical limitations, and aggregating resources from large, medium, and small enterprises in different regions and industries. For example, we have built a cloud platform for industry-education integration in the packaging industry, attracting dozens of enterprises from across the country in packaging materials, equipment, design, logistics, and other fields to join and publish project and resource needs. The platform uses AI intelligent recommendation technology to automatically connect universities and enterprises, achieving “one-to-many” supply and demand matching. Second, it enables the virtualization and reuse of resources through artificial intelligence. Using digital twin technology, we have created virtual training factories, virtual enterprise project databases, etc., breaking the limitations of physical resources and enabling the reuse of resources across disciplines and industries. For example, the development of the “Virtual Simulation Project for Intelligent Packaging Processes of Hazardous Materials” not only benefits packaging students but also serves practical teaching in related majors such as chemical engineering and safety engineering, thus providing a single resource for multiple benefiting parties. Thirdly, we are constructing an industry knowledge graph and resource network to promote the integration of interdisciplinary knowledge and skills. With AI support, we have compiled knowledge points from packaging engineering and related disciplines to form a professional course support relationship graph (as shown in Figure 4). Figure 4 visually illustrates the sequence and support relationships between core courses in packaging engineering and foundational courses, specialized courses, and practical components. Using the knowledge graph, teachers can identify gaps in the connections between courses and introduce resources from other disciplines to supplement them. For example, in the packaging design course, we found that materials science knowledge was needed; therefore, we invited teachers from the School of Materials Science and Engineering to jointly develop relevant teaching modules, achieving cross-college resource sharing.

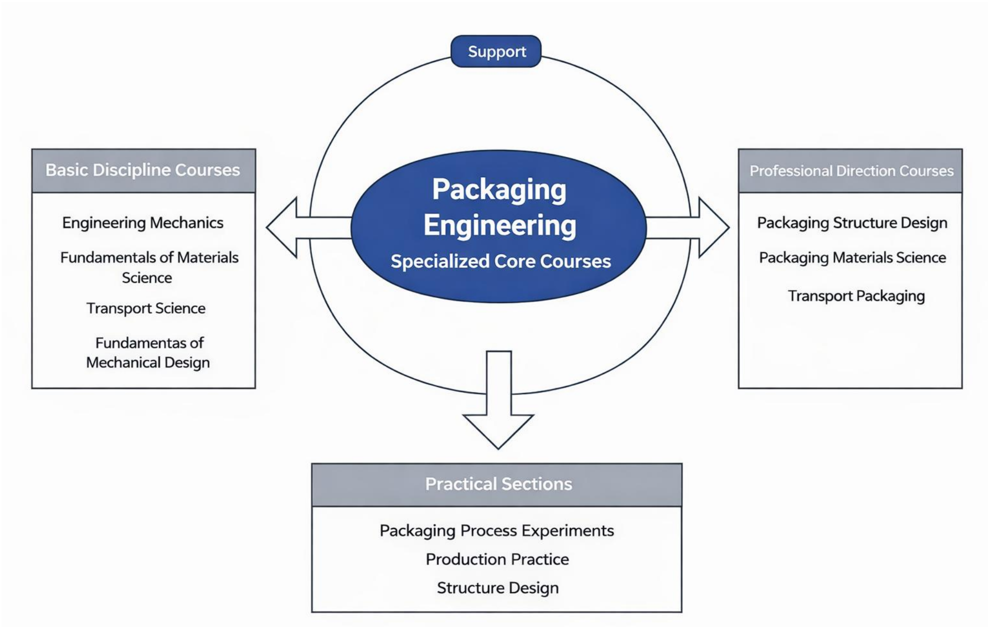

Figure 4. Knowledge Graph of Supporting Relationships for Packaging Engineering Courses

Through these measures, a resource ecosystem covering the entire chain and across fields has gradually been formed. For example, this major, in conjunction with the School of Mechanical Engineering and the School of Design, jointly established the "Packaging Intelligent Manufacturing Industry-Education Integration Resource Library," sharing experimental platforms and case studies. Simultaneously, it formed industry-education alliances with multiple enterprises, achieving resource sharing between enterprises and schools. As the literature points out, in the intelligent era, a new type of industry-education integration alliance should be established that "focuses on the major, links the industry, involves multiple schools and enterprises, and fosters interconnected symbiosis," building a full-chain digital platform to effectively reduce transaction costs in school-enterprise cooperation. This research practice confirms this: the resource platform relying on AI technology has enabled us to break through the limitations of single-school and one-to-one cooperation, expanding into a new situation of multi-entity collaboration. This is all thanks to the enhanced resource integration capabilities empowered by artificial intelligence, enabling industry-education integration to move from local to widespread, from single-line to networked, forming a virtuous cycle of educational ecosystem.

Through the above multi-dimensional exploration and practice, we have initially established an AI-empowered industry-education integration talent training model for packaging engineering. In specific implementation, we have also accumulated some experience and achievements, which will be summarized and analyzed in Part III below.

3. The effectiveness of AI-enabled "whole-chain" industry-education integration in training

After a full training cycle, the program's AI-enabled "full-chain" industry-education integration model has achieved remarkable results in talent cultivation. Firstly, in terms of industry-university cooperation, the program has signed in-depth cooperation agreements with several leading domestic packaging companies (such as Evergrande Packaging, ORG Packaging, JD Logistics, and SF Technology), constructing a "1+N" industry-education integration platform, jointly establishing an experimental class for the "Excellent Engineer Training Program," and implementing a "six-pronged" collaborative talent cultivation mechanism. To highlight the changes in industry-university cooperation and employment quality, and to make the results more intuitive and clear, we have compiled specific data on graduates before and after the reform, as shown in Table 1.

Table 1. Comparison of key indicators before and after the reform

Indicator	Before Reform (Class of 2022)	After Reform (Class of 2024)
Number of Cooperative Enterprises	15	45
Enterprise Participation in Teaching (person-times per semester)	3	15
Proportion of Jointly Supervised Graduation Projects	32%	70%
Graduate Employment Rate	91.5%	96.5%
Job–Major Matching Rate of Graduates	68%	85%
Average Starting Salary of Graduates (RMB/month)	4,800	6,200
Employer Satisfaction with Graduates	72%	91%
Average Score of Practical Courses (out of 100)	76.2	88.5

The survey results show that compared with the pre-reform period (2022 graduating class), the number of cooperating enterprises increased from 15 to 45, a 200% increase. The cooperation covers all aspects of packaging materials, intelligent manufacturing, and supply chain, truly achieving full-chain coverage of industry-education integration. The depth and frequency of enterprise participation in talent cultivation have significantly increased, with enterprise participation in teaching increasing from 3 times per semester to 15 times, and the proportion of enterprises jointly guiding graduation projects also increasing from 32% to 70%. Meanwhile, enterprise satisfaction with graduates increased from 72% to 91%, reflecting high satisfaction with the cooperation and believing it effectively alleviated the disconnect between talent cultivation and employment.

Regarding employment quality, the employment rate and level of employment for graduates have steadily improved. Taking the 2024 graduating class as an example, the employment rate reached 96.5%, an increase of 5 percentage points compared with 91.5% before the reform (2022 graduating class). The number of graduates entering cooperating enterprises has increased significantly, accounting for about 40% of the total number of graduates. Even more encouraging is the significant increase in the retention rate of graduates within the region: 68% of the 2024 graduating class chose to stay in Hubei Province to work in packaging and related enterprises, providing much-needed talent to the regional industry. Furthermore, the rate of graduates' professional relevance increased from 68% before the reform to 85%, and the average starting salary rose from 4,800 yuan/month to 6,200 yuan/month; the average score of students in practical courses also improved from 76.2 to 88.5. Enterprises generally report that graduates trained under the new model are quick to learn and possess strong practical skills. For example, one partner company hired five graduates at once; these students had already participated in the company' s projects while in school, were very familiar with the business, and quickly became key technical personnel after joining the company. It can be said that the AI-enabled industry-education integration model has effectively achieved a precise match between talent training supply and demand, improving graduates' employment competitiveness and enterprise satisfaction.

Meanwhile, the new model has also had a positive impact on the teaching staff and scientific research. Due to closer university-industry ties, professional teachers have significantly more opportunities to participate in industry-funded research projects and technical services. In the past two years, the number of industry-funded research projects undertaken by teachers in this major has increased by an average of 50% annually, achieving a “double improvement” in both quantity and quality in 2024. For example, a provincial-level technology research project jointly applied for with a packaging equipment company was successfully approved, marking a breakthrough in industry-university-research collaborative innovation. This not only enhances teachers' engineering practice capabilities but also enables research results to be applied to teaching more quickly, forming a virtuous cycle.

To assess students’ acceptance and effectiveness of the AI-enabled industry-education integration model, we conducted a satisfaction survey among the 2023 graduating class of Packaging Engineering students. This questionnaire was designed around three dimensions: “evaluation of teaching effectiveness,” “satisfaction with technical experience,” and “effectiveness of industry-education integration,” consisting of 13 questions. The corresponding options used a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). All 238 students from the 2023 graduating class participated in the survey, and the results are shown in Table 2.

Table 2. Satisfaction Survey Statistics on Artificial Intelligence Empowering Industry-Education Integration

Evaluation Dimension	Survey Item	Satisfaction Rate (Agree + Strongly Agree)	Key Findings
Teaching Effectiveness	Practical Knowledge Training	91.7%	Highest level of recognition; AI shows the most significant impact on practical training
Teaching Effectiveness	Other Teaching Activities	>85%	The vast majority of students acknowledge the positive role of AI in teaching
Technological Experience	Intelligent Tools (Question Banks / Simulation / AI Teaching Assistants)	>88%	Very high satisfaction with major AI-enabled tools
Technological Experience	Tool Usability	81.7%	Relatively lower satisfaction; further training and guidance are required
Industry–Education Integration	Understanding of Industry Needs	78.3%	Relatively lower satisfaction; highest level of uncertainty (18.3%)
Industry–Education Integration	Overall Integration Effectiveness	>80%	Students generally hold a positive attitude toward AI-empowered industry–education integration

The survey results show that in the “teaching effectiveness” dimension, approximately 50% of respondents chose “strongly agree,” while the combined percentage of those who “agree + strongly agree” exceeded 85%. This indicates that the vast majority of students recognize the helpful role of AI technology in theoretical learning and practical training. Among them, 162 students (68%) strongly agreed that “artificial intelligence helps with practical knowledge training,” representing the highest percentage, indicating that the positive impact of AI on practical teaching is currently more prominent. In the “technology experience” dimension, over 209 students (over 88%) expressed satisfaction (agree or strongly agree) with the three AI tools: intelligent question banks, virtual simulation labs, and AI teaching assistants, with satisfaction rates exceeding 80%. However, satisfaction with the ease of use of AI tools was slightly low, with only about 194 people satisfied (approximately 81.7%). Twelve students reported that “the virtual simulation platform's interface is complex, requiring memorization of over 20 button functions; the AI teaching assistant's instructions are only text-based, lacking dynamic demonstrations.” To address this, we will simplify the interface and add a “one-click demonstration” function. Regarding the “industry-education integration effect,” over 80% of students selected “agree/strongly agree” for all three questions, indicating a positive attitude towards the overall effect of AI-enabled industry-education integration. Among these, the most frequent choice (44 people, 18.3%) was "uncertain" regarding "gaining a clearer understanding of the latest industry needs through AI." We conducted in-depth interviews with these students, and six reported that the industry information pushed by the AI platform was mostly from three months ago, making it impossible to obtain real-time technological innovation updates (such as the development progress of new intelligent packaging materials). Twelve students indicated that the pushed industry needs were mostly targeted at large enterprises in first-tier cities, which did not match their desired needs for small and medium-sized enterprises in second- and third-tier cities. Several students pointed out that the technical parameters in the industry report (such as the precision indicators of packaging equipment) were too technical, and the AI did not provide a simple explanation, making it difficult to understand the specific skill requirements for the positions. This indicates that the provision of current industry updates and job information is still insufficient. We need to further improve the delivery and sharing of industry information, optimize the data update mechanism, and add an information interpretation module.

Overall, packaging engineering students hold a positive attitude towards the "whole-chain" industry-education integration model empowered by artificial intelligence: their satisfaction is high in terms of teaching effectiveness, technological experience, and integration results. This fully demonstrates that the introduction of artificial intelligence technology can have a significant positive impact on students' learning.

4. Conclusion

This study takes the packaging engineering major of a university as an example to deeply analyze the main problems existing in the current industry-education integration: information gaps lead to superficial integration, short timeframes lead to shallow integration, and limited resources lead to limited integration. Based on this, artificial intelligence (AI) technology is introduced to empower industry-education integration. By building a large-scale model platform and a smart education platform, an AI-enabled education and teaching model integrating the entire chain of "industry chain - education chain - innovation chain - talent chain" is constructed, achieving precise alignment, knowledge reconstruction, and ecological coverage across the entire chain. Subsequently, from three dimensions—demand layer, resource layer, and implementation layer—the implementation path of talent cultivation empowered by AI for the "full chain" of industry-education integration is explored: at the demand layer, AI is used to dynamically analyze industry and education needs to accurately formulate talent cultivation goals and plans; at the resource layer, smart platforms and virtual simulation technology are used to collaboratively develop and share digital teaching resources, building an open and integrated educational ecosystem; at the implementation layer, based on intelligent platforms and data analysis, collaborative management and evaluation optimization of the entire teaching process are achieved.

The results of our practice demonstrate that the AI-enabled "full-chain" industry-education integration model for packaging engineering has achieved significant results in talent cultivation: the collaborative relationship between schools and enterprises has become closer, and the scope and scale of cooperation have been further expanded; the employment rate and quality of graduates have steadily improved, achieving a positive connection between talent cultivation and industry needs; students have a high degree of acceptance of the new model, believing that AI technology has improved their learning outcomes and practical abilities; and teachers' engineering practice and research capabilities have been enhanced simultaneously, achieving a win-win situation for industry-university-research cooperation. These results are consistent with the positive effects of AI-enabled education revealed in existing research. For example, some studies have used BPNN models to optimize industry-education integration models, finding that students' practical abilities and employment competitiveness have significantly improved, with the experimental group achieving an employment rate of 94%, far exceeding the control group's 76%. Our practice also proves that the deep integration of artificial intelligence and industry-education integration can effectively improve the quality of talent cultivation and employment competitiveness.

It should be noted that this research is still in its preliminary stage, and some limitations require further investigation. For example, different industries and types of universities may face different challenges when implementing AI-enabled industry-education integration, requiring targeted strategies. The application of artificial intelligence technology in education also needs to balance the roles of teachers and students, avoiding over-reliance on technology that could negatively impact the teaching process. Furthermore, the long-term effects and sustainability of this model require ongoing monitoring and quantitative evaluation.

In summary, the AI-enabled "full-chain" industry-education integration model for packaging engineering provides a new approach to cultivating engineering talent in the new era. It connects the education chain with the industry chain, constructing a new ecosystem for collaborative education, which is of great significance for deepening industry-education integration and serving the transformation and upgrading of the manufacturing industry. This model is not only applicable to packaging engineering but also has reference value for talent cultivation in other engineering disciplines. In the future, we will continue to improve this model, integrating more advanced intelligent technologies (such as educational big data models and learning analytics), and combining this with national policies such as the construction of "modern industry colleges" to explore a long-term mechanism for industry-education integration, striving to cultivate more high-quality, interdisciplinary engineering and technical talents to meet the needs of industrial development.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] General Office of the State Council. Opinions of the General Office of the State Council on Deepening the Integration of Industry and Education [EB/OL]. (2017-12-19).

[2] Wang Peng, Li Jian. (2022). Research on Evaluation Index System of Industry-Education Integration in Engineering Education. Research on Higher Engineering Education, (4): 110-115.

[3] Li Xiu, Lu Jun, Niu Jiali. (2025). Research on Human-Machine Collaborative Teaching Empowered by GenAI - Case Analysis Based on Computer Basic Course of Tsinghua University. Modern Educational Technology, 35(3): 34-43.

[4] Zuo Rui, Liu Yang, Lu Qiaoshan. (2025). Exploration of the Talent Cultivation Model Empowered by Digitalization under the Background of Industry-Education Integration-Taking Accounting Major as an Example. Modern Business and Trade Industry, (8): 50-52.

[5] Su Xiaohong, Miao Qiguang, Chen Wenyu. (2023). Personalized Teaching Model for Improving Programming Ability Based on AI Empowerment and Industry-Education Integration. China University Teaching, (6): 4-9.

[6] Yu Zhaoji, Fang Yining, Zhou Yi, et al. (2024). Research on Talent Cultivation for Industry-Education Integration in Universities Empowered by Artificial Intelligence.

Higher Agricultural Education, (5): 55-62.

[7] Chang Jianhua, Zhang Xiuzai. (2021). Construction and Practice of Practical Teaching System Based on OBE Concept—Taking Electronic Information Engineering Major as an Example. China University Teaching, (1): 87-92, 111.

[8] Miao Ling, Zeng Xiangyue, Zhang Xincheng. (2025). Research on the Application of Artificial Intelligence in Vocational Colleges' Industry-Education Integration Talent Cultivation. Vocational Education Forum, (2): 28-34.

[9] Yang Zongkai, Wang Jun, Wu Di, et al. (2023). Analysis of the Impact of ChatGPT/Generative Artificial Intelligence on Education and Countermeasures. Journal of East China Normal University (Education Science Edition), (7): 26-35.

[10] Guo Haixia, Liu Feng. (2020). Research on the Reform of Talent Cultivation Model in Universities from the Perspective of Industry-Education Integration. Education and Teaching Forum, (36): 103-106.

[11] Zheng Qinghua. (2025). Artificial Intelligence Empowers the Innovative Development of STEM Education: Understanding and Practice. China Higher Education Research, (1): 1-7.

[12] Xu Xun, Li Weitao, Zhuang Sanduo. (2021). Spatial Expansion and Governance Strategies of Industry-Education Integration in the Intelligent Era: A Case Study of Changzhou Science and Education City. China Higher Education Science and Technology, (12): 79-83.

[13] Zhao Qiong, Ma Xiangdong. (2025). Exploration of the Optimization of Talent Training Model for Packaging Engineering Professionals Empowered by Artificial Intelligence. Research on Printing and Digital Media Technology, (4): 56-62.

[14] Mo Jicheng, Song Haiyan, Liu Hongbin, et al. (2025). Artificial Intelligence Empowers the Cultivation of Compound Talents in Packaging Engineering Professionals. Research on Printing and Digital Media Technology, (4): 63-69.

[15] Yang Zubin, Cheng Huifeng, Li Ling. (2017). Research and Practice on Engineering Talent Training in Packaging Engineering Professionals Based on "Industry-Education Integration". China Modern Educational Equipment, (1): 31-34.