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Junior-College-to-Bachelor Articulation and Industry-Education Integration: An Innovative Training Model for High-End Technical and Skilled Talent in Intelligent Medical Equipment Technology

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Abstract: In response to the national reform of vocational education as a distinct education type and the policy requirement of integrating vocational and general education, and to address such problems as the insufficient supply of high-end technical and skilled talents for the medical device industry, the disconnection between junior college and undergraduate training stages, and students' weak practical and innovative abilities, the Intelligent Medical Equipment Technology program of Chongqing Medical and Pharmaceutical College, in collaboration with the Measurement and Control Technology and Instrumentation program of Chongqing University of Science and Technology, has developed an integrated talent training model featuring "junior-college-to-bachelor articulation and industry-education integration" under the Chongqing municipal pilot project for articulated junior-college-to-bachelor training. Through a series of reform measures—including the joint development of an articulated training plan by the two institutions, the establishment of a joint examination mechanism for general foundation courses, the deepening of industry-education integration in practice-based education, and the implementation of whole-process multi-dimensional quality control and academic atmosphere building—the program has achieved knowledge connectivity, skill integration, and smooth progression between the junior college stage and the undergraduate stage. Practice has shown that this model has effectively improved the quality of talent training: remarkable results have been achieved in academic atmosphere building, students demonstrate outstanding innovation and entrepreneurship capabilities, and the training outcomes have been recognized by the partner undergraduate institution and disseminated within the college. The model thus provides a replicable practical paradigm for articulated junior-college-to-bachelor talent training in engineering-related programs of vocational colleges.

Keywords: junior-college-to-bachelor articulation; industry-education integration; intelligent



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medical equipment technology; high-end technical and skilled talent; talent training model; vocational education reform.

1. Introduction

With the successive issuance of national policy documents such as the *National Implementation Plan for Vocational Education Reform* (2019, widely known as the “20 Measures for Vocational Education”) and the *Guidelines on Promoting the High-Quality Development of Modern Vocational Education* (2021, issued by the General Offices of the CPC Central Committee and the State Council), building a modern vocational education system that vertically connects secondary vocational education, higher vocational education, and undergraduate education has become a core pathway for consolidating the status of vocational education as a distinct education type and cultivating high-end technical and skilled talent for industry. As an important form of undergraduate-level talent training in vocational education, articulated junior-college-to-bachelor segmented training plays a critical role in linking higher vocational colleges with application-oriented universities and in opening up the career development pathway for technical and skilled talents [1]. Meanwhile, school-enterprise cooperation has been a central pillar of China’s vocational education policy reforms over the past four decades, evolving through multiple stages from spontaneous development to institutional construction [2].

At present, China’s intelligent medical equipment industry is in a period of rapid upgrading, with the domestic production and intelligent transformation of medical devices accelerating continuously, and the industry’s demand for high-end technical and skilled talents—who possess solid engineering foundations, proficient practical abilities, and innovative thinking—keeps rising. However, the existing talent training system still has obvious shortcomings: first, the training stages at the higher vocational and undergraduate levels are fragmented, with redundancy and discontinuity in the curriculum system and poor articulation between stages; second, students admitted to higher vocational colleges have relatively weak academic foundations and insufficient adaptability to undergraduate study; third, practice-based education is detached from industrial needs, and students’ engineering innovation capability can hardly meet the requirements of high-end positions in the industry [3].

Against this background, the Intelligent Medical Equipment Technology program of Chongqing Medical and Pharmaceutical College and the Measurement and Control Technology and Instrumentation program of Chongqing University of Science and Technology were jointly approved in 2019 as a Chongqing municipal pilot project for articulated junior-college-to-bachelor segmented training, adopting a “3+2” training model in which students study at the junior college level for the first three years and, upon passing the transition assessment, proceed to two years of undergraduate study. Since the implementation of the project, the two institutions have adhered to inter-institutional collaboration and industry-education integration, systematically advancing reforms across the entire chain of the training plan, curriculum system, management mechanisms, and practice-based education. They have explored and developed a training pathway for high-

end technical and skilled talents characterized by “junior–college–to–bachelor articulation and industry–education integration”, achieving remarkable construction results.

2. Practical challenges in articulated junior–college–to–bachelor talent training

As a typical engineering program at the intersection of medicine and engineering, the Intelligent Medical Equipment Technology program combines medical and engineering attributes and places high demands on students’ theoretical foundations, practical abilities, and comprehensive qualities. In the initial stage of articulated training, the program faced four major core challenges.

2.1. *Poor articulation between stages and discontinuity in the curriculum system*

There are inherent differences in the training orientation of higher vocational colleges and undergraduate institutions: the former emphasizes job–specific practical skills, while the latter emphasizes engineering theory and design capability [4]. At the initial stage of the project, the curriculum systems of the two institutions were designed independently, resulting in problems such as loose articulation of specialized courses, mismatched requirements for general foundation courses, and partial redundancy or discontinuity of content, making it difficult to ensure that students met the knowledge and competency standards for undergraduate admission upon junior college graduation.

2.2. *Weak academic foundations*

All students in the articulated program cohort were admitted through the spring separate–enrollment examination (chunji danzhao), an alternative admission track held each spring in which higher vocational colleges independently set and administer their own entrance examinations, and had not undergone systematic preparation for the national college entrance examination (gaokao). Their foundations in general foundation courses such as mathematics and English were weak, and their pre–enrollment learning habits and study discipline needed to be cultivated. In contrast, the undergraduate stage sets high requirements for foundational courses such as advanced mathematics and college English. The evident gap between students’ academic foundations and the requirements of undergraduate study became a core bottleneck constraining the quality of articulated training.

2.3. *Monolithic practice–based education and insufficient cultivation of innovation and entrepreneurship capabilities*

Under the traditional training model, practical teaching consisted mainly of verification experiments, with a low proportion of comprehensive and design–oriented training. Innovation and entrepreneurship education was not deeply integrated with specialized teaching, and students lacked the ability to solve complex engineering problems as well as

innovative thinking, making it difficult to match the innovation capability requirements of high-end technical positions in the medical device industry.

2.4. Insufficient process control and an incomplete quality assurance system

Articulated training spans a long cycle across two educational stages. In the initial stage, there were problems such as imperfect management mechanisms, unsystematic process assessment, and insufficient leverage for academic atmosphere building. There was no process-based evaluation system covering the full dimensions of academic performance, personal qualities, and practical ability, making it difficult to achieve dynamic, whole-process control of talent training quality.

3. Construction and implementation of the “junior-college-to-bachelor articulation and industry-education integration” talent training model

In response to the above challenges, the project took “knowledge connectivity, skill integration, and smooth progression” as its core objectives and established “junior-college-to-bachelor articulation with industry-education integration” as the overall talent training model. Reforms were systematically advanced along three dimensions: the inter-institutional collaboration system, industry-education integrated practice, and multi-dimensional process control. The specific implementation pathways are as follows.

3.1. Inter-institutional collaboration: building an integrated talent training system

3.1.1 Joint development of an articulated talent training plan

A regular liaison mechanism was established between the program leaders and teaching and research groups of the two institutions. Through full deliberation on the training orientations, competency requirements, and curriculum systems of the junior college and undergraduate stages, the two institutions jointly developed an integrated talent training plan, and invited industry and enterprise experts from the Chongqing Medical Vocational Education Group to review and validate the plan, ensuring that it both met the admission standards of the undergraduate institution and closely aligned with the development needs of the medical device industry.

The plan defines the overall training objective of “solid foundations, comprehensive qualities, and outstanding innovation.” The junior college stage focuses on consolidating professional foundations and practical skills, while the undergraduate stage focuses on deepening engineering theory and design innovation capability, thereby achieving a progressive gradient and seamless articulation between the two stages and avoiding curriculum redundancy and knowledge discontinuity.

3.1.2 Establishment of a joint examination mechanism for general foundation courses

To address students' weak academic foundations, a joint examination system featuring the separation of "teaching, testing, and grading" was implemented for the two core general foundation courses, *Advanced Mathematics* and *College English*: Chongqing University of Science and Technology is responsible for formulating the syllabi, setting examination papers, organizing invigilation inspections, and grading, while Chongqing Medical and Pharmaceutical College is responsible for daily teaching implementation. Through this joint examination mechanism, the curriculum standards and quality requirements of the two institutions were unified, which in turn compelled the improvement of teaching quality and ensured that students met the foundational competency requirements for undergraduate admission during the junior college stage.

3.1.3 Articulation of the specialized curriculum system

Focusing on the competency requirements of high-end positions in the medical device industry, the specialized curriculum systems of the junior college and undergraduate stages were systematically reviewed, and course content and teaching sequences were optimized to ensure the progression and coherence of professional knowledge. At the junior college stage, practice-oriented courses such as Medical Sensors, Assembly and Debugging of Medical Electronic Instruments, and Maintenance of Medical Imaging Equipment were offered to consolidate students' engineering practice foundations. Content from undergraduate prerequisite courses was organically integrated into junior college teaching, laying the groundwork for students' specialized learning after advancing to the undergraduate stage.

3.2. Industry–education integration: strengthening the cultivation of practical and innovation–entrepreneurship capabilities

3.2.1 Building a multi-level practical teaching system

Relying on a national-level productive training base, a virtual simulation training base, and resources from off-campus partner enterprises, the program established a three-level practical teaching system of "basic verification—comprehensive design—job practice." The project offers a total of 28 courses containing practical components, with an experiment delivery rate of 100%. Building on verification experiments, simulation training and comprehensive design training were added to cultivate students' engineering thinking and problem-solving abilities.

At the same time, job shadowing was organized through affiliated hospitals and partner enterprises, enabling students to go deep into hospital equipment departments and the front lines of medical device manufacturing and operation-and-maintenance enterprises, gain a direct understanding of industrial job requirements, enhance their job awareness, and achieve an organic combination of theoretical learning and industrial practice.

3.2.2 Implementing innovation and entrepreneurship education through “competition–driven learning and course–innovation integration”

Innovation and entrepreneurship education was integrated throughout the entire talent training process. Using academic competitions and innovation-entrepreneurship contests as levers, a capability–building chain of “classroom teaching—research participation—competition refinement” was constructed. Students were guided to participate in teachers’ research projects and in various skill competitions and innovation-entrepreneurship contests at all levels, forming a practical teaching model of “promoting teaching through competitions and promoting learning through competitions.”

Relying on the “second classroom”—extracurricular activities such as clubs, competitions, and volunteering that count toward holistic student evaluation beyond formal coursework—innovation and entrepreneurship interest groups were formed under the full guidance of specialized teachers, transforming professional knowledge into innovation projects and comprehensively enhancing students’ innovative thinking, hands–on abilities, and teamwork qualities.

3.3. *Multi–dimensional control: improving the whole–process education management mechanism*

3.3.1 Formulating a whole–process assessment implementation plan

In accordance with the relevant Chongqing municipal documents on articulated junior–college–to–bachelor training, the *Implementation Plan for Process (Formative) Assessment of “3+2” Articulated Junior-College-to-Bachelor Talent Training* was formulated. From the three dimensions of daily performance, academic achievement, and social practice, students’ comprehensive qualities and learning progress were assessed and evaluated throughout the entire process, and the results of process–based assessment were linked to eligibility for stage transition, thereby strengthening the dynamic control of training quality.

3.3.2 Implementing a professional tutor system

A professional tutor system was fully implemented in the articulated program cohort, with each specialized teacher mentoring six to seven students. Tutors provide continuous guidance on professional learning, career planning consultation, job–awareness orientation, and advice on further education and employment, realizing personalized and precise education and promptly resolving problems in students’ learning and development.

3.3.3 Strengthening the cultivation of academic ethos

The educational role of the teaching and research section was brought into full play: the Medical Electronics Teaching and Research Section paired with students of the articulated cohort, participated in class league and student activities, and conducted heart–to–heart talks

to gain an in-depth understanding of students' learning and living conditions, providing targeted assistance and guidance.

To address students' weak learning habits, the cultivation of academic ethos was systematically advanced: students were guided to attend morning and evening supervised self-study sessions, with teachers present at scheduled times to answer questions and provide tutoring; online platforms were used to design pre-class quizzes and after-class exercises, strengthening process control of learning; and through measures such as checking class notes and organizing mistake notebooks, students were helped to develop rigorous and pragmatic learning habits.

4. Practical Outcomes

After seven years of construction and practice, the quality of talent training in the articulated program has steadily improved, with remarkable results achieved in academic atmosphere building, innovation and entrepreneurship capability cultivation, and model dissemination.

4.1. Remarkable results in academic atmosphere building and comprehensive improvement of students' qualities

Students in the articulated program cohort have clear learning goals, a strong learning atmosphere prevails, and self-directed learning awareness and good learning habits have been gradually developed; morning and evening self-study and self-directed laboratory training have become routine. To date, students of the seven articulated cohorts have received more than 100 honors and commendations in various activities at all levels, and the Class of Intelligent Medical Equipment Technology (Articulated Program) was becoming a benchmark class for academic atmosphere building within the school and across the entire college.

The pass rates of the joint examinations for general foundation courses have steadily improved; students' foundations in mathematics and English have been significantly strengthened; and the overall academic level has met the transition admission requirements of the undergraduate institution, earning high recognition from Chongqing University of Science and Technology.

4.2. Fruitful achievements in innovation and entrepreneurship practice and enhanced job adaptability

The effect of competition-driven learning has been outstanding. From 2020 to 2025, students of the articulated cohort repeatedly achieved excellent results in innovation and entrepreneurship competitions at various levels: they received more than 30 innovation and entrepreneurship awards at the Chongqing municipal level or above.

Through multi-level practical teaching and job shadowing, students' understanding of the medical device industry has deepened, their engineering practice abilities and innovative

thinking have been significantly enhanced, and the alignment between talent training and the demands of high-end industry positions has continued to strengthen.

4.3. High recognition of the model and obvious demonstration and dissemination effects

The “junior-college-to-bachelor articulation and industry-education integration” talent training model and its educational outcomes have been fully affirmed by the partner undergraduate institution; the inter-institutional collaborative education mechanism operates smoothly, and the quality of post-transition training has met expectations.

The model has been replicated and promoted within the college. Since 2021, it has been applied to the Pharmaceutical Equipment Application Technology program, providing a mature practical template for the articulated training development of other engineering-related programs in the college and playing a positive demonstrative and leading role.

5. Experience summary and prospects for optimization

5.1. Summary of practical experience

First, inter-institutional collaboration is the fundamental prerequisite for articulated training. The core of articulated junior-college-to-bachelor training lies in “articulation”. Only by establishing a regular communication mechanism between the higher vocational college and the undergraduate institution and reaching consensus on training plans, curriculum standards, and assessment and evaluation can genuine stage articulation be achieved and the problem of “two parallel tracks” be avoided.

Second, process control is an important guarantee of training quality. In view of the characteristics of the articulated cohort’s student intake, academic atmosphere building and whole-process management must be strengthened. Through multi-dimensional measures such as the professional tutor system, process assessment, and Party-building leadership, students’ foundational weaknesses can be remedied and good learning habits cultivated, laying a solid foundation for undergraduate study.

Third, industry-education integration is the core support for cultivating high-end talents. The medical device industry is highly practice-oriented with rapid technological iteration. Only by deepening industry-education integration and school-enterprise collaboration—integrating industry standards, real-world projects, and innovation-entrepreneurship competitions into teaching—can high-end technical and skilled talents who meet industrial needs be cultivated. International experience corroborates this point: even in Germany’s mature dual apprenticeship system, insufficient collaboration between companies and vocational schools remains a persistent structural challenge [5], suggesting that institutionalized school-enterprise coordination mechanisms are critical to the success of articulated cultivation models such as China’s “3+2” program.

5.2. Future directions for optimization

First, the integrated design of the curriculum system should be further deepened, promoting mutual faculty appointment and resource sharing between the two institutions and developing more articulated specialized core courses and loose-leaf teaching materials, so as to reduce content redundancy and strengthen the progression of competencies. Second, the depth of industry–education integration should be expanded by introducing more real engineering projects and technical research tasks from leading enterprises, enhancing students’ ability to solve complex engineering problems. Third, the diversified transition assessment and evaluation system should be improved by incorporating practical ability, innovation literacy, and professional qualities more fully into the transition assessment, so as to comprehensively evaluate students’ overall capabilities. Fourth, the collaborative development of a dual–qualified faculty across the two institutions should be strengthened, building an articulated teaching team that combines the practical teaching capacity of higher vocational education with the engineering teaching and research capacity of undergraduate education, thereby providing more solid faculty support for talent training.

6. Conclusion

Articulated junior–college–to–bachelor segmented training is an important measure for opening up the development pathway of technical and skilled talents and building a modern vocational education system, and it is also a key lever for supporting the high–end development of industry. Through the model innovation of “junior–college–to–bachelor articulation and industry–education integration,” the Intelligent Medical Equipment Technology program of Chongqing Medical and Pharmaceutical College has effectively resolved practical challenges in stage articulation, student academic foundations, and practice-based education, and has cultivated a cohort of reserve talents for the medical device industry with solid foundations, comprehensive qualities, and outstanding innovation. In the future, the program will continue to deepen inter–institutional collaboration and industry–education integration, continuously optimize the articulated training system, supply more high-quality, high–end technical and skilled talents to the medical and health industry, and provide more practical experience for the high-quality development of vocational education.

Declaration of Generative AI and AI–assisted Technologies

During the preparation of this manuscript, the authors used generative AI tools only to improve language and readability. The authors take full responsibility for the content of the manuscript.

Supplementary data

The authors confirm that the supplementary data are available within this article.

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Authors' contribution

Conceptualization, methodology, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, Wu Wenzhu; supervision, project administration, Wu Wenzhu. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The authors declare no conflict of interest.

Ethical statement

This study did not involve human or animal experiments; ethical approval was not required.

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