

Research and Practice on the Construction of Production Education Integration Training Base under the Background of Four Rail Transit Networks Integration

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Abstract

This paper starts from the logical origin of the construction of the rail transit industry-education integration training base and proposes that the construction of the training base must connect with industrial development and meet the needs of enterprise talents; secondly, it proposes that the construction of the industry-education integration training base needs to meet the three connotations of "productivity", "professionalism", and "adaptability". Finally, taking the urban rail transit operation management professional group as an example, it proposes a construction plan for the rail transit training base under the background of "four rail transit networks integration" from three aspects: school-enterprise cooperation in building an industry-education integration training base, a virtual simulation training base, and the development of typical production training projects, providing ideas for the construction of an industry-education integration training base under the background of "fournetwork integration".

Keywords

Training Base, Four Rail Transit Networks Integration, Virtual Simulation, Industry-Education Integration

1. Introduction

In 2005, the Ministry of Education and the Ministry of Finance issued the "Trial Standards for Support and Reward Evaluation of Vocational Education Training Base Construction Projects Supported by Central Finance," which determined to further increase the investment of special funds to support and guide the construction of vocational education training bases across the country. In 2006, the Ministry of Education first proposed the concept of "productive training" in the "Several Opinions on Comprehensively Improving the Teaching Quality of Higher Vocational Education," and the construction of on-campus training bases became one of the key contents of higher vocational education. In 2019, the State Council issued the "Implementation Plan for the Reform of National Vocational Education," which proposed to "build a number of high-level training bases." In 2023, the Ministry of Education released 11 key tasks for the construction and reform of the modern vocational education system, including the construction of open regional industry-education integration practice centers, the construction of demonstrative virtual simulation training bases for vocational education, and the implementation of typical production practice projects for school-enterprise cooperation in vocational education. The "Implementation Plan for Empowering and Enhancing the Integration of Industry and Education in Vocational Education (2023-2025)" in 2023 clearly defined the construction of industry-education integration training bases. In 2024, the Ministry of Education and the Ministry of Finance's "Notice on the Implementation of the Construction Plan for High-Level Vocational Schools and Majors with Chinese Characteristics (2025-2029)" proposed to adhere to quality as the foundation, with improving the quality of talent training as the core, and to build gold majors, gold courses, gold teaching materials, gold teachers, and gold bases through school-enterprise cooperation to meet demand. The construction of industry-education integration training bases is one of the nine major reform tasks of the "New Double High" plan. It can be seen that as an important carrier for vocational colleges to cultivate high-skilled talents, the construction of industry-education integration training bases that align with industry needs is crucial.

2. The Logical Starting Point for the construction of a Training Base for the Integration of Industry and Education in Rail Transit

2.1. Industry Development: The Development of "Four-Network Integration" in Rail Transit

The "Guiding Opinions of the National Development and Reform Commission on Cultivating and Developing Modern Metropolitan Areas" [1] proposes: "Promote the 'four-network integration' of trunk railways, intercity railways, suburban (suburban) railways, and urban rail transit, and explore the 'one-network' operation and management of urban rail transit"; The "Outline of the Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area" [2] of the State Council proposes: "Promote the bus-like operation of intercity passenger transport in the Greater Bay Area, and promote 'one-ticket' combined and 'onecard' services"; The "Outline of the Construction of a Powerful Transportation Country" [3] of the State Council proposes "to promote the integrated development of trunk railways, intercity railways, suburban (suburban) railways, and urban rail transit"; The "Outline of the National Comprehensive Three-dimensional Transportation Network Plan" [4] of the State Council proposes: "Promote the integrated construction of trunk railways, intercity railways, and suburban (suburban) railways, and coordinate with urban rail transit to build an 'one-network' for operation management and services, and achieve facility interconnection, ticket interchange, security inspection recognition, information sharing, and payment compatibility." Under the background of "four-network integration", realizing "one-ticket pass, one-stop security check" is an important part of the integrated development of regional rail transit.

Meeting the development needs of "four-network integration" of trunk railways, intercity railways, suburban (suburban) railways, and urban rail transit and serving the training of high-skilled talents in rail transit in the Guangdong-Hong Kong-Macao Greater Bay Area is the logical starting point for the construction of the training base.

2.2. Talent Demand: "Operations and Maintenance Integration" Cross-Functional Collaboration

With the continuous advancement of artificial intelligence technology, the rail transit industry chain is also in a critical period of transformation and upgrading, and a large number of repetitive labor positions are facing elimination. At the same time, artificial intelligence has also created some new positions, and enterprises' demand for composite technical skills talents is also rising. The "four-network integration" of rail transit has given rise to new positions such as "multifunctional team members", whose job content involves smart station services, intelligent train inspection, equipment remote maintenance, etc., requiring employees to use intelligent technology to complete the "operations and maintenance integration" work of receiving and dispatching trains and maintenance of electromechanical equipment on fully automated operation lines. The integration of railway and urban rail transit requires employees to possess cross-system operation, cross-professional collaboration, and multi-position integration capabilities. For example, railway station traffic operators and urban rail transit service personnel must simultaneously possess the ability to operate both railway CTC and urban rail ATS systems to handle traffic operations, and railway electrical engineering and technical personnel must simultaneously possess the ability to operate traffic terminal equipment and maintain communication signal equipment.

3. Enhancing the Connotation of the Construction of Industry-Education Integration Training Bases

3.1. Aligning with Industries to Meet "Productive" Demands

Under the context of industry-education integration, the fundamental principle of constructing training bases in higher vocational colleges is to align with industry demands and meet the "productive" needs of industries. "Productivity" is reflected in aspects such as enterprise production, the cultivation of skilled technical personnel, the enhancement of practical skills, and the mutual employment of teachers between schools and enterprises. It is characterized by the interconnection and mutual promotion of industry demands, the demand for skilled technical personnel in enterprises, and the training of technical and skilled personnel in schools, which jointly constitute the productive construction system of training bases [5]. With the development of the "four-network integration" industry in rail transit and the transformation and upgrading of the industrial structure, the demand for skilled personnel in enterprises is not only about mastering single-system, single-position skills but also requires the ability to collaborate across systems and positions.

The cultivation of talent in vocational colleges must align with the practical needs of industry and enterprise development. This is achieved through a schoolenterprise cooperation model, which ensures targeted and productive talent development. Jointly formulating talent cultivation programs that cater to enterprise demands drives the reform of talent development models. Training bases are crucial for practical teaching in vocational colleges. School-enterprise collaboration and the deep integration of industry and education facilitate the combination of practical teaching and actual production. This enables students to acquire vocational skills and enhance their professional competence through practical training. School-enterprise collaboration also involves the mutual employment of instructors to advance practical teaching. Enterprises select skilled technicians to teach practical courses in schools, providing hands-on guidance and sharing industry expertise and the latest technologies. Simultaneously, schools arrange for teachers and students to undertake internships and training in enterprises, allowing them to understand actual production processes and improve students' practical operational skills and professional qualities. Furthermore, schools and enterprises jointly construct and share training equipment and facilities. Enterprises establish production lines within the school's training bases, and schools develop industry-integrated training bases that meet "productive" requirements, closely aligning with the development needs of industries and enterprises.

3.2. Aligning with Job Roles to Meet "Vocational" Requirements

The construction of industry-education integration training bases necessitates the clear identification of corresponding job roles and their specific tasks. This is primarily reflected in simulating authentic enterprise work environments, job content, and operational process standards. It is crucial to closely align with the practical needs of vocational colleges from industry and enterprises to better leverage the vocational education function of training bases, thereby cultivating a greater number of versatile, highly skilled professionals with practical operational capabilities.

Vocational education possesses a clear vocational orientation. It aims to cultivate highly skilled professionals with practical operational abilities who meet industry demands and enterprise needs. Therefore, vocational college training bases must closely integrate with the actual requirements of industries and enterprises, constructing them with a job task orientation and conducting targeted, practical teaching and skills training. The construction of training bases should simulate real vocational environments, allowing students to engage in practical operations in near-real-world conditions, thereby enhancing their vocational skill levels and improving their adaptability to job roles. The practical teaching in vocational colleges is the core content and standard of training bases, requiring alignment with job operation standards, vocational skill level standards, and skill competition regulations. This ensures timely adjustments to practical teaching content, guaranteeing that the skills and knowledge students acquire to meet the requirements of industries and enterprises, thus improving the alignment between practical teaching and actual vocational demands. Through methods such as the introduction of partner enterprises' culture and on-the-job internships, students' teamwork abilities, communication skills, and professional ethics are cultivated, enhancing their overall quality and competitiveness in their respective job roles.

3.3. Aligning with the "Four New Trends" to Meet "Adaptability" Requirements

The construction of vocational college training bases needs to align with industry enterprises' "new technologies, new processes, new standards, and new business formats." Under the development trend of the "four-network integration" new business format in rail transit, the construction of training bases needs to be industry-oriented. Vocational colleges should promptly understand industry development trends, changes in talent demand, and the application of new technologies and processes, and upgrade or replace training equipment in a timely manner to enable students to master the latest technologies and processes. Based on market demand research, the school should adjust the practical curriculum settings in a timely manner to ensure that the content of training teaching meets professional standards and industry norms, thereby enhancing the vocational competitiveness of vocational students. The school closely aligns with industry enterprises and, through the construction of a sound school-enterprise collaborative cooperation mechanism, builds majors that highly align with industrial development, improves the quality and adaptability of vocational education, and provides vocational college students with diversified practical teaching models and content to adapt to the characteristics of professional adjustments and industrial transformation and upgrading.

The enhancement of practical training base construction conditions facilitates collaborative research between educational institutions and enterprises to address technical challenges. This collaboration supports joint applications for patents and copyrights, thereby advancing technological progress within industry enterprises. It also elevates the research capabilities of school faculty, provides technical support to enterprises, and offers practical experience opportunities for students. Furthermore, the practical training base actively promotes the transformation and dissemination of research outcomes into tangible productivity, generating value for the industry and society. Leveraging the resource advantages of the practical training base, vocational skills training and certification programs are conducted, along with the provision of technical consultation and services. This contributes to the enhancement of workers' skill levels and the elevation of the institution's social influence.

4. The Construction Plan for a Practical Training under the Background of "Four Rail Transit Networks Integration"

The construction of the training base must closely follow the industrial development needs of the "integration of four networks" in rail transit. It should jointly build and share virtual simulation training bases and industry-education integration training bases with leading rail transit enterprises. Based on the pain points and difficulties of "three highs and three difficulties" in rail transit training, develop virtual simulation resources of "reality-driven virtuality, virtuality-assisted reality, and the combination of virtuality and reality". Develop typical production practice projects that adapt to the new technologies, new standards, and new specifications of the "integration of four networks" in rail transit. Jointly create a "golden land" for industry-education integration training in rail transit, and provide strong support for the cultivation of high-skilled talents in rail transit.

4.1. Integrate Enterprise Resources and Establish an Open and Shared Industry-Education Integration Training Base through School-Enterprise Cooperation

Taking the urban rail transit operation professional cluster of our school as an example, this professional cluster is composed of two core majors, urban rail transit operation management and railway transportation operation management, supported by three majors: railway signal automatic control, railway communication and information technology, and urban rail transit electric mechanical technology. The construction of the professional cluster training base should integrate the resources of Guangzhou Metro, the leading enterprise in the rail transit industry chain in the Guangdong-Hong Kong-Macao Greater Bay Area. It should focus on the new demands brought by the "four-network integration" development of rail transit, including "facility interconnection (cross-line operation), ticket system interoperability, security inspection mutual recognition, information sharing, and payment compatibility." It should also connect with the training needs of key positions such as "rail transit signal workers, rail transit communication workers, train dispatchers, and passenger service personnel" in the professional cluster, as well as the research and development needs of new technologies for the "four-network integration" operation organization of rail transit by school teachers. It should make full use of new-generation information technologies such as artificial intelligence, virtual reality, and smart sensing and build a "rail transit 'four-network integration' smart operation and maintenance industry-education integration training base" in accordance with the principles of consistent work scenarios, consistent facilities and equipment, and consistent operation processes. This base should be open and shared with vocational schools and rail transit enterprises in the Guangdong-Hong Kong-Macao Greater Bay Area to meet the needs of students for production training in positions such as station staff, passenger service personnel, signal workers, and communication workers; to carry out popular science education on rail transit for primary and secondary schools; to carry out employee training for rail transit enterprises on the application of different types of rail transit signal communication systems, passenger transport organization, and other aspects under the "four-network integration"; and to meet the needs of teachers for horizontal technical services such as "research on multi-mode rail transit multi-level interconnection and intercommunication transportation organization technology" and "development of multimode rail transit information network standards" in response to the new challenges faced by the development of "four-network integration" in rail transit. The construction of "four networks integration" production education integration training base for rail transit is shown in Table 1 below.

number	Project Name	Targeting vocational schools Targeting vocational schools seconda school		Enterpri	Jointly build enterprises	
		Course practical training and teaching	Popular Science Education	Job training	Technical Services	
1	Integrated Dispatch and Command Training Center	"Organization of Rail Transit Operations" "Train Dispatch Command" "Train Operation Schedule Preparation Training" "Train Operation Control System Maintenance"	Train Simulatior Driving Experience	Dispatcher Train duty officer, duty station master Signal worker Communication worker	Research on New Technologies for Integrated Transport Organization of Four Networks	Guangzhou Railway Group Co., Ltd
2	City Rail/Suburbar Station Training Center	"Emergency Response in Rail Transit" "Ticketing Operations in Rail Transit" "Rail Transit Lines and Stations" "Operation of Rail Transit Transport Equipment" "Maintenance of Computer Interlocking Devices"	Subway ticket sales operations	Station staff Train duty officer Signal worker	Development of Emergency Rescue Coordination Plan for Stations Under the Integration of Different Rail Transit Systems	China Railway Signal & Communication Corporation
3	Four-network integration signal training center	Maintenance of Interval Signal Equipment Maintenance of Computer Interlocking Equipment Maintenance of Dispatch Centralized System	Hand-cranked switch	Signal worker, electrical staff	Research on the integration of different standard rail transit signal systems	Guangzhou Metro Group
4	Integrated Communication and Training Center for Four Network Convergence	Railway Transmission System Maintenance Dispatch Communication System Maintenance of Railway Specialized Communication Equipment	Release scheduling command	Telecommunications Engineer	Development of Multi-Standard Rail Transit Information Network Standards	Guangdong Intercity Railway Group Co., Ltd

Table 1. Case study of the "Four-Network Integration" industry-education integration training base construction in rail transit.

4.2. Targeting the "Three Highs and Three Difficulties" in Practical Training, Jointly Build, Share, and Utilize Virtual Simulation Training Bases

Based on the practical training needs of the intelligent transportation professional cluster curriculum under the "four-network integration" of rail transit, and in response to the "high investment in facilities and equipment, high difficulty in transportation organization, high risk of accident rescue, difficult implementation of track area operations, difficult observation of real production, and difficult reproduction of emergencies" in rail transit training, we leverage the advantages of school-enterprise cooperation with leading rail transit enterprises in the Guangdong-Hong Kong-Macao Greater Bay Area, such as Guangzhou Railway Group, Guangzhou Metro, and Guangdong Intercity. We collaborate to establish a virtual simulation resource development and digital remote training platform construction team, effectively integrating new-generation information technologies such as virtual reality and artificial intelligence with professional cluster training courses. We develop "practice-oriented, virtual-assisted, and virtual-real combined" training resources and build a digital remote training platform to achieve "training anytime, anywhere, and for everyone." This platform will be open and shared with vocational schools and industry enterprises such as Guangzhou Metro and Guangzhou Railway Group within the Guangdong-Hong Kong-Macao Greater Bay Area. This will revolutionize the traditional training model of "insufficient training stations, high training difficulty, and difficult observation of real production," effectively serving the practical training of key positions such as "rail transit signal workers, rail transit communication workers, train dispatchers, passenger service personnel, and freight personnel" for professional cluster students. It also supports online training for enterprise employees to enhance "multi-skill proficiency" under the development needs of rail transit "four-network integration," and serves school teachers in researching new technologies for

Table 2.	Construction of	of a virtual	simulation	training b	base and dig	gital remote	training p	olatform	for rail	transit.
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Serial number	Resource/System Name	Carry out training projects	The problem to be solved
1	Virtual Simulation System for Integrated Transportation Organization of the Four Rail Transit Networks	Dispatch Command Training Train Fault Rescue	High difficulty in vehicle organization High risk in accident rescue
2	Intelligent Passenger Transport Organization Virtual Simulation System for Rail Transit Stations	Passenger flow optimization Special passenger services	Emergencies are hard to replicate.
3	Signal Safety Education Virtual Simulation System	High-altitude fall simulation training Body invasion and collision simulation training	Operational tasks in the track area are difficult to implement.
4	5G Network Deployment and Optimization Simulation System	5G Network Deployment Training	High investment in facilities and equipment
5	5G Station Project Virtual Simulation System	5G Site Engineering Installation Training	It is difficult to observe real production.

rail transit operation and organization under the "four-network integration" background. Simultaneously, it meets the needs of enterprises to conduct vocational skill level assessments in areas such as train operation, passenger transport, freight transport, signaling, and communication, To fulfill the requirements of provincial-level vocational skills competitions in urban rail transit intelligent transportation, high-speed rail signaling, and passenger transport organization, a virtual simulation training base for rail transit will be established. This base will integrate practical teaching, production training, social training, technical services, skills assessment, and skills competitions, effectively supporting the construction of the Greater Bay Area's rail transit systems. The construction of rail transit virtual simulation training base and digital remote training platform is shown in **Table 2**.

4.3. Adapt to the New Requirements of "Four-Network Convergence" and Develop Typical Production Practice Projects

In the operational management of rail transit, collaboration and coordination among various departments and positions within the transportation system are essential to enhance transportation efficiency, service quality, and incident response capabilities, thereby ensuring the stable and safe provision of all services [6]. To accommodate the "four-network integration" transportation development in the Guangdong-Hong Kong-Macao Greater Bay Area, and in response to the new requirements for talent cultivation, which demand that professionals, such as rail traffic dispatchers, passenger service staff, freight personnel, signal technicians, and communication technicians, should "be proficient in the operation of a single-system rail transit network and also master the interoperability of multisystem rail transit networks," we have organized the new technologies, standards, and specifications of the "four-network integration" of rail transit. Based on the real production tasks, work processes, and work scenarios of rail transit enterprises in the Guangdong-Hong Kong-Macao Greater Bay Area, such as the Guangzhou Railway Group, Guangzhou Metro, and Guangdong Intercity Railway, and leveraging the 26-year advantage of school-enterprise cooperation with leading rail transit enterprises in the Guangdong-Hong Kong-Macao Greater Bay Area, we have collaboratively developed a three-level progressive typical production practice task system for single-system rail transit network operation, including "position-specific tasks-comprehensive position tasks-position group linkage tasks." Additionally, we have developed "four-network integration production practice projects" to meet the multi-level interoperability and integrated development needs of high-speed rail and subway, intercity railway and subway, and suburban railway and subway in the multi-system rail transit networks of trunk railways, intercity railways, suburban (suburban) railways, and urban rail transit, forming five production practice projects for professional groups, covering 76 training tasks, as shown in the table below (Table 3). We fully utilize digital technologies such as big data, artificial intelligence, blockchain, and digital twins, and jointly develop a smart management system for training and teaching, strengthening the management of internships and practical training, and achieving traceability of the training process and evaluation of training results.

Table 3. Examples of typical production practice projects in collaborative development between schools and enterprises.

Serial number	Project Name Production Practice	Types of practical projects	Task Type	Task Name	Collaborating enterprises
	Station attendant Typical production practice project		Job-specific tasks	Handling of subway platform door malfunctions, train dispatch operations at the platform.	Guangzhou Metro Group Co., Ltd
		Single Standardized Production Practice Project	Comprehensive task of the position	sHandling of subway train squeezing people and objects Manual switch operation.	Shenzhen Metro Group Co., Ltd
1			Job group coordination tasks	Metro train failure rescue operation, organized train operations using the telephone blocking method.	Foshan Metro Group Co., Ltd
		Four-network integration production practice project	Job integration tasks	Railway, intercity, and urban rail station operations for train dispatching, railway, intercity, and urban rail security inspection mutual recognition operations.	Guangdong Intercity Group Co., Ltd
	Typical Production Practice Projects for Train Dispatchers		Job-specific tasks	Station ATS signal system operation Vehicle control room IBP panel equipment operation.	Guangzhou Railway Group Co., Ltd
		Single Standardized Production Practice	Comprehensive tasks of the position	Section fault lockout handling, emergency stop button activation handling	
2		Project	Job group coordination tasks	Emergency response to sudden fire at the station Handling of widespread malfunctions in ticket sales and inspection equipment.	
		pro	Four-network integration production practic project	Job integration tasks	The application of railway station computer interlocking equipment, the application of railway dispatch centralization system, and the operation of the CTCS train control system.
			Job-specific tasks	Inspection and maintenance of switches and turnout machines, inspection and maintenance of track circuits.	
2	Typical Production	Single Standardized Production Practice Project	Comprehensive task of the position	Troubleshooting of signal track side ^s equipment, Troubleshooting of signal onboard equipment.	
3	for Signal Workers		Job group coordination tasks	Interval blockage system debugging, train operation control system debugging.	
		F	Four-network integration production practice project	Job integration tasks	Signal system centralized monitoring data analysis Signal system comprehensive joint debugging and testing.

5. Conclusion

This paper initiates with an analysis of the industrial development trends of "fournetwork integration" in rail transit, proposing two fundamental logical starting points for the construction of training bases: aligning with industry demands and talent requirements. Subsequently, it examines the three core connotations of industry-education integration in the construction of training bases: "productive," "professional," and "adaptive." Finally, taking the urban rail transit operation management professional cluster as an example, it presents a construction plan for industry-education integrated training bases from three dimensions: base construction, virtual simulation system development, and production training project development, offering a reference for the construction of training bases in rail transit colleges and universities.

Foundation

1) Guangdong Province Higher Vocational Education Teaching Reform Research and Practice Project: Research on the Integration of "Job, Course, Competition, and Certification" under the Application of Virtual Simulation Technology—Based on the Practice and Certification of Urban Rail Transit Operation Management Major.

2) Guangdong Province Ordinary Colleges and Universities Young Innovators Project: Research on the Interconnection of Multiple-Mode Rail Transit Networks in the Guangdong-Hong Kong-Macao Greater Bay Area under the Background of "Integration of Four Networks"

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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