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Research on the Construction Mode of Rail Transit Popular Science Bases under the Background of Integration of Industry and Education

—Taking Guangzhou Railway Polytechnic as an Example

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Abstract

Against the backdrop of the "Double High Plan" and high-quality vocational education development, practical training resources in colleges have become potential assets for social popular science. However, issues such as low openness and insufficient resource conversion mechanisms persist. Adopting a qualitative single-case study approach, this paper investigates Guangzhou Railway Polytechnic, analyzing its transformation path under the "Integration of Industry and Education". Data were collected through document analysis, participant observation, and operational metrics. Relying on the "14th Five-Year" Education Power Promotion Engineering Project, the school integrated advanced hardware resources ("1 Line, 4 Trains, 4 Centers") and established a "Teaching during Regular Times, Popular Science during Idle Times" mechanism. The results indicate that this mode effectively activates idle resources and enhances social service capabilities. In 2024, the base received 4150 visitors, with K-12 students accounting for 48%. Furthermore, the "New Speed" volunteer service system has proven effective in talent cultivation, as evidenced by a 98.5% employment rate for registered volunteers in state-owned enterprises. This study provides a replicable reference paradigm for vocational colleges to break the "walled garden effect," achieving mutual empowerment between teaching and popular science.

Keywords

Integration of Industry and Education, Rail Transit, Popular Science Base, Higher Vocational Colleges, Dual Functions, Resource Sharing

1. Introduction

1.1. Research Background

Scientific literacy is an important component of national quality and the foundation of social progress and civilization. The "Outline of the Action Plan for National Scientific Literacy (2021-2035)" issued by the State Council clearly proposes strengthening the construction of popular science infrastructure and encouraging universities and research institutes to open laboratories and practical training bases to the public, thereby promoting the transformation of scientific and technological resources into popular science resources (The State Council, 2021). As a highland for cultivating high-quality technical and skilled talents, higher vocational colleges play an increasingly important role in popular science work. The newly revised "Vocational Education Law of the People's Republic of China" in 2022 explicitly stipulates that vocational schools should utilize their own resources to provide technical skills training and popular science services to the community and society (Ministry of Education, 2022). Furthermore, the "Opinions on Promoting the High-Quality Development of Modern Vocational Education" (General Office of the State Council, 2022) issued by the General Office of the CPC Central Committee and the General Office of the State Council, also points out the need to enhance the ability of vocational education to serve lifelong learning for all.

Concurrently, with the in-depth implementation of China's "Traffic Power" strategy, the country's rail transit industry has achieved significant progress, and the public's desire to explore scientific knowledge regarding high-speed rail, subways, and other forms of rail transit is growing daily. However, current rail transit popular science faces a contradiction of supply and demand misalignment. On one hand, public science and technology museums often suffer from limitations such as lagging equipment updates, insufficient professional depth, and a lack of real-scene experiences. On the other hand, higher vocational colleges, under the background of industry-education integration—particularly those relying on projects like the National Development and Reform Commission's "14th Five-Year" Education Power Promotion Engineering—have built a large number of high-level training bases that are synchronized with the industry's front line (Nie & Qiu, 2024). However, restricted by traditional management systems and closed-school thinking, these high-quality resources are mostly confined to on-campus teaching, creating a "walled garden effect" with low social openness and utilization rates that need improvement.

1.2. Research Significance

Existing literature mainly focuses on deepening the integration of industry and education is a basic feature of modern vocational education and a key solution to the problem of social utilization of practical training resources. In recent years, the academic community has conducted multi-dimensional explorations into the construction of popular science bases in higher vocational colleges (Zheng, 2018;

Wang & Chen & Wang, 2025; Guo & Li, 2024). Some scholars point out that higher vocational colleges should rely on advantageous professional groups to build a characteristic service mode of "Major + Popular Science," transforming professional advantages into popular science advantages (Long, Zhao, Yang et al., 2025). Other studies emphasize that the school-enterprise collaborative mechanism under the background of industry-education integration can be effectively extended to the field of popular science, achieving complementary advantages between enterprise and school resources (Lv, 2025). Additionally, digital transformation offers new ideas for the development of popular science resources, with resources based on virtual simulation technology becoming an important means to enhance interactivity.

However, existing research mostly concentrates on single aspects of popular science activities or theoretical discussions, lacking in-depth case analyses of building full-chain, systematic popular science scenarios relying on major national industry-education integration projects. In this context, exploring how higher vocational colleges can break down walls and transform high-quality industry-education integration training resources into social public products for popular science has significant theoretical and practical implications. This is not only an effective way to improve the utilization rate of state-owned assets but also an important mission for vocational education to serve lifelong learning and feed back into talent cultivation. Taking Guangzhou Railway Polytechnic as an example, this paper discusses its construction mode of "Resource Sharing, Dual-Teacher Co-construction, and Theory-Practice Integration" relying on the national-level rail transit industry-education integration training base, aiming to provide a pathway reference for vocational colleges to exert their social service functions.

2. Methodology

2.1. Research Design

This research employs a qualitative single-case study design to investigate the construction mode of popular science bases within higher vocational colleges. This methodological approach was selected for its capacity to facilitate an in-depth examination of complex phenomena within their authentic contexts, making it particularly well-suited for analyzing the operational mechanisms underpinning the "Integration of Industry and Education."

2.2. Case Selection

Guangzhou Railway Polytechnic was selected as the purposive case study subject due to its high representativeness and typicality. As a designated institution under the "Double High Plan" and a beneficiary of the National Development and Reform Commission's "14th Five-Year" Education Power Promotion Engineering project, the college hosts a comprehensive resource system characterized as "1 Line, 4 Trains, 4 Centers". The college's strategic shift from a closed teaching fa-

cility to a dual-function base provides a paradigmatic exemplar for examining the social utilization of vocational education resources.

2.3. Data Collection

To ensure the validity and reliability of the findings, this study applied methodological triangulation by synthesizing data from three primary channels. First, a systematic document analysis was conducted on external policy directives, such as the Outline of the Action Plan for National Scientific Literacy (2021-2035), and internal institutional protocols, including the Popular Science Work Management System and the Popular Science Base Opening Management System, which collectively established the institutional context and operational standards. Second, the research team engaged in longitudinal participant observation of the base's operations, specifically monitoring "National Science Popularization Day" events and "Rail Transit Station Passenger Service" experience activities, enabling a direct assessment of the interaction dynamics between the base and the public. Finally, operational metrics were extracted from administrative logs to quantitatively evaluate social impact, utilizing data on opening frequency, visitor flow (exceeding 4000 annually), and volunteer engagement (343 registered participants through the "New Speed" Train Association).

2.4. Data Analysis

Data were processed using thematic analysis. The construction mode was deconstructed into three core dimensions: hardware resource foundation, organizational management mechanisms, and talent team construction. This analytical framework seeks to elucidate the pathways through which the structural barriers between "Teaching" and "Popular Science" are bridged within the context of industry-education integration.

3. Resource Foundation and Construction of Industry-Education Integrated Popular Science Bases

3.1. Relying on National-Level Projects to Build "Full-Chain" Physical Popular Science Scenarios

This popular science base relies on the construction of the Guangzhou Railway Polytechnic Rail Transit Industry-Education Integration Training Base project, a part of the National Development and Reform Commission's "14th Five-Year" Education Power Promotion Engineering, with a total investment exceeding 200 million RMB. To address the shortcomings of traditional popular science bases that only have models or display boards and lack real industrial scene experiences, the school has constructed a full-chain real production scenario of "1 Line, 4 Trains, 4 Centers." This covers an all-encompassing facility system including outdoor infrastructure, core popular science equipment, and indoor professional venues. The facilities operate in coordination, providing solid hardware support for both rail transit technical training and public popular science.

Regarding outdoor infrastructure construction, the focus is on creating an outdoor comprehensive training line (the "1 Line"). This line covers an area of 11,913 square meters with a total track length of 1586 meters. It includes both ballastless and ballasted tracks, six sets of turnouts, and supporting teaching facilities such as bridges and tunnels. This setup restores the complex scenarios of outdoor railway transport operations, combining practical training with immersive popular science functions to facilitate the dissemination of railway infrastructure knowledge.

Regarding core popular science equipment, the base is equipped with a full pedigree of practical training trains (the "4 Trains") representing China's rail transit speed and technological level. This achieves full-type coverage from normal speed to high speed, and from locomotives to rolling stock, providing core carriers for rail transit technology popular science. The Fuxing Intelligent EMU can simulate various faults, focusing on high-speed rail technology popular science; the HXD1D electric locomotive and the Metro Type B car both possess contact-net-free operation capabilities, demonstrating electric locomotive principles and urban rail vehicle structures respectively; the 25T passenger car is used for the popularization of knowledge regarding normal-speed trains.

Regarding indoor professional venue construction, four comprehensive training centers (the "4 Centers") have been built through resource integration. These achieve professional coverage of the entire rail transit industry chain, guaranteeing indoor venues for specialized training and in-depth popular science. The Rolling Stock Center displays train maintenance and operation technology; the Power Supply Center reveals the energy supply mechanism of electrified railways; the Communication and Signal Center analyzes the principles of safe train operation control; and the Virtual Simulation Center utilizes VR/AR technology to provide highly immersive popular science training experiences.

3.2. Technical Empowerment via "Combination of Virtual and Real"

Addressing popular science difficulties that are high-risk, high-cost, or difficult to reproduce—such as high-speed rail driving, high-voltage maintenance, and tunnel emergency rescue—the base employs advanced virtual simulation technology for empowerment. In the Rail Transit Virtual Simulation Comprehensive Training Center, the school has built VR/AR/MR virtual teaching training rooms equipped with EMU driving simulators and metro driving simulation systems. The EMU Driving Examination Center is based on the Guangzhou Railway Group's standard CR400AF driving simulator, simulating 180 kilometers of the Wuhan-Guangzhou High-Speed Railway environment, including real scene data for 5 stations and 1 EMU depot. The Metro Vehicle Simulation Driving Training Room uses Guangzhou Metro Line 21 as a blueprint to provide full-function driving simulation training, including systems for the central dispatch center and station operation ATS/LOW training. Through digital twin technology, the general public and primary/secondary students can experience driving operations at 350 km/h in a controlled environment and observe the precision structure of the train

undercarriage, greatly enhancing the interactivity, interest, and safety of popular science. This resource allocation strategy of "combining the virtual and the real" not only solves the problem of high operating costs for physical equipment but also expands the depth and breadth of popular science education.

4. Innovation of Operation and Management Mechanisms

To fully utilize the popular science value of the aforementioned high-end resources, the school has explored a construction mode for the popular science base that integrates "Resource Sharing, Organizational Operation, and Team Building," achieving the organic integration of vocational education and social popular science.

4.1. Resource Sharing Mode

Two-way Conversion of Teaching and Popular Science The school implements a decentralized resource management mode of "Teaching during Regular Times, Popular Science during Idle Times," allowing for flexible switching between the functions of a "School-Factory" and a "Science Museum."

First, achieving functional reuse and spatiotemporal decentralization. According to the "Popular Science Base Opening Management System," the base opens to the public on weekends, winter and summer vacations, and specific periods like "National Science Popularization Day," provided that normal planned teaching and training are guaranteed. The Rail Transit Industry-Education Integration Training Base, various model training trains, and the four major training centers have set opening times on working days during March-June and September-December. The upper limit for single-visit reception is set between 20 to 100 people, ensuring a balance between teaching order and popular science activities. This staggered sharing mechanism effectively solves the problem of idle university training resources and significantly improves the utilization efficiency of state-owned assets.

Second, achieving content conversion and simplified dissemination. The school transforms profound professional teaching standards into easy-to-understand popular science courses. Complex train operation organization processes are converted into "Hand Signal Virtual Simulation Experiences"; dry train structural knowledge is transformed into a "Fuxing EMU" exploration tour; and professional passenger service standards are converted into "Rail Transit Station Passenger Service Eight Steps" experience classes. This transformation revitalizes idle resources and significantly reduces the production cost of popular science content, realizing the effective penetration of professional resources into popular science resources.

4.2. Organizational Operation Mode

Multi-department Collaboration and Institutional Guarantee To ensure the long-term standardized operation of popular science work, the school has constructed

a grid management architecture featuring school-level coordination and departmental collaboration. The school established a "Railway Popular Science Education Base" Leading Group headed by the Principal, with members covering the Party and Administration Office, Science and Technology Industry Division, Academic Affairs Office, and heads of various secondary colleges. The Leading Group has an office within the Science and Technology Industry Division, equipped with 5 full-time management staff to coordinate daily work. Simultaneously, a popular science liaison (served concurrently by the research secretary) is established in each secondary college, forming a three-level linkage mechanism of "School - Functional Department - Secondary College." This grid management architecture ensures that popular science work is supervised, managed, and implemented.

The school has formulated the "Guangzhou Railway Polytechnic Popular Science Work Management System" and the "Popular Science Base Opening Management System," clarifying the organizational structure, team building, activity planning, and incentive mechanisms for popular science work. Regarding funding, the school has established a special popular science fund included in the annual financial budget, implemented for specific purposes to guarantee the development of popular science activities and equipment maintenance/renewal.

4.3. Team Building Mode

Combination of Full-time and Part-time Staff with Students as the Main Body Talent is the core of popular science work. The school has built a diversified popular science team system of "Expert Leadership, Full-time Backbone, and Student Main Body."

Building dual-teacher leadership and full-time teams: The base possesses a popular science advisory group composed of on-campus professors and enterprise experts, as well as a core team of 15 full-time personnel (including 5 management staff and 10 guides). These full-time personnel are mostly backbone teachers from various colleges, such as the Locomotive and Rolling Stock College and the Electrical Engineering College, ensuring the accuracy and professional depth of popular science knowledge.

Simultaneously establishing student associations (New Speed Train Association): This is a major feature of the base's construction. Relying on the "New Speed Train Association," the school has formed a massive volunteer service team, currently consisting of 65 part-time popular science personnel and 343 registered volunteers. In the process of serving as popular science guides and equipment demonstrators, students internalize and output what they have learned in class. This not only serves society but also greatly consolidates their own professional skills, achieving the organic integration of "Popular Science + Labor Education." To substantiate this skill consolidation, the college employs a comparative assessment method. Analysis of practical course results reveals that active volunteers (with service duration exceeding 20 hours) consistently outperform non-volunteers in

core technical modules, such as "EMU Driving Operation," with an average score advantage of approximately 15%. Additionally, qualitative feedback from student reflection logs indicates that the process of "translating" complex professional terminology for the public compels volunteers to restructure their knowledge systems, thereby deepening their theoretical understanding and operational confidence. The volunteer list covers students from multiple colleges such as Locomotive and Rolling Stock, and Transportation Logistics, forming a "senior guiding junior" inheritance mechanism. This popular science service mode with students as the main body solves the shortage of human resources for popular science while becoming an important platform for the school's practical education.

5. Research Results

Through the continuous operation of the industry-education integration mode, the Guangzhou Railway Polytechnic Popular Science Base has achieved significant results in social service efficacy, brand activity creation, and international influence dissemination, becoming an important position for regional popular science education.

First, the scale and quality of social services have achieved dual improvement. Relying on the flexible mechanism of "Teaching during Regular Times, Popular Science during Idle Times," the base is open for over 200 days annually. According to the operation logs from 2024, the base received a total of 4150 visitors. A breakdown of the audience demographics reveals that K-12 students constitute the primary group, accounting for 48%, largely driven by school-organized study tours and summer camps. Community residents represent 32%, typically engaging in immersive experiences during weekend open days. The remaining 20% consists of industry professionals and peer researchers participating in technical exchanges and training seminars. This diverse demographic structure indicates that the base effectively serves multileveled social needs, ranging from basic science literacy to professional development. By virtue of solid construction results and a comprehensive service system, the base was successfully approved as a "National Railway Popular Science Education Base" recognized by the China Railway Society in September 2024, and was jointly recognized as a "Guangdong Provincial Popular Science Education Base" by the Department of Science and Technology of Guangdong Province and the Guangdong Association for Science and Technology. These honors mark that the school has received high recognition in both industry popular science and social popular science fields, effectively exerting the function of universities serving society.

To further validate these effectiveness claims, the research team conducted a quantitative assessment based on visitor feedback and student career tracking. Regarding public scientific literacy, an analysis of 500 post-visit questionnaires distributed in 2024 indicates that 92.4% of visitors reported a "significant increase" in their understanding of rail transit technologies, specifically in areas such as "High-speed rail power supply principles" and "Subway safety emergency proce-

dures." Regarding student skill consolidation, comparative data shows that the employment rate of registered volunteers in state-owned railway enterprises reached 98.5% over the past three years, which is 4.2 percentage points higher than the college's average. This suggests that the immersive practice in the popular science base effectively enhances students' professional competitiveness and employability.

Second, popular science brand activities and immersive experiences have effectively engaged with the public. The base makes full use of high-end practical training equipment to plan and implement a series of popular science brand activities with distinct rail transit characteristics. For example, the "Rail Transit Station Passenger Service Eight Steps" experience activity allows students from surrounding schools, such as Fengxiu Primary School, to personally experience the entire process of entering the station, purchasing tickets, security checks, waiting, alighting, exiting gates, and leaving the station. This transforms theoretical regulations of civilized riding into immersive role-playing, achieving a deep integration of knowledge popularization and quality education. Furthermore, relying on resources like the Virtual Simulation Center, the base regularly conducts "AI + STEM" science and innovation education summer camps, organizing students to engage in drone flying, robot programming, and metro simulation driving experiences. This "learning by doing" immersive experience mode greatly stimulates adolescents' engineering thinking and scientific interest, implementing national requirements on strengthening labor education and science education in primary and secondary schools.

Finally, the base actively serves national strategies, with international influence beginning to emerge. Based in the Guangdong-Hong Kong-Macao Greater Bay Area, the base actively responds to the "Belt and Road" initiative, undertaking popular science exchange tasks such as railway operation and management seminars for countries like Serbia. By organizing international trainees to visit the CRH6A EMU training room and experience the Guangzhou Metro Line 21 simulation driving, the base intuitively displays China's railway construction standards, technological strength, and vocational education level to international friends. This not only builds a bridge for Sino-foreign rail transit cultural exchange but also effectively exerts the role of the popular science base as an international communication window for Chinese railway technology "Going Global," realizing the international value-added of vocational education resources.

6. Conclusion and Implications

6.1. Conclusion

The practical exploration of the school shows that under the background of industry-education integration, relying on higher vocational colleges to build high-level rail transit popular science bases is a viable pathway. This mode utilizes the physical resource investment of "1 Line, 4 Trains, 4 Centers" to solve the contradictions of slow updates, high costs, and lack of realism in traditional popular sci-

ence facilities. Through the soft service output of the "New Speed" student association, it resolves the contradiction between the shortage of popular science human resources and the students' need for skills practice.

6.2. Practical Implications

The findings of this study offer meaningful implications for other higher vocational colleges aiming to enhance their social service capabilities. First, the "Teaching during Regular Times, Popular Science during Idle Times" mechanism provides a replicable model for institutions facing resource constraints, demonstrating how to maximize the utility of state-funded assets without disrupting core educational functions. Second, the integration of student volunteer services suggests that popular science work can be effectively aligned with talent cultivation, transforming external service pressures into internal educational opportunities. Finally, as the "Base+" strategy and digital transformation deepen, this case serves as a reference framework for vocational colleges to contribute to the construction of a learning society and support national transportation development strategies.

Foundation

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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