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Research on the Training Mode of Graduate Degree in Transportation under the Background of Integrated Education, Science and Technology, and Talent

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Abstract

The integrated development of education, science and technology, and talent requires professional degree postgraduate education to move beyond a one-way, university-based model of provision towards coordinated interaction among the education, innovation, talent, and industry chains. The transportation sector is characterised by complex engineering systems, rapid technological change, and diverse application settings. Current programmes face several challenges, including weak alignment between training objectives and industry needs, separation between coursework and research practice, overly formalised professional practice, and insufficient coordination between academic and industry supervisors. With the development of practical innovation capability at its core, this study seeks to establish a training mechanism that connects the education chain, the scientific and technological innovation chain, the talent development chain, and the transportation industry chain. It proposes a reform framework based on engineering-demand orientation, the integration of research and education with industry and education, and coordination among multiple stakeholders. The aim is to develop an actionable, assessable, and transferable model for training professional degree postgraduates in transportation, thereby providing a reference for local universities seeking to support China's strategy of building a strong transportation nation and the upgrading of regional transportation industries.

Keywords

Integrated development of education, science and technology, and talent; transportation; professional degree postgraduates; training model; integration of research and education.

1. Introduction

Professional degree postgraduate education has been explicitly positioned as an important form of education that responds to the development needs of industries and sectors and prepares practice-oriented innovators. Training programmes should emphasise professional practice and strengthen students' capacity to solve real-world problems through the integration of research and education, the integration of industry and education, and project-based training [1]. The Outline for Building a Leading Country in Education (2024-2035) further calls for the vigorous development of professional degree postgraduate education and for a mutually reinforcing cycle among education, science and technology, and talent [2]. The transportation sector is undergoing accelerated digital, intelligent, green, and integrated transformation and is shifting from traditional factor-driven growth towards innovation-led development. Problems in the sector increasingly involve interdisciplinary knowledge, the coupling of complex systems, and open engineering environments. Accordingly, the capabilities required of professional degree postgraduates in transportation must extend beyond

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individual technical operations to encompass complex systems analysis, interdisciplinary collaboration, digital decision-making, and engineering innovation [3].

Existing studies have produced a substantial body of research on the evolution of the professional degree system, differentiated development, the integration of industry and education, industry colleges, dual-supervisor arrangements, and practice bases. Niu Jingjing and Liu Huiqin analysed the drivers and internal logic of institutional change in China's professional degree education [4]. Li Fengliang and Meng Yaqin discussed the development of a high-quality professional degree postgraduate education system [5]. Wang Li and Ma Yonghong et al. examined policy evolution and international trends, respectively, and demonstrated the need for professional degree education to emphasise professional practice and its distinctive identity as a type of education [6-7]. At the level of training mechanisms, Wu Kaijun et al. noted continuing constraints, including assessment indicators that favour academic performance, high participation costs for enterprises, outdated course content, and loosely coordinated multi-stakeholder governance [8]. Drawing on enterprise needs, Liang Chuanjie et al. proposed joint university-enterprise selection and training, dual-supervisor guidance, and collaborative assessment [9]. Gu Yongdong et al. argued that industry colleges should encompass the entire process of curriculum, discipline, supervisor, and platform development [10]. Xiong Ling et al. proposed that professional degree courses in engineering should address major national needs and bring together industry resources [11]. Overall, research on the integrated development of education, science and technology, and talent has largely remained at the macro level and has yet to be applied in depth to specific transportation contexts. This article therefore focuses on how the requirements of such integration can be translated into implementable arrangements for professional degree postgraduate education in transportation. On the basis of an analysis of current constraints, it clarifies the implications of integration and develops a reform framework centred on engineering-driven training, the integration of research and education, and multidimensional coordination.

2. Problems in the Training of Professional Degree Postgraduates in Transportation

Professional degree postgraduate education in transportation simultaneously serves three functions: advanced education, engineering and technological innovation, and workforce development for the sector. Its quality depends not only on teaching arrangements within universities, but also on the combined influence of the national strategy for building a strong transportation nation, the sector's digital and green transformation, and regional transportation governance needs. Integrated development requires the education, innovation, talent, and industry chains to form an interconnected system characterised by mutual reinforcement and cyclical feedback. Current practice, however, has yet to establish a stable value cycle linking technological innovation, talent development, and industry practice within professional degree postgraduate education in transportation.

(1) Course provision lags behind developments at the technological frontier

Transportation technology is characterised by rapid iteration, strong systems coupling, and complex application environments. Some current curricula nevertheless remain organised around conventional disciplinary modules. Even when artificial intelligence, big data, digital twins, new energy, advanced materials, and related topics are included, they are often appended to the existing curriculum as specialist lectures, electives, or tool-based training. Students may encounter new concepts without necessarily understanding the transportation problems to which a technology is suited, the data conditions on which it depends, or the engineering constraints and ethical standards that govern its use. Courses jointly developed by universities and enterprises also tend to focus on an enterprise's existing products and specific

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technical processes, with insufficient attention to underlying principles, transferability, and future technological directions. Consequently, a curriculum may lag behind technological development while also being overly driven by short-term job requirements, making it difficult to maintain an appropriate balance between frontier knowledge and fundamentals, and between specialised and transferable capabilities.

(2) Scientific and technological practice has not yet been transformed into an effective vehicle for education

The practical capabilities of professional degree postgraduates should develop progressively through authentic tasks, complex constraints, and collaboration among multiple stakeholders. Although transportation programmes commonly include professional practice, joint training, or enterprise placements, some practical projects remain fragmented and auxiliary, with an excessive emphasis on formal outputs. University-enterprise collaboration often depends on an individual lecturer's projects or short-term agreements. Students therefore have limited opportunities to understand the entire engineering process, from identifying a need and evaluating options to implementation and assessment. They also lack a sufficiently independent problem space and meaningful opportunities for trial and error, while the practical process rarely produces reusable course cases, experimental modules, or evidence for capability assessment. Transportation systems also have a public-service function and are subject to stringent safety and regulatory requirements. Many authentic projects involve multi-agency data, major infrastructure, and continuously operating systems, creating high barriers to student participation. When scientific and technological projects cannot be converted into educational projects, and educational outcomes cannot in turn inform technological improvement, the intended cycle among education, science and technology, and talent remains largely procedural.

(3) A multi-stakeholder mechanism for collaborative education has yet to be established

Training professional degree postgraduates in transportation involves university academics, industry supervisors, research platforms, transportation enterprises, and sector regulators. The presence of multiple stakeholders, however, does not in itself create collaborative education. In many settings, the dual-supervisor system continues to involve the university supervisor leading academic training while the industry supervisor provides practical opportunities. Each supervisor assumes only a limited part of the responsibility, with few shared tasks, limited routine communication, and little joint assessment focused on the student's capability development. Academic and industry supervisors also differ in their evaluation cycles, specialist language, and interests. Without clear statements of rights and responsibilities, recognition of workload, arrangements for distributing benefits, and mechanisms for resolving conflict, joint supervision can easily be reduced to procedural participation at the proposal, mid-term review, and thesis defence stages. Moreover, challenges such as smart motorways, coordinated hub operations, rail transit safety, and low-carbon transport organisation require knowledge spanning transportation engineering, control science, computer science, mechanical and civil engineering, and management. A single academic supervisor and a single industry supervisor cannot readily cover this breadth. In the absence of shared cases, shared data, and platforms for joint discussion, supervisors struggle to integrate knowledge into coherent solutions, thereby limiting the sustainability of collaborative education.

3. Implications of Integrated Development for Professional Degree Postgraduate Education in Transportation

Integrated development does not mean separately adding content on education, science and technology, and talent to an existing training programme, nor does it mean simply placing

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universities, research institutes, and transportation enterprises alongside one another. Rather, it entails using major needs in the transportation sector to drive the systematic redesign of training objectives, knowledge production, and vehicles for practice. Its central purpose is to enable education to continuously supply the talent and knowledge base required for scientific and technological innovation, while enabling postgraduates to progress from learners of knowledge to participants in technological innovation and industry transformation through the resolution of authentic problems. This requires the following:

(1) Align the orientation of training with the needs of building a strong transportation nation and emphasise integrated practical innovation capability

Integrated development requires training objectives to shift from the completion of a degree to the strengthening of innovation capability in transportation. Professional degree postgraduates should be prepared to contribute to a comprehensive transportation system that is safe, convenient, efficient, green, economical, inclusive, and resilient, and should be able to translate scientific knowledge, engineering technology, and governance requirements into implementable transportation solutions. Training objectives should emphasise the interrelated capabilities of knowledge integration, practical application, cross-boundary collaboration, and value judgement. This orientation reflects the foundational role of education, the leading role of science and technology, and the agency of talent. Education provides theoretical foundations, methodological training, and professional ethics; the technological frontier introduces new problem domains and new tools for solving them; and talent becomes the link between education and technology through the reorganisation of knowledge and innovation in practice. Training providers should therefore develop observable and assessable capability frameworks that translate broad objectives into specific requirements for coursework, project practice, thesis outcomes, and career development, thereby preventing training objectives from remaining abstract statements.

(2) Reorganise the knowledge system around complex transportation problems and establish a mechanism through which frontier technologies inform the curriculum

Integration requires the curriculum to move from arranging knowledge by disciplinary category to organising it around complex problems. Tasks such as managing traffic congestion, enabling intelligent infrastructure operation and maintenance, ensuring the safety of autonomous driving, coordinating integrated transport hubs, and optimising low-carbon transport cross the boundaries of engineering technology, data science, organisational management, and public policy. Curriculum design should therefore use representative problem chains as its organising framework, embedding fundamental transportation theory and emerging technologies such as artificial intelligence, digital twins, intelligent sensing, advanced equipment, and green energy within a common analytical framework. This approach enables students to understand the conditions for applying a technology, its system interfaces, risk boundaries, and social implications. Interdisciplinarity is not achieved merely by adding several emerging-technology courses; it requires students to complete a cognitive cycle encompassing problem identification, knowledge selection, model construction, solution design, validation, and iteration. Training providers can also convert industry technology roadmaps, enterprise technical challenges, outputs from research platforms, and cases of engineering failure into modular teaching resources. Annual refinements, updated specialist modules, and iterative project courses can improve the curriculum's responsiveness to technological change and establish a two-way channel through which technological needs enter education and educational outcomes support technological development.

(3) Use major scientific and technological tasks and authentic engineering settings to connect the four chains

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In practice, integrated development means transforming the process of scientific and technological innovation into a process of talent development. Professional degree postgraduate education in transportation should move from isolated placements towards organised, task-driven practice. Authentic problems arising from critical industry technology projects, regional transportation governance, enterprise technological upgrading, and major engineering construction should be converted, in accordance with educational principles, into postgraduate projects that can be decomposed, iterated, and assessed. This creates a cycle of scientific and technological projects, course cases, degree outcomes, and industry applications. Scientific and technological projects provide frontier problems and data-rich settings; courses provide the theory and methods needed for project work; degree outcomes offer systematic investigations of key project problems; and the application of results, together with feedback from practice, informs subsequent teaching. Papers, patents, standards, software, consultancy proposals, and engineering designs are thus no longer isolated outputs, but different vehicles for students' capability development and the creation of industry value. De-identified data, digital twins, simulation experiments, and tiered access can be used to construct training environments that approximate authentic constraints, although virtual settings must ultimately be tested against engineering logic and industry standards.

(4) Reshape collaborative education through multiple stakeholders and build an open, mobile platform community

Integration requires government, universities, research institutes, transportation enterprises, and industry organisations to move from being providers of resources to becoming co-educators. Government and sector authorities should primarily assume responsibility for policy coordination, standards guidance, and public-data governance. Universities should take responsibility for knowledge systems, educational principles, and academic standards. Enterprises should contribute authentic problems, engineering settings, and technical experience, while research institutes and innovation platforms should provide advanced facilities and interdisciplinary research environments. Supervisory arrangements should likewise move from a fixed dual-supervisor pairing towards task-oriented, dynamically constituted interdisciplinary supervisory teams. Universities should also recognise the educational value of academics' industry placements, case development, and knowledge transfer in workload allocation, promotion assessment, and the distribution of outcomes. Enterprises, in turn, should incorporate supervision into their talent-development and innovation-performance systems. Cross-boundary collaboration can develop from nominal cooperation into a long-term community only when incentives are aligned.

4. Reform Pathways for Professional Degree Postgraduate Education in Transportation

Integrated development calls for a paradigm shift in professional degree postgraduate education in transportation: from fragmented inputs to systems integration, from knowledge transmission to capability development, and from unilateral university provision to collaborative education involving multiple stakeholders. To address the misalignment between training objectives and industry needs, slow curriculum renewal, fragmented practice, and inadequate coordination between academic and industry supervisors, programmes should be driven by engineering tasks, organised around the integration of research and education, and supported by multidimensional collaboration. On this basis, an interconnected training model comprising four forms of guidance, five joint mechanisms, and six dimensions of collaboration can be established.

(1) Engineering-driven training: reconstruct capability development through four forms of guidance

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Professional degree postgraduate education in transportation has a strong engineering-practice orientation. Its central purpose is not to add several practical courses, but to enable students to develop knowledge integration, technological application, engineering decision-making, and professional capability in a coordinated manner as they continuously address complex transportation problems. Four forms of guidance - course guidance, competition-based guidance, research guidance, and supervisor guidance - can be used to integrate otherwise separate coursework, research training, innovation competitions, and professional practice into a continuous and progressively demanding process of capability development. Course guidance converts the transportation frontier, national and regional transportation needs, and engineering constraints into project-based course units, creating a connected curriculum of general foundations, disciplinary practice, and specialist pathways. Competition-based guidance links postgraduate innovation funds, supervisors' research projects, enterprise technical problems, and science and technology competitions to create a progression from course prototypes to deeper research, competition-based validation, and knowledge transfer. Research guidance draws on publicly funded and industry-funded projects and research platforms to establish tiered pools of topics, enabling students to experience problem definition, literature and data acquisition, method design, validation and analysis, and delivery of outcomes. Under supervisor guidance, the academic supervisor is responsible for theory, methods, and academic standards, while the practice supervisor is responsible for context, technology, and professional standards. Both jointly supervise the same engineering task. In this way, continuous tasks replace disconnected components, integrating knowledge acquisition, research training, and engineering practice and enabling postgraduates to progress from recipients of knowledge to solvers of complex transportation problems.

(2) Integration of research and education: establish a joint training mechanism through five joint arrangements

The essence of integrating research and education is to transform scientific and technological innovation resources into educational resources and to ensure that the outcomes of talent development continue to support technological progress in the sector. In conventional university-enterprise cooperation, enterprises often play a supporting role by providing venues, equipment, or placements, with limited substantive involvement in defining training objectives or evaluating quality. Cooperation can therefore become project-specific, participation can be confined to particular stages, and supervision can become a formality. To address these problems, a joint training mechanism covering admission, training, practice, and outcome evaluation should be established through joint recruitment, joint programme design, joint development of practice bases, joint supervision, and joint problem-solving. Joint recruitment brings information about industry capability requirements, enterprise culture, and career development into the admissions and selection process. Joint programme design enables university, enterprise, and industry experts to collectively define graduate capabilities, curriculum structure, and practice standards. Joint development of practice bases involves not only providing facilities and equipment, but also continuously supplying authentic topics, data, supervisors, and assessment settings. Joint supervision implements whole-of-programme guidance through a pool of external supervisors, joint supervisory teams, and regular consultation. Joint problem-solving aligns enterprise problems, supervisors' research topics, student projects, and practice outcomes. The mechanism turns enterprises from resource providers into co-definers of training objectives, co-implementers of the training process, and co-evaluators of training quality. It also uses formal arrangements to clarify the boundaries governing data use, intellectual property, ownership of outcomes, and research ethics, allowing the integration of research and education to develop from short-term project cooperation into a stable educational system.

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(3) Multidimensional coordination: broaden the educational ecosystem through six dimensions of collaboration

Transportation systems span different transport modes, administrative regions, technological fields, and governance bodies. No single university or enterprise can independently provide a complete set of training resources. Integrated development therefore requires institutions to move beyond organisational boundaries and establish an open educational ecosystem comprising collaboration within the university, between universities and local government, between universities and enterprises, among universities, with industry, and internationally. Multi-level resource flows can thereby improve the adaptability and innovativeness of talent development. Internal university collaboration focuses on removing barriers among schools, disciplines, and platforms. Cross-enrolment in courses, credit recognition, shared experimental platforms, and interdisciplinary supervisory teams can connect transportation with computer science, control science, mechanical and civil engineering, management, and law. University-local government collaboration should engage with practical tasks such as regional integrated transportation planning, urban traffic governance, logistics-hub development, and urban-rural transportation integration, embedding postgraduate education in local transportation development and public governance. University-enterprise collaboration enables transportation construction, equipment manufacturing, transport operations, and digital technology enterprises to provide technical projects, practice supervisors, data resources, and validation environments so that innovative solutions can be tested against engineering conditions and market settings. Inter-university collaboration addresses the limitations of a single institution's courses, staff, and platforms through high-quality course sharing, joint training, open access to research platforms, and postgraduate academic communities, allowing institutions' areas of strength to complement one another. International collaboration should extend beyond short study visits or academic conferences. Joint courses, collaborative projects, cross-cultural engineering projects, and placements with international organisations can help students understand transportation regulations, technical standards, and governance approaches in different countries, while strengthening international communication, cross-cultural collaboration, and the capacity to analyse global transportation challenges.

5. Conclusion

The integrated development of education, science and technology, and talent is both a major strategic component of China's national innovation system and a new basis for action in reforming professional degree postgraduate education in transportation. As the transportation sector becomes increasingly digital, intelligent, green, and integrated, conventional training centred on disciplinary knowledge transmission and completion of a degree thesis can no longer adequately meet the practical needs associated with solving complex engineering problems, transferring scientific and technological outcomes, and developing interdisciplinary professionals. In response to current problems - including the misalignment of training objectives and industry needs, slow curriculum renewal, fragmented practical tasks, insufficient coordination between university and enterprise supervisors, and narrow assessment criteria - this study proposes a model grounded in the foundational role of education, the leading role of science and technology, and the agency of talent. The model translates national strategies, regional needs, and industry frontiers into engineering tasks that run throughout the training process. Course guidance, competition-based guidance, research guidance, and supervisor guidance create a continuous progression across knowledge acquisition, research training, and engineering practice. Joint recruitment, joint programme design, joint development of practice bases, joint supervision, and joint problem-solving strengthen collaborative training. Collaboration within the university, between universities

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and local government, between universities and enterprises, among universities, with industry, and internationally broadens the range of educational resources. This model can improve alignment among training objectives, curricula, practice platforms, supervisory teams, and assessment mechanisms; transform scientific and technological innovation into a process of talent development; and enable training outcomes to support technological progress and governance innovation in transportation.

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