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REFORM AND PRACTICE OF TALENT CULTIVATION IN THE CIVIL AVIATION TRANSPORTATION PROGRAM UNDER THE FRAMEWORK OF EMERGING ENGINEERING EDUCATION

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Abstract: The development of smart civil aviation, the rapid growth of the low-altitude economy, and the new round of scientific and technological revolution have brought new requirements for talent cultivation in civil aviation transportation programs. In response to existing problems in traditional training models, including insufficient industry–education integration, delayed curriculum updating, weak alignment between practical teaching and real operational scenarios, and an incomplete closed-loop quality evaluation mechanism, this study explores the reform of talent cultivation for civil aviation transportation under the framework of Emerging Engineering Education. Guided by an industry-oriented philosophy, the reform aims to cultivate applied talents who understand aviation operations, possess strong practical competence, demonstrate innovation capability, and uphold a strong awareness of safety. Accordingly, a cultivation framework characterized by strategic guidance, industry–education integration, digital and intelligent empowerment, and continuous improvement is constructed. Reform practices are implemented through the reconstruction of training objectives, optimization of the curriculum system, development of virtual simulation and full-mission simulation platforms, promotion of collaborative education by dual-qualified teaching teams, and improvement of competence-based achievement evaluation. This reform framework provides a systematic pathway for aligning program development, curriculum renewal, practical teaching, and competency evaluation, and offers a useful reference for talent cultivation reform in transportation-related programs at civil aviation-oriented universities under Emerging Engineering Education.
Keywords: Emerging Engineering Education; Civil aviation transportation; Industry–education integration

1 INTRODUCTION

The rapid emergence of new economic forms and the ongoing transformation of industries have imposed new requirements on the knowledge structure, competency profile, and training models of engineering professionals. In response, higher engineering education needs to become more closely aligned with industrial demands and future technological development. Its focus should gradually shift from the mere transmission of disciplinary knowledge to the cultivation of innovation-oriented practice, interdisciplinary integration, and the ability to solve complex engineering problems. Against this background, the development of Emerging Engineering Education has become a major direction in the reform of higher engineering education in China. A series of policy documents, including the Fudan Consensus on Emerging Engineering Education [1], the Tianda Action Plan[2], and the Beijing Guide [3], have emphasized that engineering education reform should be driven by the needs of the new economy and emerging industries, and should promote systematic innovation in educational philosophy, program structure, curriculum design, teaching models, and collaborative talent cultivation mechanisms. Existing studies have further elaborated the theoretical connotations of Emerging Engineering Education, highlighting that its development should be oriented toward future industrial and technological change and should aim to cultivate innovative engineering professionals capable of meeting evolving societal and industrial needs [4]. More recent discussions have further emphasized that Emerging Engineering Education should not be regarded merely as curriculum adjustment, but as a paradigm shift in higher engineering education that requires systematic innovation in disciplinary organization, curriculum structure, practice-based learning, and collaborative governance [5].

Civil aviation transportation is a safety-critical, systems-oriented, technology-intensive, and highly regulated field. Talent cultivation in this discipline must therefore not only satisfy the general requirements of engineering education in transportation-related programs, but also respond to the competency demands of civil aviation operations. Positions in air traffic management, airline operations control, aeronautical information services, flight dispatch, and low-altitude flight service support require graduates to possess a solid understanding of operational rules, systems thinking, data analysis, collaborative decision-making, and emergency response capabilities. The 14th Five-Year Plan for Civil Aviation Development identifies smart civil aviation as a central development pathway and calls for the accelerated construction of a modern civil aviation system that is safer, higher-quality, more efficient, more equitable, and more sustainable [6]. The guiding opinions issued by the Civil Aviation Administration of China on accelerating the development of smart civil aviation further stress the importance of digital transformation, intelligent applications, and integrated smart aviation systems [7]. Meanwhile, the rapid development of emerging scenarios, including the low-altitude economy, general aviation, and unmanned aircraft operation management, has created new demands for knowledge renewal and competency expansion in civil aviation transportation education.

Although traditional talent cultivation in civil aviation transportation has developed strong industry-oriented characteristics through long-term practice, it still faces several limitations in the context of smart civil aviation and Emerging Engineering Education. First, professional curricula remain insufficiently integrated with emerging technologies and operational scenarios such as artificial intelligence, big data, digital twins, and low-altitude operation management. Second, the connections among theoretical instruction, license-oriented training, engineering practice, and innovation education need to be further strengthened. Third, a contextual gap still exists between classroom teaching and real-world civil aviation operations, and students' ability to solve complex engineering problems requires more systematic training. Fourth, the quality assurance system for talent cultivation needs to better incorporate industry feedback, competency attainment evaluation, and continuous improvement mechanisms. Therefore, guided by the philosophy of Emerging Engineering Education, it is necessary to reconstruct the applied talent cultivation system for civil aviation transportation and develop a training framework that is more responsive to industrial transformation, technological innovation, and the evolving needs of civil aviation operations.

2 PRACTICAL RATIONALE FOR TALENT CULTIVATION REFORM IN CIVIL AVIATION TRANSPORTATION

2.1 Industrial Transformation and the Demand for Interdisciplinary Competence

The civil aviation transportation program directly serves the development of China's integrated transportation system and the national strategy of building a strong civil aviation sector. With the advancement of smart air traffic management, low-altitude flight service support, and aviation operational safety governance, graduates are expected to possess not only professional knowledge of air traffic management, aviation regulations, flight performance, communication, navigation and surveillance, and aviation meteorology, but also broader competencies in data-driven analysis, system modelling, digital platform operation, teamwork, and risk control. Therefore, the goal of talent cultivation should be extended from meeting basic occupational requirements to supporting the digital, intelligent, and collaborative transformation of the civil aviation industry.

2.2 New Engineering as a Framework for Educational Reform

New Engineering education emphasizes interdisciplinary integration, industry collaboration, practice-based innovation, and sustainable development. For the civil aviation transportation program, New Engineering does not simply mean adding several information technology courses to the existing curriculum. Rather, it requires the systematic reconstruction of both the knowledge system and the practical training system around authentic operational scenarios. This involves the organic integration of air traffic operation rules, aviation safety management, complex systems engineering, artificial intelligence and data analytics, virtual simulation training, and industry standards and regulations. Such integration helps students develop a holistic understanding of complex operational systems and strengthens their ability to design engineering solutions for real-world civil aviation problems.

2.3 Industry-Oriented Education as a Practical Foundation

The reform is also built upon a solid foundation of industry-oriented education. Supported by the national first-class undergraduate program in transportation, engineering education accreditation, and long-standing experience in civil aviation education, the university has established relatively mature teaching teams in air traffic management, flight dispatch, aeronautical information services, and low-altitude operations. It has also developed various experimental and practical training platforms and a sound basis for university–industry collaboration. The in-depth participation of industry instructors in simulator-based teaching, curriculum development, and practical training provides favorable conditions for advancing an integrated cultivation model that combines degree education, job competency development, and engineering innovation capability. This foundation is consistent with the broader reform logic of application-oriented undergraduate education under Emerging Engineering Education, which emphasizes the coordinated reconstruction of talent cultivation objectives, curriculum systems, practical teaching, and institutional support in response to industrial transformation [8].

3 OVERALL FRAMEWORK FOR TALENT CULTIVATION REFORM IN CIVIL AVIATION TRANSPORTATION UNDER EMERGING ENGINEERING EDUCATION

The reform of talent cultivation in civil aviation transportation follows an educational orientation that is industry-oriented, industry-supported, and industry-serving. Guided by the principles of student-centered education, outcome-based education, and continuous improvement, and supported by engineering education accreditation and first-class undergraduate program development, the reform proposes a cultivation framework built on strategic guidance, industry–education integration, digital-intelligent empowerment, and continuous improvement. The key objective is to align national strategic needs, industry operational standards, authentic engineering scenarios, and students' competency attainment. In doing so, the reform aims to promote three fundamental transformations: from knowledge transmission to competency development, from university-centered education to university–industry collaborative cultivation, and from single-position training to the development of integrated engineering competence.

In terms of cultivation objectives, the reform centers on the applied talent profile of understanding operations, strengthening practice, enabling innovation, and safeguarding safety. On this basis, three progressive cultivation pathways are established: engineering application-oriented talent, engineering technology-oriented talent, and engineering science-oriented talent. The first pathway emphasizes operational competence and standardized task execution; the second focuses on system analysis, operational support, and technological application; and the third highlights complex problem investigation, methodological and model innovation, and the transformation of emerging technologies into practical applications. These pathways are not separate or isolated tracks. Instead, they are built upon a shared professional foundation and support differentiated student development through curriculum modules, practical projects, industry mentoring, innovation training, and graduation design.

In terms of competency structure, the reform highlights five core competencies. First, students should be able to understand civil aviation operational rules and identify safety risks. Second, they should be able to analyze complex engineering problems in scenarios such as air traffic management, flight dispatch, aeronautical information services, and low-altitude operations. Third, they should be able to carry out engineering practice by using simulators, virtual simulation platforms, and real operational data. Fourth, they should develop competencies in multi-stakeholder coordination, standardized radiotelephony communication, emergency response, and team-based decision-making. Fifth, they should acquire the ability to learn emerging technologies, integrate interdisciplinary knowledge, and pursue continuous improvement. Through this reconstruction of the competency system, students are expected to better meet the evolving requirements of operational, technical, and managerial positions in the context of smart civil aviation. The overall reform framework is shown in Figure 1.

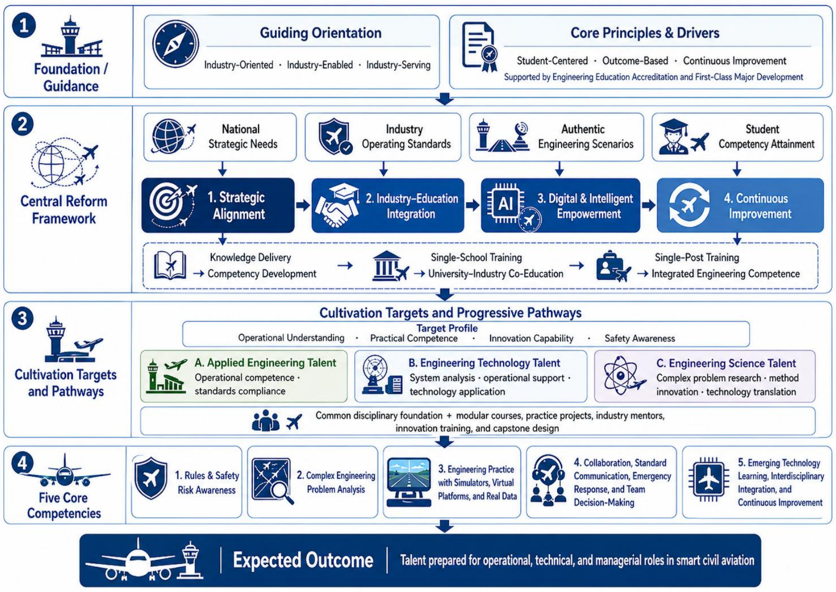

Figure 1 Overall Framework for Talent Cultivation Reform in Civil Aviation Transportation under Emerging Engineering Education

4 PRACTICAL PATHWAYS FOR TALENT CULTIVATION REFORM IN CIVIL AVIATION TRANSPORTATION

4.1 Developing a Multi-Stakeholder Collaborative Education Mechanism Driven by Industry–Education Integration

In response to the strategic goals of building a strong civil aviation sector and a strong transportation system, the university has established a collaborative education mechanism involving industry, academia, research, application, and administration. This mechanism brings together air traffic management authorities, airlines, airports, industry associations, and training resources related to the International Civil Aviation Organization. Industry partners are engaged in the formulation of training objectives, curriculum optimization, practical training, and quality evaluation, thereby promoting closer alignment between talent cultivation standards and job competency requirements, between course content and operational regulations, and between practical projects and authentic industry scenarios. Recent studies on modern industrial colleges have shown that multi-stakeholder co-construction, shared governance, and iterative collaboration are important organizational approaches for aligning talent cultivation with industrial innovation and urgent workforce needs [9].

The university has also invited experienced frontline civil aviation instructors to participate in practical teaching in areas such as airport control, radar control, procedural control, and airline operations control. Through their involvement, operational requirements, working procedures, professional culture, and safety discipline are integrated into classroom teaching and practical training, making the cultivation process more responsive to real civil aviation operations. Such a mechanism also reflects the evolving role of industry–education integration in Emerging Engineering Education.

4.2 Reconstructing a Curriculum System Oriented Toward Complex Engineering Problems

The curriculum reform is designed to integrate national educational standards, industry requirements, and engineering education accreditation criteria. A curriculum structure has been developed in which general education, professional core courses, engineering practice, smart civil aviation modules, and innovation and entrepreneurship training mutually support one another. From the perspective of engineering education redesign, complex engineering systems require deep integration rather than a simple linear arrangement of general education, professional courses, and practical training. Therefore, curriculum reform should strengthen the structural connection among disciplinary knowledge, engineering scenarios, design activities, and reflective assessment [10].

Professional core courses focus on fundamental competencies in air traffic management, aviation regulations, aviation meteorology, flight performance, communication, navigation and surveillance, air traffic control radar principles, aeronautical information services, and flight dispatch procedures. Extended modules strengthen students' understanding of big data, artificial intelligence, aviation operational data analysis, low-altitude traffic management, and smart air traffic management systems. Practical courses are organized around tasks such as air traffic control simulation, operations control, emergency response, aeronautical information processing, and low-altitude service support, thereby ensuring a continuous connection between theoretical learning and engineering application.

4.3 Building an Integrated Practice Platform Combining Virtual Simulation and High-Fidelity Simulation

Civil aviation transportation is characterized by complex operational scenarios, high safety sensitivity, and limited access to real operational training environments. Classroom instruction alone is therefore insufficient to support competency-oriented talent cultivation. To address this limitation, the university has relied on platforms such as the Transportation Navigation Experimental Center, the Airline Operations Control Virtual Simulation Experimental Teaching Center, and the Communication, Navigation and Surveillance Virtual Simulation Laboratory to develop a comprehensive practical training environment.

This environment includes a VR-based three-dimensional visualized training platform for airport tower control, a VR simulation platform for emergency drills, and a multi-runway panoramic tower simulator. Together, these systems support practical teaching in airport control, approach control, area control, operations control, emergency coordination, and low-altitude operations. Within safe, repeatable, and assessable simulation scenarios, students can undertake task-based training and progressively improve their situational awareness, conflict identification, command decision-making, collaborative communication, and post-task reflection capabilities.

4.4 Improving a Competency-Oriented Quality Evaluation and Continuous Improvement Mechanism

Based on the concept of outcome-based education, the program has established a clear mapping among training objectives, graduation requirements, course objectives, teaching activities, and assessment evidence. A dual-cycle evaluation mechanism involving both internal and external stakeholders is formed through student learning outcomes, simulation training data, course assessments, industry mentor evaluations, graduate follow-up feedback, and employer satisfaction surveys. This design is aligned with the quality assurance logic of engineering education accreditation, in which student-centered education, outcome-based orientation, and continuous improvement are regarded as key principles for promoting undergraduate education reform and improving talent cultivation quality [11].

When problems such as outdated course content, insufficient practical projects, or unsatisfactory competency attainment are identified, feedback is promptly incorporated into the revision of the training program, the updating of course resources, the improvement of platform functions, and the enhancement of teaching practices. This mechanism supports the dynamic optimization of the talent cultivation system. In addition, ideological and political education and civil aviation professional ethics are embedded into professional courses and simulation training, ensuring that safety awareness, professional responsibility, teamwork, and ethical conduct are integrated throughout the entire cultivation process.

5 REFLECTIONS ON THE REFORM AND DIRECTIONS FOR CONTINUOUS IMPROVEMENT

5.1 Strengthening Dynamic Responsiveness to Industry Needs

Civil aviation transportation is a highly industry-oriented discipline. Talent cultivation in this field should therefore be closely aligned with strategic priorities such as building a strong civil aviation sector, advancing smart civil aviation, developing the low-altitude economy, and promoting more refined airspace management. In future reform, a more systematic feedback mechanism should be established with the participation of industry experts, employers, graduates, and current students. Regular surveys should be conducted to identify evolving job competency requirements, and emerging technologies, updated standards, and new occupational demands should be incorporated into cultivation objectives, graduation requirements, and the curriculum system in a timely manner. This will further improve the alignment between talent cultivation and the evolving development of the civil aviation industry.

5.2 Deepening the Integration of Digital and Intelligent Technologies into Professional Courses

With the wider application of artificial intelligence, big data, digital twins, and virtual simulation in civil aviation, the curriculum system of civil aviation transportation needs to move beyond a traditional single-discipline knowledge structure. Future reform may focus on developing modular course clusters in areas such as smart air traffic management, aviation operational big data analytics, low-altitude traffic management, and risk assessment for complex operations. These course clusters should promote the deep integration of civil aviation expertise with information technology, systems engineering, and safety science.

At the same time, smart course development should serve as an important driver of curriculum reform. A comprehensive course resource system should be developed by integrating online learning resources, virtual simulation experiments, typical operational cases, intelligent assessment, and learning process analytics. Through this approach, courses can gradually shift from knowledge-based instruction to a data-driven, scenario-oriented, and competency-generating model.

5.3 Improving Competency Attainment Evaluation and Closed-Loop Improvement

Practical teaching is a key component of cultivating engineering application-oriented talent. In future reform, a progressive practical teaching system should be further strengthened, following the sequence of basic cognition, specialized training, integrated simulation, job-oriented practice, and innovation practice. Supported by virtual simulation platforms, high-fidelity simulation systems, real operational cases, and industry-based practice projects, students should be guided to move from mastering basic operational skills to solving complex operational problems. Teaching oriented toward complex engineering problem solving should further incorporate knowledge-construction scaffolds, reflective guidance, collaborative inquiry, and process-data-based feedback, so that students' problem-solving processes can be transformed into observable and improvable learning evidence [12].

Meanwhile, greater emphasis should be placed on the integrated use of training data, learning process records, industry evaluations, and graduate follow-up feedback. This will support a more accurate evaluation of competency attainment and help establish a closed-loop mechanism for continuous improvement.

6 CONCLUSION

In the context of Emerging Engineering Education, talent cultivation reform in civil aviation transportation is a systematic undertaking involving cultivation objectives, curriculum design, practical training platforms, teaching methods, quality assurance, and educational culture. Drawing on the reform practice of transportation programs in civil aviation-oriented universities, this study proposes a cultivation framework characterized by strategic guidance, industry–education integration, digital-intelligent empowerment, and continuous improvement. Within this framework, a reform pathway is developed through multi-stakeholder collaborative education, curriculum system reconstruction, virtual simulation and high-fidelity simulation support, problem-driven teaching, and the integration of ideological-political education with civil aviation professional ethics. This pathway provides a structured approach to strengthening students' complex engineering problem-solving ability, engineering practice and innovation competence, and adaptability to civil aviation positions. Overall, the proposed reform offers a practical reference for advancing civil aviation transportation programs under Emerging Engineering Education and for cultivating high-quality applied professionals who can meet the evolving demands of smart civil aviation and the low-altitude economy.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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COMPETINGINTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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