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Exploration of Talent-training Mode for Low-altitude Economy — Taking the Course of UAV Design and Development as an Example

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Abstract: The low-altitude economy has been included in the Government Work Report for three consecutive years and established as a new pillar industry. As its core carrier, unmanned aerial vehicle (UAV) makes the training of relevant professional talents of great strategic significance. At present, UAV-related courses in colleges and universities suffer from such drawbacks as low standardization of curriculum system, insufficient practical conditions and single evaluation method, which cannot meet the industry demand for compound innovative talents. By sorting out and comparing domestic and foreign research on teaching reform of UAV courses, this paper takes the course *UAV Design and Development* as a practical carrier, and constructs a four-in-one teaching-reform path of "project-driven approach, virtual-real integration, curriculum-competition integration, and industry-education collaboration". Implementation strategies are put forward from four aspects: curriculum standards, practical platforms, evaluation mechanisms and teacher team building. It breaks down barriers between theories and engineering applications, narrows the skill gap between talent cultivation and industrial demands, and facilitates high-quality development of the low-altitude economy.

Keywords: Low-altitude economy; Talent cultivation; UAV design and development; Teaching reform; Industry-education integration

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1. Introduction

The low-altitude economy is a comprehensive economic form featuring multidisciplinary joint development. It not only covers traditional general-aviation business forms, but also embeds service modes carried by unmanned aerial vehicles. Its development unlocks people's capacity for low-altitude flight, thus satisfying diversified demands brought by economic growth [1]. In fact, the low-altitude economy has been written into the Government Work Report for three consecutive years. It was first listed as a "new growth engine"

in 2024, positioned as an "emerging industry" in 2025, and further established as a "new pillar industry" in 2026. It also became a hot topic at this year's Two Sessions, fully demonstrating the consistency of national strategic orientation [2].

For the low-altitude economy, UAVs act as the most essential technical tool, just as automobiles serve the transportation industry. UAVs are mainly applied in logistics transportation, agricultural irrigation, power line inspection, environmental monitoring, emergency rescue and other fields, greatly improving operational safety and efficiency. While UAVs play key roles in numerous industries, higher requirements are raised for their load capacity, endurance performance and intelligence level, which in turn set higher standards for the professional competence of technicians engaged in UAV control, maintenance, research-and-development and innovation [3]. Against such background, as the core carrier for cultivating professional talents, the teaching quality of UAV courses exerts direct influence on the quantity and quality of talents supplied for the industry. Nevertheless, engineering courses currently still commonly prioritize theoretical lecturing over practical competence training. Consequently, students struggle to flexibly apply knowledge to design and research-and-development scenarios when confronted with complex engineering practice. Serving as a bridge connecting multidisciplinary knowledge, the course *UAV Design and Development* inherently features project-driven teaching and practice-oriented education. Therefore, research on teaching reform of UAV courses oriented toward demands of the low-altitude economy and exploration of effective ways to deeply integrate innovative practical sessions into course teaching carry important practical and strategic value [4].

2. Domestic and foreign research status

Centered on industrial development demands and teaching rules, domestic teaching-reform researches for UAV courses have yielded abundant achievements in teaching modes, curriculum systems, teaching technical resources and other dimensions, forming a multi-dimensional and multi-level research landscape covering primary education, secondary vocational education, higher vocational education, undergraduate education and military academies.

2.1. Domestic research status

2.1.1. Teaching mode reform

Teaching-mode reform constitutes one of the core directions of domestic UAV-course teaching reform. In vocational education, the project-based teaching method has been widely adopted. Based on the vocational competence model, Yu Long constructed the "UAV Application Technology: Campus Flight Series Teaching Projects" containing four teaching units: campus aerial photography, inspection, plant protection and mapping. Quasi-experimental studies verified that this mode can effectively improve students' vocational competence and satisfaction among enterprise employers [5]. The blended teaching mode also shows remarkable advantages in the secondary-vocational course *UAV Technology*. By integrating online theoretical learning and offline hands-on practice, Zhang Huan resolved the disconnection between theory and practice in traditional teaching and enhanced students' learning ability and practical proficiency [6].

Hao Liguo carried out teaching-reform practice for the course *Application of UAV Technology* based on the EPIP teaching mode, emphasizing integration of engineering practice and project innovation. Yang Fan applied the GBL teaching method to secondary-vocational UAV practical-training courses, effectively stimulating students' learning interest and teamwork spirit. Within higher education, Wang Gang et al.

adopted problem-guided heuristic teaching in the course *Quadcopter UAV Control Theory and Design*. Students were divided into groups of three to five members to complete comprehensive projects ranging from modeling-simulation to hardware development through division-of-labor collaboration, which significantly enhanced students' engineering practical capabilities [7].

Diversified teaching modes have been explored for police-oriented UAV courses. Liu Shuangzhen proposed adopting receptive teaching for theoretical modules, self-study-plus-tutoring teaching for practical-training modules, and a combination of example-based teaching and inquiry-oriented teaching for practice modules. Via the teaching procedure of "question-hypothesis-reasoning-verification-summary-impro vement", deep integration between teaching and actual police operations was realized [8]. Military academies have developed distinctive teaching modes. Ma Xiaolin et al. constructed a three-stage progressive teaching mode of "principle teaching-specialized practice-equipment training". Relying on the trinity teaching environment consisting of information-based classrooms, teaching laboratories and specialized training rooms, students' theoretical foundation and hands-on capabilities were strengthened [9].

2.1.2. Curriculum system construction

Curriculum-system construction focuses on core logics including integration of "posts-courses-com petitions-certificates", vocational-competence orientation and interdisciplinary integration. From the perspective of comprehensive education via "posts-courses-competitions-certificates", Zhu Likai explored the talent-training mode for the UAV application-technology major. By integrating post requirements, course contents, skill-competition standards and vocational-certificate criteria, a modular curriculum system was built to achieve precise alignment between talent cultivation and industrial demands [10]. Targeting insufficient alignment between core courses and vocational standards, Yang Guowen put forward teaching-reform countermeasures such as curriculum-content optimization, teaching-method innovation and evaluation-system reconstruction [11].

Interdisciplinary curriculum systems represent an important exploration direction in higher-education research. Taking Jinling College of Nanjing University as a pilot site, Zeng Shuting et al. cooperated with the School of Information Science and Engineering, School of Media and Communication, School of Art, and School of Urban and Resource Sciences to build an interdisciplinary curriculum cluster centered on "intelligent journalistic UAVs". Course contents cover four major modules: basic theories, flight training, professional application and curriculum integration. Students from different faculties completed comprehensive projects collaboratively, which effectively improved their interdisciplinary application capabilities [12]. Jin Qichun proposed the talent-training mode of "three-dimensional integration, four-party linkage". Through coordination among universities, enterprises, industries and governments, a three-dimensional curriculum system covering theoretical knowledge, practical skills and professional literacy was established [13].

2.1.3. Teaching technology and resource development

Integration of virtual simulation and artificial intelligence with UAV courses has become a research hotspot. Fei Chen built a flight-training platform relying on virtual-simulation technology, solving bottlenecks of limited training-site conditions, equipment wear and safety risks in conventional practical training and providing a low-cost all-weather practical-training environment. Liu Shuangzhen applied flight simulators and virtual-reality technologies to police-UAV training, constructed virtual police scenarios for swarm-combat drill and improved training safety and efficiency.

Artificial intelligence empowers innovation of course contents. Li Chengcheng integrated intelligent algorithms and data analysis into UAV mapping courses to cultivate students' innovative capacity for intelligent mapping. Ding Hua explored a photogrammetry teaching mode combining UAVs with real-scene three-dimensional modeling to expand course application scenarios.

Development of teaching resources keeps advancing: Wang Gang's research team self-developed integrated hardware-and-software teaching aids to tackle deficiencies in flight-control teaching platforms. Ma Xiaolin attached importance to developing characteristic teaching textbooks matching post requirements and career-development demands. He Guang transformed scientific-research achievements such as neural-network-based navigation into classroom teaching resources.

Ideological and political education within courses also draws attention. Liu Yaohui integrated patriotism and professional-responsibility education into UAV aerial-survey courses. At the basic-education level, emphasis is placed on popular-science education. Xu Wenqun carried out UAV curriculum design based on the STEAM concept, while Han Lixiang developed UAV popular-science courses according to primary-school students' cognitive characteristics.

2.2. Foreign research status

Researches on teaching reform of foreign UAV courses started relatively early. Distinctive features are reflected in curriculum standardization, depth of technology integration, industry-university-research collaboration and safety education, forming relatively mature teaching systems. Researches mainly focus on higher education and vocational training.

2.2.1. Curriculum standards and systems

Foreign countries attach great importance to standardization construction of UAV courses and have established curriculum systems covering different skill levels and application fields. Led by industry associations with participation of colleges and universities, the United States, the European Union and other regions have formulated unified UAV-operation training standards and curriculum specifications. Course contents strictly align with civil-aviation-authority UAV-pilot competence models and industrial vocational standards.

Within higher education, foreign universities generally incorporate UAV courses into core curriculum systems for majors such as aerospace engineering, geographic information science and agricultural engineering. Curriculum design balances theoretical depth and practical application and stresses integration and application of interdisciplinary knowledge. Curriculum systems are usually divided into three tiers: basic theories, core specialized courses and practical application.

2.2.2. Teaching modes and innovations

Project-Based Learning (PBL) serves as the mainstream teaching mode for foreign UAV courses. Compared with domestic project-oriented teaching methods, foreign practice lays greater stress on introducing real-world industrial projects and fostering students' independent inquiry capabilities. Aiming at severe dropout rates among engineering students, Tauro F et al. carried out UAV project-based learning courses oriented toward real-world problems. By engaging students in actual UAV-application projects, students' learning motivation and engineering practical capabilities were effectively enhanced [14]. Application of virtual-simulation technologies is more mature. Tawfik A adopted software to construct virtual enterprise

project environments to facilitate implementation of project-based teaching for UAV courses and provide highly simulated practical-training scenarios for students [15].

2.2.3. Technology integration and industry-university-research collaboration

Teaching practice of foreign UAV courses closely follows cutting-edge technological progress and deeply integrates artificial intelligence, big data, Internet of Things and other new technologies into course contents. Advanced technologies including intelligent navigation, autonomous obstacle avoidance and intelligent data analysis are widely incorporated into application-oriented courses for UAV mapping, plant protection and inspection. Sankey J B et al. integrated UAV multispectral and structure-from-motion photogrammetry technologies into teaching, enabling students to master UAV application skills for rangeland ecological monitoring [16].

In-depth industry-university-research collaboration is implemented: enterprises participate in curriculum design, teaching implementation and assessment throughout the whole process by providing technologies, equipment and practical-training sites. Enterprise experts give in-class guidance for projects and bring cutting-edge industrial cases and engineering experience into teaching. Foreign UAV courses attach importance to safety-regulation education, with air-space management, flight safety and privacy protection set as core contents. The United States requires mastery of FAA air-space rules and passing assessments to obtain flight qualifications. The European Union prioritizes privacy protection and defines boundaries for legal flight activities.

2.3. Comparative analysis of domestic and foreign researches

Domestic and foreign UAV-course teaching share common features: consistent core objectives focused on improving teaching quality and cultivating industry-oriented professional talents; emphasis on integration of theory and practice to strengthen students' hands-on and innovative capabilities; converging technology-integration trends adopting virtual-simulation, artificial intelligence and other technologies to empower teaching and break limitations of traditional teaching resources and time-space constraints; industry-demand-oriented curriculum contents aligned with post and vocational standards to match talent cultivation with industrial application.

Obvious differences also exist between domestic and foreign practice. In terms of curriculum systems, foreign systems are led by industry associations and governments with high standardization, and courses connect with vocational certifications. Domestic curricula feature diversified design while standardization construction is still underway, with integration of "posts-courses-competitions-certificat es" and interdisciplinary development as major orientations. For safety education, foreign regulation-safety teaching runs through the whole teaching process supported by complete assessment systems. Domestic safety-education contents are fragmented with insufficient hands-on training, and only partial characteristic curricula possess complete systems. In terms of research scope, foreign researches delve deeper into teaching of cutting-edge technologies such as UAV-system design and intelligent collaboration. Domestic researches yield abundant achievements in popular-science education and vocational-skill training, whereas high-level technical courses and interdisciplinary teaching in domestic universities remain in the exploratory stage.

Comparative analysis reveals four prominent deficiencies in domestic teaching: insufficient standardization of curriculum systems and inadequate connection with industrial demands; shortcomings in practical conditions including training hardware and virtual-simulation platforms; teachers' insufficient

engineering-practice and interdisciplinary teaching competence; single-dimensional evaluation with inadequate process assessment and insufficient enterprise participation, which cannot comprehensively evaluate students' comprehensive capabilities.

3. Teaching-reform path for UAV courses oriented toward the low-altitude economy

Based on experience summarized from domestic and foreign researches and above problem analysis, taking the course *UAV Design and Development* as the reform carrier, this paper puts forward a four-in-one teaching-reform path of "project-driven approach, virtual-real integration, curriculum-competition integration, and industry-education collaboration". Systematic promotion is conducted from four dimensions: curriculum standards, practical platforms, evaluation mechanisms and teaching staff.

3.1. Construct project-driven curriculum system

Drawing lessons from foreign curriculum standards and domestic concepts of "posts-courses-competitio ns-certificates", traditional chapter-based lecturing is restructured into a project-oriented system centered on the whole UAV-development workflow. Five modules are established: overall design, aerodynamic simulation, flight-control algorithm, prototype manufacturing, and joint commissioning-and-testing, with project milestone checkpoints set up. Low-altitude application tasks are assigned within the overall-design module to guide students to complete parameter design by synthesizing multidisciplinary knowledge. For flight-control-algorithm sessions, modeling, simulation and automatic code generation are completed via MATLAB/Simulink to realize transformation from control theories to embedded codes. Civil-aviation airworthiness specifications for light-and-small UAVs are integrated into the course. Students are required to conduct system safety and reliability assessment in design reports to foster awareness of engineering compliance.

3.2. Build virtual-real integrated practical-teaching platform

Relying on virtual-simulation technologies, a two-tier practical-training system of "virtual pre-research plus physical verification" is constructed to break constraints of sites, equipment and safety risks. At the virtual tier, UAV digital-twin models are built based on Modelica to simulate extreme working conditions such as stall and power failure, supporting low-cost trial-and-error practice. At the physical-testing tier, standardized hardware platforms are equipped. Students import simulated parameters into real UAV prototypes and carry out hover, wind-resistance and route-flight tests. They compare gaps between simulated and measured data, perceive discrepancies between theoretical models and engineering reality, and develop rigorous engineering thinking.

3.3. Implement curriculum-competition integrated innovation-competence cultivation mechanism

Aligning with aircraft-design competitions, the "Internet +" Innovation and Entrepreneurship Competition and other contests, a mode of promoting competition via learning and verifying learning via competition is constructed. Competition indicators for load capacity, endurance and precision are adopted as key assessment criteria for course comprehensive assignments. Under given constraint conditions, students

complete configuration design, component machining and system integration. Pressures from project cycles cultivate their teamwork and project-management capabilities. Students are encouraged to conduct secondary development for projects oriented toward low-altitude scenarios. Under guidance by dual university-enterprise supervisors, excellent achievements can be used for patent applications and business-plan composition, promoting innovative transformation of learning outcomes.

3.4. Deepen industry-education-collaborated university-enterprise cooperation mode

Cooperating with aerospace enterprises and research institutes, real-world enterprise engineering problems are introduced as comprehensive-design topics for the course to implement real-project practice. Enterprises provide measured data, cost constraints and process constraints. Students propose optimization schemes and deliver defense presentations before enterprise technical teams. Hierarchical guidance by dual university-enterprise supervisors is implemented: enterprise engineers participate in scheme evaluation, bringing engineering feasibility and cost control into assessment items. Enterprise experts deliver special lectures to continuously bring cutting-edge industrial technologies and engineering challenges into classrooms and ensure teaching keeps pace with industrial demands.

3.5. Improve multi-dimensional process-oriented evaluation system

Targeting drawbacks of the original single-mode evaluation system, a multi-subject whole-process assessment scheme is constructed: theoretical knowledge accounts for 20 %, project-process documents for 30 %, physical-prototype demonstration for 30 %, and defense presentation for 20 %. Enterprise supervisors take part in prototype evaluation and defense assessment. Industrial evaluation indicators including engineering feasibility, innovation and cost control are introduced. Phased reviews are arranged at each project milestone to record students' process performance such as teamwork and problem-solving capacity. Formative assessment is emphasized, and practical-training assessment criteria are unified with reference to competition scoring standards.

3.6. Strengthen construction of dual-competency teaching staff

Aiming at teachers' insufficient engineering-practice and interdisciplinary teaching capabilities, full-time teachers are arranged for enterprise secondment to accumulate engineering experience by participating in UAV research-and-development projects. Enterprise technical experts are recruited as part-time instructors to take part in curriculum construction and project guidance. An on-campus interdisciplinary teaching-research mechanism is established. Teachers majoring in mechanics, control science and information science conduct collaborative lecturing and joint project supervision. Via the strategy of "going out, bringing in experts, and interdisciplinary collaboration", a dual-competency teaching team with solid theoretical foundation and rich engineering-practice experience is built.

4. Conclusion

Based on talent-cultivation demands of the strategic emerging low-altitude-economy industry, this paper sorts out and compares domestic and foreign researches on UAV-course teaching reform, and identifies core domestic problems including insufficient curriculum-system standardization, deficient practical-training conditions and single evaluation mechanisms. Taking the course *UAV Design and Development* as the carrier,

drawing on advanced foreign teaching experience while combining domestic education characteristics, this paper proposes the four-in-one teaching-reform path of "project-driven approach, virtual-real integration, curriculum-competition integration, and industry-education collaboration". Barriers between theoretical knowledge and engineering application are broken through improvement of curriculum systems, practical platforms, evaluation mechanisms and teaching-team building. In the future, cutting-edge teaching contents will be dynamically updated and university-enterprise industrial linkage will be further deepened to continuously deliver high-quality specialized talents for high-quality development of the low-altitude economy.

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