World Journal of Educational Studies
Print ISSN: 2959-9989
Online ISSN: 2959-9997
DOI: https://doi.org/10.61784/wjes3062

CONSTRUCTION AND PRACTICE OF "POST-COURSE-COMPETITION-CERTIFICATE" TALENT TRAINING MODE FOR INTERNET OF THINGS APPLICATION TECHNOLOGY MAJOR FOR INTELLIGENT CIVIL AVIATION

YuTong Chen
Guangzhou Civil Aviation College, Guangzhou 510403, Guangdong, China.
Corresponding Email: chenyutong@gcac.edu.cn

Abstract: Against the backdrop of accelerated development in smart civil aviation, the aviation industry urgently requires interdisciplinary technical professionals who combine core IoT capabilities with aviation industry expertise. This study examines talent cultivation pathways for IoT professionals in smart aviation through the talent development framework of Guangzhou Civil Aviation Vocational College's IoT Application Technology program. The analysis systematically explores five dimensions: professional positioning, curriculum design, practical training, faculty development, and quality assurance. Research findings indicate that implementing a model anchored by industry demands, using job requirements to guide curriculum design, integrating virtual and real-world training systems, ensuring teaching quality through dual-teacher teams, and adopting a closed-loop evaluation system can effectively cultivate high-caliber professionals qualified for IoT equipment maintenance, logistics system operations, and intelligent system integration roles. These insights provide practical references for cultivating aviation-related technical talents in vocational education.
Keywords: Smart civil aviation; Internet of Things application technology; Higher vocational education; Post-course competition certificate; Talent training mode

1 INTRODUCTION

1.1 The Construction of Smart Civil Aviation gives rise to the Demand for Talents

The "14th Five-Year Plan for Civil Aviation Development" explicitly states that "the construction of smart civil aviation should lead the way in deeply integrating new technologies with aviation," positioning IoT technology as the core supporting solution for smart airports, intelligent logistics, and aviation security systems[1]. By 2024, China's major airports with annual passenger throughput exceeding 10 million had achieved 100% IoT coverage in baggage sorting systems and over 85% adoption of smart terminal equipment. However, the industry faces a talent shortage of 12,000 professionals in civil aviation IoT, with over 60% of positions requiring equipment maintenance and system integration expertise. Traditional IoT programs predominantly focus on general domains, lacking adaptation to specialized aviation equipment (e.g., Bag Handling Systems, BHS), industry standards (e.g., Civil Aviation Cybersecurity Protection Level 2.0), and operational protocols (e.g., airport equipment inspection guidelines). This gap results in graduates requiring extended adaptation periods to their roles and diminished competitiveness within the aviation sector.

1.2 Vocational college construction needs to strengthen industry characteristics

The core mission of higher vocational education is to cultivate technical professionals who are "positionally competent and capability-aligned." Civil aviation vocational colleges' Internet of Things (IoT) Application Technology programs must transcend the superficial integration model of "general technology + basic industry case studies," establishing a talent development system that "integrates civil aviation characteristics throughout the entire educational journey." The IoT Application Technology program at Guangzhou Civil Aviation Vocational College (hereafter "the Program") adopts a "service-oriented smart aviation" positioning[2]. By precisely aligning with aviation industry job requirements, restructuring curricula, and deepening industry-academia collaboration, it pioneers a distinctive training approach that combines "aviation expertise with IoT technology." This initiative holds research value as a replicable and scalable practical model for similar programs.

2 PROFESSIONAL POSITIONING: ANCHOR THE CORE POSITION GROUP OF SMART CIVIL AVIATION

2.1 Precision of career orientation

The program is designed to meet the industrial demands of aviation transportation (56) and computer, communication, and other electronic equipment manufacturing (39), establishing three core occupational categories and job clusters to form a three-tier positioning system of "industry-occupation-position" (Table 1)[3]. Compared with general IoT specialties, the job positions emphasize "civil aviation-specific attributes": For instance, "Civil Aviation IoT Equipment Maintenance Technicians" must master flight dynamic data transmission protocols (e.g., MQTT QoS classification) and flight data encryption standards (AES-256); "Airport Logistics System Maintenance Technicians" need expertise in baggage sorting system (BHS) and AGV vehicle civil aviation adaptation technologies; "Intelligent System Integration Engineers" must comply with CAAC-145 equipment installation and debugging specifications to ensure talent cultivation perfectly aligns with job requirements.

Table 1 Career orientation of Internet of Things Application Technology Major

Major category (code) of the major	Professional category (code)	Corresponding industry	Main occupational categories	Main job category (or technical area)	Examples of vocational qualification or skill level certificates
Electronic and Information (51)	Electronic information (5101)	Air transportation (56); Computer, communications and other electronic equipment manufacturing (39)	Internet of Things Engineering Technician (2-02-38-02)	Civil aviation Internet of Things equipment operation and maintenance technician; Airport logistics system operation and maintenance technician; Intelligent system integration engineer	Computer technology and software professional technical qualification certificate (primary, intermediate); Internet of Things single chip application and development vocational skill level certificate (primary, intermediate); electrician certificate (primary)

2.2 Differentiated Training Objectives

The program clearly defines the educational objective of "cultivating both moral integrity and technical expertise while integrating job certifications with professional development". Building upon general competencies, it emphasizes three distinctive civil aviation capabilities: First, industry literacy competence − instilling a professional ethos of "respect for life, adherence to regulations, and dedication to duty" through mastery of aviation safety protocols and cybersecurity standards. Second, specialized technical competence − acquiring expertise in selecting, installing, commissioning, and maintaining IoT equipment for aviation (e.g., runway object detection radars, baggage RFID tags). Third, complex problem-solving competence − developing the ability to resolve unique aviation challenges such as baggage sorting system failures during peak hours or IoT node disruptions during extreme weather[4]. This approach cultivates versatile professionals who are "technically proficient, industry-savvy, and capable of hands-on implementation".

2.3 Concrete Training Specifications

The program establishes concrete training specifications across three dimensions: quality, knowledge, and competency, with "civil aviation characteristics" consistently emphasized[5]. The quality requirements highlight "mastering civil aviation cybersecurity standards and adapting to smart airport operational rhythms." The knowledge requirements specify "proficiency in civil aviation-specific wireless network technologies and flight data encryption standards." Competency requirements detail "equipment operation capabilities compliant with CCAR-25 standards and fault maintenance competencies meeting CAAC-145 requirements," forming a training framework that combines "universal specifications with civil aviation-specific features."

3 CURRICULUM SYSTEM: BUILDING A CIVIL AVIATION CHARACTERISTIC CURRICULUM GROUP INTEGRATING "POST, COURSE, COMPETITION AND CERTIFICATE"

3.1 The Design Logic of Curriculum System

The program employs the "Job Task Analysis Method," starting with typical work tasks of three core positions to identify professional competencies and design a curriculum system through reverse engineering (Figure 1). For example, the typical tasks of an "Airport Logistics System Operations Technician" include "Baggage Sorting System Inspection," "RFID Equipment Deployment," and "SCADA System Monitoring." These are then broken down into specific skills: "Sensor Calibration Competency,"[6] "Industrial Communication Protocol Application Skills," and "Data Analysis Skills." This approach enables the development of courses like "Airport Smart Logistics Information Technology," "IoT Wireless Communication Technology," and "Database Technology and Applications," achieving precise alignment between "job requirements, professional competencies, and curriculum content."[7]

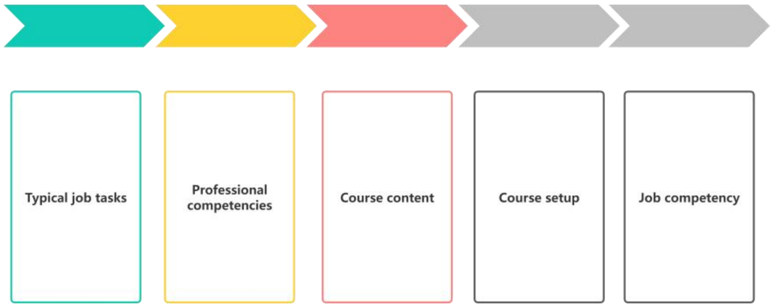

Figure 1 Curriculum System Design Logic Diagram

3.2 Specialized Setting of Curriculum Modules

The program divides the course into four modules: public basic course, professional course, comprehensive quality and ability course, and concentrated practice course. Among them, "civil aviation characteristics" runs through all modules, forming a four-level curriculum system of "foundation + core + expansion + practice"[8].

3.2.1 Public basic courses: integration of civil aviation literacy education

Breaking through the "general applicability" limitations of core public courses, we have introduced aviation-specific elements: The "Current Affairs and Policies" course features a "Smart Aviation Development Special Topic," demonstrating IoT technology applications in airport construction. The "Labor Education" program organizes hands-on tasks like simulated baggage sorting system maintenance and sensor calibration through practical airport equipment operation training. The "Military Theory" module integrates aviation security knowledge, explaining how IoT alarm systems work in airport perimeter protection. The "Career Development" section invites technical directors from aviation IoT companies to conduct career lectures, helping students clarify industry development paths and cultivate professional identity[9].

3.2.2 Professional courses: focus on key civil aviation technologies

Specialized courses are divided into specialized basic courses, core courses and extended courses, forming a curriculum structure of "general technology to lay the foundation and civil aviation technology to strengthen the characteristics":

Core Curriculum: The program features foundational courses such as "Fundamentals of Circuits", "Electronic Technology", and "Microcontroller Principles & Applications"[10]. Through the "Smart Electronics Project for Freshmen" course, students are required to develop aviation-related projects including a "Airport LED Flight Information Display Simulation System" and a "Simple Luggage Tag Reader Prototype", bridging basic technical knowledge with real-world industry applications.

Core Professional Courses: The seven core courses incorporate distinctive civil aviation content (Table 2). For instance, "Internet of Things Information Security Technology" not only covers general data encryption techniques but also emphasizes the access control requirements for terminal devices under Civil Aviation Cybersecurity Protection Level 2.0, along with practical implementation of flight data encryption using AES-256. The course "IoT Protocol Principles and Applications" features optimized instruction tailored to aviation scenarios, including Quality of Service (QoS) tier configuration for MQTT protocol in flight status information transmission, and practical applications of CoAP protocol in airport low-power sensor networks[11].

Specialized Extension Courses: The program offers courses such as "Civil Aviation Low-Altitude Intelligent Link Technology", "Hongmeng Application Development", and "Artificial Intelligence Technology Applications", covering emerging fields in smart civil aviation. The course "Civil Aviation Low-Altitude Intelligent Link Technology" explains drone applications in airport logistics and runway inspections, including low-altitude traffic management and aviation regulation compliance[12]. The course "Artificial Intelligence Technology Applications" cultivates students' technological innovation capabilities through scenarios like baggage damage detection (using YOLO algorithm) and perimeter intrusion recognition (based on OpenCV).

Table 2 Comparison Table of Civil Aviation-specific Content in Professional Core Courses

Core Professional Courses	General Technical Content	Civil Aviation-Specific Content
Computer Networks	Network protocols, device configuration	Configuration of civil aviation-specific wireless networks (airport mobile communication private networks), optimization of flight data transmission networks
IoT Wireless Communication Technology	Wi-Fi, Bluetooth, LoRa technologies	Application of RFID in baggage tracking, deployment of ZigBee in airport sensor networks
Airport Smart Logistics Information Technology	Smart logistics system architecture	Maintenance of Baggage Handling System (BHS), scheduling of AGV (Automated Guided Vehicle) in airport cargo terminals
Operating System	Linux / HarmonyOS operation	Customization of Linux system for civil aviation IoT devices, permission management of flight data storage

Database Technology and Application	SQL language, data management	Optimization of airport baggage data storage and query, design of flight dynamic database
IoT Information Security Technology	Data encryption, firewall configuration	AES-256 encryption for flight data, access control of civil aviation terminal devices
IoT Protocol Principles and Application	MQTT, CoAP protocols	MQTT QoS hierarchical transmission of flight information, application of CoAP protocol in airport low-power devices

3.2.3 Centralized practice courses: strengthening job skills training

Practical courses account for 56.11% of the total class hours, and a three-level practical system of "basic training-professional training-post internship" is constructed to realize the skill progression from "simulation to reality, simple to complex":

Basic Practical Training: The "Primary Electrician Training" requires students to complete hands-on tasks such as "Airport Lighting Circuit Wiring" and "Civil Aviation Equipment Power Troubleshooting". Meanwhile, the "Electronic Technology Training" cultivates skills in electronic component soldering and circuit debugging through projects like "Audio Amplifier Construction" and "Traffic Light Circuit Assembly", laying a solid foundation for subsequent civil aviation equipment operation and maintenance[13].

Professional Training: The "Comprehensive Cabling Training" simulates airport terminal network cabling processes, including Ethernet cable installation, fiber optic cabling, and information outlet setup[14]. The "Airport Smart Logistics Information Technology Training" utilizes RFID readers and tags to simulate the entire baggage tracking process from check-in to loading. Through LiDAR testing, it evaluates AGV (Automated Guided Vehicle) obstacle avoidance and scheduling capabilities in airport cargo terminals, recreating authentic operational scenarios.

Internship Program: Supported by five off-campus training bases including Shenzhen Guangqi Advanced Institute of Technology and Guangzhou Xinguanglian Electronic Technology Co., Ltd., the program adopts a "3+8" internship model (3 weeks of orientation training + 8 weeks of on-the-job practice). The orientation phase helps students understand airport IoT system architecture and equipment layout. During the on-the-job phase, students participate in real-world tasks such as IoT equipment inspections, baggage sorting system maintenance, and flight data platform testing. With full guidance from corporate part-time instructors, this program achieves seamless integration between academic learning and workplace practice.

3.2.4 Deep integration of "position, course, competition and certificate"

The program integrates vocational skill level certificates and vocational skill competitions into curriculum teaching, forming a training mechanism of "integrating courses and certificates, promoting learning by competition":

Curriculum-Certification Integration: The core knowledge points of the "IoT Microcontroller Application and Development Vocational Skill Certificate" (Primary/Middle Level), such as microcontroller interface development and sensor data acquisition, are integrated into courses like "Microcontroller Principles and Applications" and "Python Intelligent Hardware Development". Meanwhile, the cybersecurity and database management components from the "Computer Technology and Software Professional Qualification Certificate" (Primary/Middle Level) are taught concurrently with courses including "IoT Information Security Technology" and "Database Technology and Applications". Students' certification pass rates are incorporated into course assessment scores[15].

Learning through Competitions: Transforming competition content from events like the "National College Students Electronic Design Competition" and "Civil Aviation IoT Technology Competition" into course projects, such as "IoT-based Airport Perimeter Security System Design", "Flight Data Collection & Analysis Platform Development", and "Luggage Tracking App Development". These team-based projects aim to enhance students' technical application skills and collaborative capabilities.

4 PRACTICAL TEACHING: BUILDING A "VIRTUAL AND REAL" CIVIL AVIATION TRAINING PLATFORM

4.1 On-Campus Training Base: Simulate the Real Scene of Civil Aviation

Relying on 8 on-campus training bases, the program builds a training environment with "full coverage of civil aviation scenarios and equipment technology benchmarking industry":

Specialized Training Zone Development: The "Electronic Circuit Assembly and Testing Training Base" will be equipped with aviation-grade electronic measurement instruments (e.g., network analyzers, oscilloscopes) for IoT device component testing. The "Comprehensive Communication Technology Training Base" will establish an airport IoT simulation system featuring baggage sorting models, flight information displays, and RFID scanning devices, enabling students to conduct equipment installation, debugging, and troubleshooting training[16]. The "IoT Security Training Area" will implement a test environment compliant with the "Civil Aviation Cybersecurity Protection Level 2.0" standard, allowing students to perform practical operations including flight data encryption, firewall configuration, and intrusion detection tasks.

Virtual Simulation Assistance: The "Airport IoT System Simulation Platform" is introduced to simulate complex scenarios such as equipment failures during extreme weather (e.g., heavy rain and dense fog) and logistics congestion during peak flight periods. Students can troubleshoot equipment malfunctions and optimize scheduling plans through the simulation software, effectively addressing the limitations of high-risk, high-cost practical training in real-world scenarios. Meanwhile, the "Microcontroller Virtual Simulation Software" and "IoT Protocol Simulation Tool" enable a closed-loop training system featuring "online preparation-offline practice-online review".

4.2 Off-Campus Internship Base: Realize "Work and Study Alternation"

The program has established in-depth cooperation with 5 civil aviation related enterprises to form a synergistic mechanism of "enterprise demand-talent training-employment delivery":

Base Construction Standards: Off-campus bases must possess civil aviation IoT-related operations (such as airport equipment maintenance and system integration), employ industry mentors with over five years of experience, and provide authentic work tasks[17]. For example, Shenzhen Guangqi Advanced Institute of Technology offers internship positions including low-altitude intelligent connectivity technology R&D and drone inspection equipment testing. Guangzhou Xinguanglian Electronic Technology Co., Ltd. arranges students to participate in airport monitoring equipment installation and debugging.

Internship Management Standards: In accordance with the "Regulations on Internship Management for Vocational School Students", a comprehensive management system has been established encompassing "internship agreements-safety training-process documentation-assessment and evaluation". Corporate mentors collaborate with school faculty to develop internship plans, conducting weekly online review sessions and monthly skill assessments. Upon completion of internships, enterprises submit "Position Internship Evaluation Reports" which are incorporated into students' graduation grades[18].

Employment connection mechanism: Students with excellent internship performance will be given priority by enterprises. In the pilot class of 2024,35% of students found employment through off-campus internship, and the job positions matched with their majors 100%. The average starting salary was 15% higher than that of general Internet of Things graduates.

5 Practical teaching: Introducing mathematical model to improve the accuracy of civil aviation training

In smart civil aviation IoT practical education, core metrics including equipment maintenance efficiency, system integration stability, and data transmission reliability require precise control through quantitative analysis. Building on typical job responsibilities outlined in talent development programs such as "Civil Aviation IoT Equipment Maintenance" and "Airport Logistics System Operations", we integrate three mathematical models: the "System Integration Reliability Assessment Model" for predictive maintenance, and the "Data Transmission QoS Optimization Model" for quality assurance. This approach embeds quantitative analysis capabilities into practical training, cultivating students' core competencies in "data-driven problem-solving and model-based decision-making". The dual skill development objectives of "practical operation + quantitative analysis" are thus effectively achieved.

5.1 Model Building

The mean time between failures (MTBF) of logical civil aviation Internet of Things equipment conforms to the exponential distribution, and its probability density function is:

$$f(t) = \lambda e^{-\lambda t}, t \geq 0 \tag{1}$$

Among them, λ is the failure rate (number of failures per unit time), and t is the equipment operation time. By collecting the historical fault data of the equipment, the value of λ can be calculated to predict the probability of failure of the equipment in the future period [t1, t2]:

$$P(t_1 \leq T \leq t_2) = e^{-\lambda t_1} - e^{-\lambda t_2} \tag{2}$$

5.2 Application of Practical Teaching

In the courses of "Electronic Technology Training" and "Civil Aviation Internet of Things Equipment Operation and Maintenance Training", the following teaching links are carried out with the RFID reader commonly used in airports as an example:

Data collection: Organize students to record the operation data of 10 RFID readers for three consecutive months, including normal operation time, fault occurrence time and fault type (such as communication interruption, reading failure), and collect a total of 28 valid fault data;

Parameter calculation: Calculate MTBF (mean time between failures) according to the data. The formula is

$$MTBF = \frac{\sum_{i=1}^{n} T_i}{n} \tag{3}$$

The MTBF of this model RFID reader is 180 hours, so the failure rate

$$\lambda = \frac{1}{MTBF} \approx 0.0056 \tag{4}$$

Fault prediction: Predict the probability of failure of a single RFID reader in the next 72 hours based on the model:

$$P(0 \leq T \leq 72) = 1 - e^{-0.0056\times72} \approx 1 - 0.66 = 0.34 \quad (5)$$

That is, the failure probability of the equipment in the next 72 hours is about 34%, and students need to make preventive operation and maintenance plans (such as replacing vulnerable parts in advance, strengthening operation monitoring) according to this;

Validation and Optimization: Continuously monitor equipment operational data, comparing predicted outcomes with actual failure occurrence times to adjust λ parameters (e.g., considering environmental temperature and usage frequency impacts on failure rates), thereby enhancing model accuracy[19]. Through this application, students not only acquire hands-on troubleshooting skills but also leverage mathematical tools to transition from "reactive maintenance" to "proactive prevention," aligning with aviation equipment operations' core requirements of "zero failures and high reliability."

5.3 System Integration Reliability Evaluation Model: Ensuring Stable Operation of Civil Aviation Intelligent

Systems The "Intelligent System Integration Engineer" position requires tasks such as integrating flight dynamic data with airport IoT platforms and connecting self-service check-in equipment with baggage handling systems. The reliability of system integration directly impacts airport service quality. The solution introduces serial system reliability models in courses like "IoT Protocol Principles and Applications" and "Airport Smart Logistics Information Technology," quantifying the stability of integrated systems to cultivate students' capabilities in system design and risk management. 1. Model Construction Logic Civil aviation intelligent integration systems (e.g., "self-service check-in-baggage weighing-RFID scanning-sorting and transmission" systems) are serial systems, meaning the entire system only operates normally when all subsystems function properly. Assuming the system contains n subsystems with reliability Ri (normal operation probability) for the i-th subsystem, the overall system reliability Rsys is calculated as:

$$R_{sys} = \prod_{i=1}^{n} R_i \quad (6)$$

In this case, the reliability of the subsystem Ri can be obtained through laboratory tests (e.g., probability of no failure for 100 hours of continuous operation) or calculated by referring to MTBF data provided by the equipment manufacturer.

6 SAFEGUARD MECHANISM: BUILDING A "FOUR-IN-ONE" QUALITY ASSURANCE SYSTEM

6.1 Faculty: Build a "Double-Qualified" Civil Aviation Teaching Team

The program builds a "school teachers + enterprise experts" dual-teacher team to ensure that the teaching content is synchronized with the industry technology:

Faculty Development at the School: Among its six full-time faculty members, all hold master's degrees or higher, with 83.33% holding senior professional titles. The "dual-qualified" faculty (certified as both academic and industry professionals) makes up 66.67% of the teaching staff. Notably, 50% have hands-on experience in civil aviation enterprises, including roles in airport baggage tracking system development and flight information platform construction. The school requires full-time faculty to complete at least one month of annual enterprise immersion, engaging in practical tasks like IoT equipment maintenance and system integration at airports to update technical expertise. Additionally, the school regularly organizes specialized training sessions on civil aviation IoT technology, inviting industry experts to deliver lectures on cutting-edge topics such as "Civil Aviation Cybersecurity Protection Level 2.0" and 5G applications in IoT systems[20].

Corporate Part-time Faculty Development: The seven corporate part-time instructors, all from aviation IoT-related enterprises, comprise 57% senior professionals. They primarily focus on practical course instruction and workplace internship guidance. For instance, senior engineers demonstrate troubleshooting procedures for baggage sorting systems during "Smart Airport Logistics Information Technology" training sessions. Industry experts deliver specialized lectures on "Low-Altitude Intelligent Connectivity Technologies in Civil Aviation", sharing real-world case studies of drone applications at airports.

6.2 Teaching Resources: Build a Digital Resource base with Civil Aviation Characteristics

Centering on the whole process of "teaching, learning, practicing and testing", the program will build a three-dimensional resource library covering teaching materials, digital resources and books:

Textbook Development: We prioritize textbooks on civil aviation IoT published within the past three years, such as "Practical Operations of Airport IoT Systems" and "Information Technology Applications in Civil Aviation Logistics". Through industry collaboration, we have developed a modular textbook titled "Civil Aviation IoT Equipment Troubleshooting Manual", which includes over 20 typical failure cases covering baggage sorting systems, flight information display systems, and other equipment. Each case study follows a structured format: "Fault Symptoms-Troubleshooting Steps-Solutions-Industry Standards", ensuring alignment with professional requirements.

Digital Resources: The institution has developed two university-level premium courses— "Principles and Applications of Microcontrollers" and "Fundamentals of Circuits" —along with six online courses, supported by teaching materials, video libraries, and question banks. Notably, the "Airport Smart Logistics Information Technology" course features over 30 practical videos demonstrating AGV operations and RFID device debugging, while the "IoT Information Security Technology" question bank incorporates exam questions aligned with civil aviation cybersecurity standards. Additionally, the establishment of the "Civil Aviation IoT Resource Platform" integrates industry standards (e.g., "Civil Aviation Cybersecurity Protection Level 2.0") and corporate case studies (such as Beijing Daxing Airport's IoT infrastructure development plan) to facilitate self-directed learning for students.

Library Collections: The library's professional book collection includes aviation-specific literature such as "Civil Aviation Internet of Things Security Technology" and "Smart Airport Construction Guide", subscribes to journals such as "China Civil Aviation News" and "Internet of Things Technology", and purchases the CNKI (China National Knowledge Infrastructure) "Civil Aviation Science and Technology" thematic database, which contains academic papers and patent documents on IoT applications in civil aviation, providing support for teaching by faculty and research by students[21].

6.3 Course Assessment: Implement the "Process + Result" of Multiple Evaluation

The scheme breaks the traditional assessment mode of "one final exam", establishes a diversified assessment system of "process evaluation + final evaluation", highlights "skill orientation and industry standards", and ensures that the evaluation results are highly matched with the job ability requirements.

6.3.1 Assessment content: meet the actual needs of the post

Theoretical course assessments are integrated with civil aviation industry standards and job responsibilities. For instance, the final exam for "Internet of Things Information Security Technology" uses "Flight Data Encryption and Terminal Access Control" as a practical task, requiring students to complete AES-256 encryption configuration and firewall rule settings according to the Civil Aviation Cybersecurity Protection Level 2.0 standard. The operational process and results account for 60% of the assessment score. The "Airport Smart Logistics Information Technology" exam adopts a project-based defense format, where students must submit a "Baggage Sorting System Troubleshooting Plan" covering fault localization, maintenance procedures, and compliance explanations. Industry mentors participate in evaluations and provide recommendations on industry applicability.

The practical course assessment emphasizes hands-on skill development. The "Primary Electrician Training" requires students to independently complete the "Airport Lighting Circuit Wiring and Fault Repair" task, with evaluation criteria including wiring compliance (meeting civil aviation electrical safety standards), troubleshooting efficiency, and tool proficiency. The "Comprehensive Cabling Training" simulates airport terminal scenarios, assessing students' Ethernet cable production accuracy, fiber optic splicing loss values, and information point deployment rationality. All practical outcomes must meet the fundamental technical specifications of civil aviation communication systems.

6.3.2 Assessment method: stratified and differentiated evaluation

Different assessment methods are adopted based on course categories: For general foundation courses, the evaluation system primarily combines "daily performance (40%) + final assessment (60%)". Courses incorporating civil aviation elements such as "Current Affairs & Policies" and "Labor Education" assess daily performance through industry case analyses and practical task completion. Core professional courses adopt a "process-based evaluation (50%) + final evaluation (50%)" model, where process-based evaluations cover classroom operations (e.g., MQTT protocol configuration), project reports (e.g., flight data transmission plan design), and team collaboration, while final evaluations focus on comprehensive skill assessments. Concentrated practical courses implement a "task completion (60%) + internship unit evaluation (40%)" system, where internship performance is assessed by corporate mentors based on work attitude, task quality, and safety compliance, supplemented by evaluations from campus instructors using internship logs and summary reports.

All course assessment results are based on the percentage system, and the five-level scoring method of "excellent, good, medium, pass and fail" is adopted for the assessment of courses. The corresponding scores are incorporated into the credit recognition system to ensure that the assessment results objectively reflect students' knowledge mastery and skill attainment.

6.4 Quality Control: Establish a Dynamic Adjustment Mechanism of "Closed-Loop Improvement"

The plan establishes a quality control system of "data collection, diagnostic analysis and continuous improvement" to ensure that the talent training process is always synchronized with the development needs of smart civil aviation.

6.4.1 Internal monitoring: multi-dimensional coverage of the whole teaching process

Classroom Teaching Process Monitoring: University and college-level administrators conduct no fewer than five monthly classroom inspections and lectures, focusing on evaluating the integration of aviation-specific content into course materials and ensuring standardized practical teaching practices. The Teaching Supervision Group regularly conducts unannounced classroom observations, reviews teaching progress and content against talent development plans, compiles the "Teaching Quality Supervision Report", and provides feedback to the academic department[18].

Student feedback mechanism: carry out student evaluation twice every semester, collect students' opinions on course content, teaching methods and practical arrangements through online platform, and make improvement plans within one week for problems such as "insufficient civil aviation technology cases" and "old practical equipment";

Data platform support: Relying on the "Quality Management System Information Platform" of the university, it collects data such as course assessment scores, completion rate of practical training tasks and certificate acquisition rate, and automatically generates professional running status analysis reports to provide data support for curriculum adjustment and resource optimization.

6.4.2 External evaluation: introduction of industry and third-party feedback

Industry Expert Involvement: A professional development committee has been established, comprising technical directors from civil aviation IoT enterprises, airport operation engineers, and academic researchers. The committee holds two annual meetings to review the job relevance of talent cultivation programs and the industry relevance of curriculum design. The 2024 revision incorporated expert recommendations to add a "Hongmeng Application Development" course while removing certain generic technical content that was deemed disconnected from civil aviation needs.

Graduate Follow-up Feedback: A graduate tracking mechanism was established, conducting surveys one year and three years after graduation to assess employers 'evaluations of graduates' "civil aviation technical application skills", "job adaptability speed", and "professional competence". The 2023 graduate survey revealed that 87% of employers believed students could "quickly master the operation and maintenance skills of civil aviation IoT equipment". In response to feedback regarding "insufficient complex system integration capabilities", the curriculum plan added an "integrated flight dynamic data with IoT platform" practical module to the "Intelligent System Integration Engineer" position course.

Third-party Evaluation: A professional assessment agency was commissioned to conduct an independent evaluation of talent development quality, establishing 20 indicators across three dimensions: "knowledge mastery", "skill application", and "industry relevance". The 2024 evaluation results showed that the core courses matched 92% of civil aviation job requirements, with 89% satisfaction in practical teaching. The improvement suggestions from the report were directly incorporated into the next round of talent development program revisions.

6.4.3 Dynamic adjustment: keep up with the technological changes in the industry

Full-time faculty members spend no less than one month annually in corporate internships, participating in projects such as IoT equipment upgrades and system renovations at airports. They transform cutting-edge topics like "5G Applications in Civil Aviation IoT" and "AI-Driven Baggage Sorting Technology" into practical course materials. The talent development program undergoes biennial revisions, with curriculum design and practical arrangements adjusted according to the China Civil Aviation Development Report and IoT Technology White Paper. This ensures continuous alignment of professional programs with evolving smart aviation technologies and evolving job requirements, establishing a closed-loop mechanism of "demand-driven cultivation, feedback, and improvement".

7 IMPLEMENTATION RESULTS AND PROSPECTS

7.1 Implementation Results

The talent training program of Internet of Things Application Technology in Guangzhou Civil Aviation Vocational and Technical College has shown significant industry adaptability and talent training advantages through the pilot (2023 and 2024 grades):

Improved skill attainment rates: In pilot classes, 95% of students obtained the "IoT Microcontroller Application and Development Vocational Skill Certificate" at the primary level, with 68% achieving intermediate certification − 20% higher than the general IoT major's average. The "Computer Technology and Software Professional Qualification Certificate" primary level acquisition rate reached 82%, while students secured three provincial awards in the National College Students Electronic Design Competition.

Optimization of employment quality: the employment rate of the class of 2023 graduates reached 98%, and the professional matching rate (positions related to civil aviation Internet of Things) reached 85%

7.2 Future Outlook

With the advancement of smart civil aviation construction to "a deeper level and a wider field", the application of Internet of Things technology in airport digital twin, low-altitude logistics, intelligent security and other fields will be further expanded, and the training of professional talents needs to be continuously optimized:

Integration of cutting-edge technologies: track the application trends of 6G and quantum communication in the field of civil aviation, and timely add "civil aviation quantum communication security" and "digital twin airport technology" course modules to train students to master the application ability of the next generation information technology;

Upgrading of practical training resources: 5 million yuan is planned to be invested in the construction of "Smart Airport Internet of Things Virtual Simulation Center" and the development of "Airport full-scenario Internet of Things system simulation platform", which simulates the whole process of digital operation and maintenance of baggage sorting, flight scheduling and perimeter security, so as to enhance the immersion and authenticity of practical training;

Deepening the collaboration between universities and enterprises: build "industry colleges" with more central civil aviation enterprises and leading Internet of Things enterprises to realize "joint curriculum construction, joint teacher training and joint project research", transform real projects of enterprises into teaching cases, and cultivate technical and skilled talents with more industry competitiveness.

8 CONCLUSION

The accelerated development of smart civil aviation requires professionals with both aviation-specific expertise and technical competencies in IoT application technologies. Guangzhou Civil Aviation Vocational College has established an innovative talent development framework for IoT application technology through "precise industry alignment, specialized curriculum design, integrated virtual-real training platforms, and enhanced quality assurance mechanisms". This "position-course-competition-certificate" integrated model effectively addresses longstanding issues in traditional programs, including insufficient industry relevance and skill gaps between academic requirements and workplace demands.

The implementation of this program demonstrates that vocational aviation IoT programs must consistently prioritize "industry service" as their core mission. By integrating aviation standards, job-specific requirements, and industry technologies throughout the talent development process, these programs can cultivate versatile professionals who are "knowledgeable in aviation, skilled in technology, and capable of practical application". Moving forward, as smart aviation technologies continue to evolve, the program framework requires ongoing dynamic adjustments. This approach will not only provide robust talent support for the digital transformation of the aviation industry but also establish replicable and scalable models for specialized development in similar vocational education programs.

COMPETING INTERESTS

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

FUNDING

This work was supported in part by Research on the Curriculum System Construction of IoT Application Technology under the Background of Smart Civil Aviation in the Teaching Guidance Committee Project of Education and Sports Majors in Guangdong Higher Vocational Colleges in 2024, and in part by Guangdong Provincial Education Science Planning Project under Grant 2024GXJK876, and in part by the Characteristic Innovation Projects of Ordinary Universities in Guangdong Province under Grant 2023KTSCX239.

REFERENCES

[1] Al-Dhaqm A, Ikuesan RA, Kebande VR, et al. Research challenges and opportunities in drone forensics models. Electronics, 2021, 10: 1519.
[2] Chen Y, Liu Y. Design and implementation of routing nodes in airport intelligent bird control system. Computer Applications and Software, 2020, 10.
[3] Shi X, Yang C, Xie W, et al. Anti-drone system with multiple surveillance technologies: architecture, implementation, and challenges. IEEE Communications Magazine, 2018, 56: 68–74.
[4] Zhang C, Li G, Lin J, et al. Design and experiment of intelligent bird repellent for farmland. Journal of Southwest Normal University (Natural Edition), 2016, 41(5): 81-87.
[5] Nowak A, Naus K, Maksimiuk D. A method of fast and simultaneous calibration of many mobile FMCW radars operating in a network anti-drone system. Remote Sensing, 2019, 11: 2617.
[6] Oh BS, Guo X, Wan F, et al. Micro-Doppler mini-UAV classification using empirical-mode decomposition features. IEEE Geoscience and Remote Sensing Letters, 2017, 15: 227–231.
[7] Torvik B, Olsen KE, Griffiths H. Classification of birds and UAVs based on radar polarimetry. IEEE Geoscience and Remote Sensing Letters, 2016, 13: 1305–1309.
[8] Wang M, Wu Q. Multi UAV collaborative airport bird drive task allocation. Journal of Jilin University (Information Science Edition), 2019, 37(1): 47-57.
[9] Ren J, Jiang X. Regularized 2D complex-log spectral analysis and subspace reliability analysis of micro-Doppler signature for UAV detection. Pattern Recognition, 2017, 69: 225–237.
[10] Redmon J, Divvala S, Girshick R, et al. Only look once: unified, real-time object detection, 2016. Available: http://pjreddie.com/yolo/
[11] Taha B, Shoufan A. Machine learning-based drone detection and classification: state-of-the-art in research. IEEE Access, 2019, 7: 138669–138682.
[12] Simonyan K, Zisserman A. Very deep convolutional networks for large-scale image recognition. International Conference on Learning Representations (ICLR), 2015.
[13] Tuchin VV. Polarized light interaction with tissues. Journal of Biomedical Optics, 2016, 21: 071114.
[14] Anwar MZ, Kaleem Z, Jamalipour A. Machine learning inspired sound-based amateur drone detection for public safety applications. IEEE Transactions on Vehicular Technology, 2019, 68: 2526–2534.
[15] Azari MM, Sallouha H, Chiumento A, et al. Key technologies and system trade-offs for detection and localization of amateur drones. IEEE Communications Magazine, 2018, 56: 51–57.
[16] Liu L, Li X, Nonaka K. Light depolarization in off-specular reflection on submicro rough metal surfaces with imperfectly random roughness. Rev Sci Instrum, 2015, 86: 023107.
[17] Fioranelli F, Ritchie M, Griffiths H, et al. Classification of loaded/unloaded micro-drones using multistatic radar. Electron Lett, 2015, 51: 1813–1815.

[18] Luo D, Xue Y, Deng X, et al. Citrus diseases and pests detection model based on self-attention YOLOv8. IEEE Access, 2023, 11: 139872–139881.
[19] Liu X, Wang Y, Yu D, et al. YOLOv8-FDD: A real-time vehicle detection method based on improved YOLOv8. IEEE Access, 2024, 12: 136280–136296.
[20] Huang T, Huang H, Li Z, et al. Citrus fruit recognition method based on improved YOLOv5 model. J Huazhong Agric Univ, 2022, 41: 170–177.
[21] Ye R, Shao G, He Y, et al. YOLOv8-RMDA: Lightweight YOLOv8 network for early detection of small target diseases in tea. Sensors, 2024, 24(9): 1424–8220.