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Construction of Teaching Mode for the Two-Dimensional Cognition Course of UAV and Logistics Equipment

Chaoru Wu, Xiangguo Tian*
School of E-commerce and Logistics, Chongqing Business Vocational College, Chongqing, China
**Corresponding Author*

Abstract: Driven by the rapid evolution of smart-logistics technologies and the vigorous growth of the low-altitude economy, the logistics industry is undergoing structural transformation from traditional equipment to intelligent equipment, which places compound requirements for technical-skill talents in terms of equipment operation capabilities and system collaboration capabilities. Nevertheless, current courses related to intelligent logistics equipment in higher vocational colleges generally suffer from problems such as one-sided cognitive dimensions and course content lagging behind technological iteration, making it difficult to meet the urgent demand for compound talents from the industry. Based on the teaching-reform practice of the course Cognition and Maintenance of Intelligent Logistics Equipment at Chongqing Business Vocational College, this paper systematically constructs a two-dimensional cognitive teaching mode for courses covering UAVs and traditional logistics equipment. Adopting the BAG analysis method to restructure the curriculum system, this mode forms a three-stage progressive framework of basic cognition, collaborative application and comprehensive practice. It develops virtual-real integrated teaching resources and introduces mixed-reality technology to support scenario-based teaching, builds a multi-dimensional evaluation system oriented toward collaborative operation capabilities, and realizes dynamic curriculum optimization relying on the school-enterprise collaboration mechanism. Practices show that the two-dimensional cognitive teaching mode effectively overcomes the limitations of single-equipment cognition, helps students establish systematic thinking for equipment collaboration, and provides a promotable practical paradigm for curriculum reform of intelligent-logistics-technology majors in higher vocational colleges.

Keywords: Two-Dimensional Cognition; Curriculum Reform; Intelligent Logistics; Higher Vocational Education

1. Research Background and Problem Orientation

With the further implementation of the National Vocational Education Reform Implementation Plan and the continuous revision of professional teaching standards for vocational education, the cultivation of technical-skill talents in the field of smart logistics has been elevated to a new strategic position. The Action Plan for Improving the Quality of Vocational Education clearly requires accelerating the cultivation of technical-skill talents adapted to new technologies, new business forms and new models, and specially emphasizes promoting the in-depth integration of new technologies such as artificial intelligence and the Internet of Things into professional teaching. Among more than 700 newly revised vocational-education professional teaching standards released by the Ministry of Education in 2025, intelligent-logistics technology has been formally incorporated into the standard system for production-service-related majors. It requires close alignment with the employment standards of industrial enterprises under new industries, new business forms, new models and new technologies [1,2], which provides clear directional guidance for the teaching reform of courses on intelligent logistics equipment.

From the perspective of industrial development, technological changes in the logistics industry are accelerating. The market scale of the smart-logistics industry keeps expanding, and new logistics equipment such as mobile collaborative robots, intelligent sorting equipment and unmanned delivery vehicles have achieved large-scale application. As a vital component of the low-altitude economy, low-altitude logistics is developing rapidly. The collaboration mode of UAVs and freight vehicles for the first-mile and last-mile delivery

makes logistics links more efficient [3]. Industry survey data indicate that the application of intelligent equipment including UAVs and automated guided vehicles keeps growing in warehousing and distribution, while traditional logistics equipment still occupies the major market share. Such an industrial pattern featuring mixed operation of intelligent and traditional equipment puts forward brand-new requirements for the competence structure of logistics talents: they shall not only proficiently operate single equipment, but also possess compound capabilities such as system integration, equipment operation-maintenance and human-machine collaboration [4].

Nevertheless, obvious lags exist in the teaching of intelligent logistics equipment in current higher vocational colleges. On the one hand, the traditional teaching mode categorized by equipment types fails to foster students' holistic cognition of the collaborative operation of intelligent systems. Students only master isolated knowledge of either traditional or intelligent equipment, resulting in fragmented professional knowledge. When facing complex operation scenarios such as UAV inventory combined with manual sorting, they show insufficient systematic thinking and collaboration competence. On the other hand, textbooks are updated slower than technological iteration; real enterprise cases are insufficient; teachers' knowledge structures are outdated. Most professional teachers have not received systematic training on intelligent logistics equipment. Teaching content is seriously disconnected from the latest development of the smart-logistics industry, and the skills mastered by graduates deviate significantly from the actual demands of employers [5]. The above-mentioned issues constitute the core proposition to be solved in this research.

2. Theoretical Foundation and Design Philosophy

The construction of this teaching mode is theoretically supported by the Cognitive Load Theory and the Dual-Coding Theory. The Cognitive Load Theory points out that learners possess limited working-memory capacity; teaching shall reduce extraneous cognitive load and optimize intrinsic cognitive load through reasonable knowledge organization and presentation. The Dual-Coding Theory emphasizes that visual processing and verbal processing of information function as two relatively independent channels. Memory and comprehension effects can be enhanced when information is presented via both channels simultaneously [6]. Based on the two theories, the two-dimensional cognitive teaching mode highlights two key points in its design. First, it presents a comparison between the intelligent features of UAVs and the mechanical features of traditional equipment to help students build a clear cognitive framework. Second, it adopts a four-step teaching method of explanation, demonstration, simulated practice and hands-on operation to realize cognitive progression from abstract concepts to embodied experience and thus reduce learners' cognitive load.

The design philosophy of the two-dimensional cognitive teaching mode can be summarized as three transformations. The first transformation is shifting from single-equipment cognition to systematic collaborative cognition. Traditional courses often teach UAVs, forklifts, automated guided vehicles and other equipment as independent knowledge modules, which leads to fragmented professional knowledge among students. The two-dimensional cognitive mode emphasizes cultivating students' systematic understanding of complex operation scenarios such as UAV inventory plus manual sorting and UAV delivery plus freight-vehicle transfer on the basis of equipment-feature cognition. The second transformation is shifting from static knowledge imparting to dynamic competence cultivation. Given the rapid technological iteration of smart logistics, course content shall keep pace with industrial development. The two-dimensional cognitive mode establishes a dynamic knowledge-updating mechanism, tracks new technologies such as intelligent obstacle avoidance, precision delivery and multi-UAV collaboration of UAVs, and incorporates new knowledge into teaching content in a timely manner. The third transformation is shifting from classroom-simulated teaching to production-education-integrated practice. Relying on in-depth school-enterprise cooperation, the two-dimensional cognitive mode integrates real enterprise business processes, project cases and technology applications into the whole teaching process, so as to effectively connect learning with front-line industrial practice [7].

3. Practical Path for Curriculum-System Restructuring

The BAG analysis method, namely the analysis of professional typical work tasks, is adopted as the methodological tool for curriculum-system restructuring [8]. A curriculum-development group consisting of in-school professional teachers and technical experts from JD.com has been formed. Through field investigations and expert seminars, typical work tasks for collaborative operations between UAVs and traditional logistics equipment are systematically extracted. The research team conducted investigations in real-work scenarios including the JD UAV Base and intelligent warehousing centers. Core work scenarios are identified: collaborative operation of UAV inventory and manual rechecking, connection operation of UAV delivery and freight-vehicle transfer, cooperation process of intelligent-sorting equipment and manual order-picking, and collaborative scheduling of automated high-rise warehouses and mobile robots. Each work scenario is further broken down into specific work tasks, with clear operation procedures, skill essentials and quality standards.

Based on the analysis of typical work tasks, the curriculum establishes a three-stage progressive framework: basic cognition, collaborative application and comprehensive practice. The first stage, the basic-cognition module, focuses on basic knowledge of UAVs and traditional logistics equipment. For the UAV dimension, it covers UAV structure and principles, flight-control systems, basic route planning and safety-operation specifications. For the traditional-equipment dimension, it involves the structure, principles, operation essentials and maintenance specifications of forklifts, pallets, automated high-rise warehouses and other equipment. Comparative teaching is applied to guide students to understand differences between the two types of equipment in technical features, applicable scenarios and operation requirements [9]. As the core link of two-dimensional cognition, the second-stage collaborative-application module centers on collaborative-work scenarios of the two kinds of equipment. It sets three training objectives: proficiency in equipment operation, system-maintenance competence and collaborative-innovation level, and matches corresponding typical work tasks. Each learning situation contains a complete action chain of planning, decision-making, implementation, inspection and evaluation to ensure high consistency between teaching content and real-work processes. The third-stage comprehensive-practice module integrates knowledge and skills from the previous two modules through project-oriented practice and comprehensive training. Divided into groups, students complete full-project tasks ranging from equipment selection and process planning to cost accounting, so as to sharpen their collaborative-operation capabilities in simulated or real-work scenarios.

The restructuring of the curriculum system is always benchmarked against the latest vocational-education professional teaching standards. The new standards require constructing modular and project-oriented curriculum systems and taking digitalization and artificial intelligence as important means to promote teaching-mode reform and improve teaching quality. Accordingly, the two-dimensional-cognition curriculum adopts modular design. Each module can dynamically adjust content in response to industrial-technology development to maintain its forward-looking nature and adaptability. Meanwhile, the curriculum attaches importance to practical teaching, whose class hours account for more than 50 % of total class hours [10].

4. Development and Implementation Path of Teaching Resources

To tackle practical difficulties such as insufficient physical equipment and inaccessible high-risk hands-on operations in traditional teaching, this research develops a three-dimensional teaching-resource system featuring virtual-real integration [11]. A dynamic case database collects real cases from enterprises such as JD.com, focusing on typical problems in collaborative operations between UAVs and traditional logistics equipment, including communication interruption, task conflicts and equipment failures. Each case contains structured information covering failure phenomena, diagnosis procedures, solutions and preventive measures, forming a closed teaching loop of case introduction, problem analysis, scheme design and implementation-verification. The mixed-reality training system integrates force-feedback handles and eye-tracking devices to enhance the sense of reality in operational training. The four-step teaching

procedure of explanation, demonstration, simulated practice and hands-on operation is implemented. Virtual reality is adopted for safety training of hazardous operations; augmented reality provides real-time guidance for conventional operations; physical equipment is used for intensive training of key skills. This design guarantees both teaching safety and authenticity of skill training [12]. Digital teaching resources include courseware, operation videos and three-dimensional models, together with audio-video materials, digital case databases and virtual-simulation software.

The curriculum is implemented relying on an in-depth school-enterprise-cooperation mechanism. The college and JD.com jointly build a dual-teacher teaching team, where senior JD technical experts participate in the whole process of curriculum development and practical-training guidance. In terms of faculty allocation, the teaching staff consists of in-school teachers and JD technical backbones. In-school teachers are responsible for theoretical teaching and curriculum design, while JD technical backbones serve as part-time teachers, bringing front-line work experience and cutting-edge industrial technologies into classrooms via lectures and practical-training guidance. This training mode featuring embedded curriculum, dual-teacher co-teaching and practical-combat empowerment ensures both in-depth theoretical teaching and practical teaching keeping up with industrial frontiers. A closed-loop management system covering demand analysis, curriculum development, teaching implementation, effect evaluation and continuous improvement has been established. Teaching content is updated each semester according to industrial-technology development and enterprise feedback so that the curriculum keeps pace with developments in the intelligent-logistics industry.

This study constructs a multi-dimensional evaluation system centered on collaborative-operation capabilities. Evaluation indicators cover three dimensions: proficiency in equipment operation, system-maintenance competence and collaborative-innovation level. The collaborative-innovation level mainly assesses students' problem-identification capacity, scheme-design competence and teamwork in multi-equipment collaboration scenarios. A third-party evaluation mechanism with enterprise participation is established: employer-satisfaction surveys are incorporated into curriculum-quality assessment. Tracking graduates' adaptability in posts concerning UAV-and-traditional-equipment collaborative-maintenance provides core evidence for curriculum optimization [13].

5. Practical Effects and Future Prospects

The two-dimensional cognitive teaching mode has been piloted in the course Cognition and Maintenance of Intelligent Logistics Equipment at Chongqing Business Vocational College. Practical results show obvious optimization in students' cognitive structures. The traditional single-equipment teaching mode easily leads to fragmented knowledge. By means of comparative teaching and training in collaborative scenarios, the two-dimensional cognitive mode helps students build a systematic cognitive framework of technical-feature matching, functional complementarity and system collaboration. Students demonstrate stronger systematic thinking and collaborative awareness when facing complex-operation scenarios. The alignment between skill cultivation and post requirements becomes more precise. With real enterprise cases and typical work tasks introduced, teaching content is highly consistent with actual industrial demands, and students' operational competence in typical scenarios such as UAV-freight-vehicle collaborative delivery and UAV-inventory plus manual rechecking has improved significantly. Breakthrough progress has been achieved in teaching-resource construction: a dynamic case database, mixed-reality training system and digital teaching resources have been developed, forming replicable and promotable teaching-resource packages.

Deficiencies exposed in practice call for continuous improvement. Developing and maintaining the mixed-reality training system incurs high costs and sets high requirements for technical conditions and teachers' competence. The depth and sustainability of school-enterprise collaboration need further enhancement, and mechanisms for enterprise experts to participate in teaching should be institutionalized. No mature quantitative tools are available for assessing the collaborative-innovation dimension in the evaluation system. Targeting the above-mentioned problems, follow-up research will explore lightweight virtual-simulation

teaching schemes to lower technical thresholds, build more stable school-enterprise-cooperation mechanisms to institutionalize enterprise experts' teaching participation, and develop standardized assessment tools for collaborative-operation capabilities to improve the multi-dimensional evaluation system.

Against the dual background of accelerated transformation in the smart-logistics industry and continuous updates to vocational-education professional teaching standards, the two-dimensional cognitive teaching mode for UAV-and-traditional-logistics-equipment courses responds to the industry's urgent demand for compound technical-skill talents. Restructuring the curriculum system via the BAG analysis method, supporting scenario-based teaching with virtual-real-integrated technologies, and guaranteeing dynamic curriculum updates through school-enterprise collaboration, this mode has preliminarily realized the transformation from single-equipment cognition to systematic collaborative competence. Admittedly, this mode remains in the exploratory stage and its effectiveness needs further verification in broader practice. Future research can be further deepened by expanding pilot scope, perfecting evaluation tools and promoting production-education integration, so as to generate more mature experience and paradigms for curriculum reform of intelligent-logistics-technology majors in higher vocational colleges.

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