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Research on the Construction of a Virtual Simulation Practice Teaching System for Airport Operations Based on the Concept of "Three Connections, Two Integrations, and Four Support"

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Abstract: *With the goal of cultivating learning ability, innovation ability, practical ability, and social adaptation ability, this paper proposes the design concept of the airport operation professional virtual simulation practice teaching system with "three connections" (connect with industry requirements, connect with enterprise production, connect with real-life enterprise scenarios); implements the design concept of the airport operation professional virtual simulation practice teaching strategy with "two integrations" (deep integration of virtual simulation teaching platform and virtual simulation teaching resources), and establishes security systems with "four support" (high-level teaching team, diversified assessment methods, systematic industry-education-research collaboration platform, stable and secure operational mode). It effectively solves the problems of the single functionality of the virtual simulation training platform, the insufficient integration of school-enterprise collaborative development of virtual simulation resources, the difficulties in implementing, observing, and reproducing practical teaching, and achieves a dynamic fit between the airport operation profession and industry development. It realizes the comprehensive integration of talent cultivation supply-side and industry demand structure in the airport operation profession.*

Keywords: *Virtual simulation; practice teaching; airport; platform*

Since the proposal of "smart airports" in 2011, airports have gradually started to promote smart construction and system intelligence upgrades. They actively introduce new technologies and equipment to enhance security and service efficiency, optimize passenger experience, and comprehensively improve the digitization level of airports in terms of smart operations, smart services, smart business, and smart management. With the construction of smart airports and the application of new technologies and concepts, airports have raised the standards for personnel selection in frontline technical positions, placing higher demands on the talent cultivation capabilities of civil aviation colleges. It calls for more applied talents with a "craftsman spirit". Cultivating a "craftsman spirit" and emphasizing practical training capabilities has become an urgent task. It is an organic combination of innovation awareness and hands-on capabilities and an indispensable pillar for enhancing students' practical training capabilities.

Virtual simulation experimental teaching is the deep integration of information technology and professional practical training teaching. It is an important part of the construction of informationization in higher vocational education. By organically integrating virtual simulation training equipment and facilities with virtual simulation experimental projects, it plays an important role in improving students' professional and innovative capabilities. Since 2011, in accordance with the concept of "smart airports," Guangzhou Civil Aviation Vocational College has been actively promoting the informationization construction and reform of experimental teaching. It fully utilizes modern computer technology, internet technology, virtual simulation technology, etc., to construct a complete system of virtual simulation practical teaching for the airport operation profession. It provides a three-in-one virtual simulation experimental teaching mode of "theory + simulation + practice" for the airport operation profession, deeply integrating practical teaching in the field of airport operation support with virtual simulation technology. It systematically promotes the informationization construction and reform and development of experimental teaching, and promotes the comprehensive improvement of talent cultivation quality. The airport operations professional virtual simulation training center has a total area of over 2,000 square meters and more than 300 training stations. It can meet the practical teaching needs of airport operation support-related majors, the technical research and development and verification needs in the field of airport operation support, the general education needs of other civil aviation-related majors, and the on-

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the-job training needs of airport staff. It was recognized as a provincial and ministerial-level virtual simulation training center in 2022.[1-2]

1. The construction concept of the virtual simulation teaching system for airport operation majors

After going through stages of development such as "electronic airports," "digital airports," and "smart airports," China's airports have gradually entered a new stage of development as "smart airports," relying on emerging technologies such as cloud computing, big data, the Internet of Things, and artificial intelligence. This allows the airports to have the capability of "sensing, analyzing, and feedback." "Smart airports" have put forward higher requirements for the comprehensive qualities and abilities of talent: the ability to perceive the airport's safety situation and risk control, the ability to manage the entire process of airport operations in a refined manner, and the ability to digitize the level of airport service operation management. This new requirement has made it important to cultivate practical skills, enhance collaborative capabilities, develop innovative thinking, improve innovation abilities, cultivate independent learning abilities, enhance the dimension of professional knowledge, which has become an important direction for talent cultivation. In response to this change, the school has been based on the concept of "smart airports" since 2011, integrating airport operation majors with relevant disciplines, continuously expanding the knowledge dimension of professional talents, promoting the cross-penetration of basic vocational abilities, professional knowledge abilities, and self-development and innovative abilities. The focus is on cultivating learning abilities, innovative abilities, practical abilities, and social adaptability. In response to the new requirements of talent cultivation brought about by airport smartization, we rely on new-generation information technologies such as virtual reality and artificial intelligence to deeply integrate information technology and practical teaching, and construct a virtual simulation practice teaching system based on three connections, two integrations, and four support.

2. The construction content of the virtual simulation teaching system for airport operation majors

2.1 Establish a systematic virtual simulation practical teaching hardware platform

The hardware platform for virtual simulation practical teaching of airport operation majors aims to achieve full-process work positions for airport flight operation support. It focuses on the simulation and training of job positions throughout the entire process, such as aircraft operation command, apron control, flight area support, and airport ground services. Through independent research and development, collaborative research, continuous investment, and the use of information technologies such as virtual reality, multimedia interaction, web, and 3D visualization, a structured, systematic, and highly realistic virtual experimental hardware environment has been constructed. In the construction process, the platform closely relies on the new trends and technological requirements of smart airport operation support development. Based on the concept of "integration of industry and education, integration of science and education, and joint construction and sharing," it promotes the use of information technology to facilitate the sharing of educational equipment and teaching content online and offline, transitions professional practical teaching from demonstrative and verificative to practical, design-based, and innovative, combines independent teaching and training with data integration, achieves unified design and centralized deployment, and effectively avoids duplicate construction and resource waste. The main platforms include the virtual simulation center for airport core business, the public simulation experience center for airport operating environments, and the virtual simulation research and creation center for airports, consisting of three types of virtual simulation platforms and a total of fifteen virtual simulation experimental teaching systems.

Airport operation environment public simulation experience center adopts distributed simulation, virtual reality, and data visualization technologies to provide students with virtual simulation environments such as terminals, airfield areas, cockpits, and cabins. By using graphic images and 3D animations, the center offers immersive and interactive experiences in departure check-in services, airline ticketing services, passenger security services, and other processes from a first-person or third-person perspective. This breaks through the limitations of relying solely on pictures and videos for airport environment experiential teaching and creates a panoramic immersive experience environment.

Airport core business virtual simulation center bases on the A-CDM collaborative decision-making operation concept, utilizing computer technology, system simulation technology, virtual reality (VR), augmented reality (AR), holographic imaging, and other technologies to realistically recreate the entire process of airport operation support. It provides students with a realistic training scenario, allowing them

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to understand and master the operation processes, key technologies, and quality management methods of apron movement management and airport operation control after learning and mastering the basic knowledge, methods, and processes of airport operation support[3-4].

Airport virtual simulation research and creation center, based on a multi-role modular architecture, which can simulate and model airport terminal layout planning, airport capacity evaluation and optimization, ground support equipment and vehicle operation rules simulation, runway capacity evaluation, and aircraft terminal area operations. It provides a good research environment for joint university-enterprise research and technology verification in the frontier field of smart airport operation support. It also supports students' innovation and entrepreneurship projects incubation.

2.2 Development of a multi-level system virtual simulation training project

Virtual simulation training projects are important carriers for phenomenon cognition, knowledge learning, application experience, and innovative exploration. In the laboratory environment, students can analyze and identify problems, independently learn methods to solve problems, conduct virtual simulation experiments to solve problems, and summarize and evaluation. The airport operation virtual simulation training project is based on the real airport flight operation support process experimental training environment simulation and real job cases. It aims to cultivate students' basic practical abilities, comprehensive practical abilities, and innovative practical abilities in the specific work positions related to airport operation support. The project is designed in three levels: immersive experience module, integrated training module, and research and innovation training module, progressing from easy to difficult, and gradually advancing through various simulated training cases. The immersive experience stage mainly focuses on virtual simulation experience to let students understand the airport system, work environment, and important knowledge points. The integrated training stage mainly guides students to apply professional knowledge to training in tasks such as apron movement management, airport operations command, and key technology and quality management methods. The innovative application stage mainly relies on the virtual simulation platform to guide students to participate in research and technology verification of smart airport operation support in frontier fields and conduct innovative and entrepreneurial projects. Based on the students' learning stages, knowledge structure, cognitive rules, and ability goals, the airport operation virtual simulation experimental project is organically combined to form a comprehensive system.

2.3 Building a multidimensional virtual simulation practice teaching support system

2.3.1 Building a professional virtual simulation practice teaching team and improving the overall teaching level

The faculty of the airport operation professional group's virtual simulation public training center consists of three parts: management team, information technology development and support team, and practical teaching professional team. The management team includes experts and relevant subject teachers, as well as expert teaching guidance teams from outside the school, responsible for planning and academic guidance of the virtual simulation public training center for the airport operation professional group. The information technology development and support team mainly consist of professional teachers in computer information technology and other fields, responsible for the operation and maintenance of various teaching platforms in the virtual simulation public training center for airport operation and the development of new functions for the platforms. The practical teaching team is mainly based on the hardware environment of the virtual simulation training platform to promote reform in virtual simulation practical teaching, and to deepen the integration of information technology and intelligent technology with teaching. Through various means such as university-enterprise cooperation, experimental teaching practice, and research cooperation, we will strive to promote the development of virtual simulation teaching resources, system development, and research work to enhance the construction of teaching faculty for the airport operation professional group. Using the measures of "key cultivation, increasing pressure on research projects, professional leadership", we will build a composite airport operation professional virtual simulation practice teaching and management team of appropriate scale, reasonable structure, and high quality.

2.3.2 Continuous optimization of the virtual simulation practice teaching assessment mechanism

The school's teaching management department is responsible for the overall management, monitoring, and guidance of the entire process of virtual simulation practice teaching. The college department is responsible for the overall coordination, planning, management, quality control, and summary of virtual

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simulation practice teaching. External institutions are also invited to conduct questionnaire surveys on graduation students and employers regarding virtual simulation practice teaching in the public training center for virtual simulation in the field of airport operation.

2.3.3 Build an industry-education-research platform and improve supporting systems

In accordance with relevant national policies, the virtual simulation center for airport operation profession adheres to the principles of highlighting characteristics, optimizing structures, and improving efficiency in investment. It is jointly constructed by the Civil Aviation Administration, the university, and enterprises. The center aims to build a platform and bond for the interactions and cooperation among the government, the university, the industry, enterprises, and research institutions. By optimizing resource allocation, promoting cross-sectoral integration and development, and forming a multi-level and multi-dimensional cooperative model with government leading, vocational education institutions as carriers, industry guidance, and enterprise integration, the center aims to create a collaborative and win-win construction pattern. By establishing an industry-education-research resource platform, the center aims to address the lack of internships, teaching, scientific research, and innovation. It adopts a three-level management model of school, college, and department, implements mechanisms for integrating industry innovation demands, integrating project information, collaborating on technology service platforms, incubating and nurturing projects, and promoting the dissemination of technological achievements. These mechanisms aim to solve the problem of scattered resources in professional industries, teaching, scientific research, and innovation, and support the training of professional talents.

2.3.4 Establish a stable and secure open operating model to achieve sustainable operation of online virtual simulation experimental teaching projects

In terms of daily management, the center has established a management mechanism involving government, industry, enterprises, and schools, clarifying the division of work and responsibilities of each party. The civil aviation authority's industry regulatory departments provide guidance for the construction of various training rooms in the center and formulate corresponding support and encouragement policies. The school is responsible for daily maintenance and management to ensure the normal operation of the platform. Industry enterprises update the equipment of the platform through cooperative projects to ensure its advanced nature.

In terms of open operation, in order to achieve the sustainable development of the center, it adheres to a combination of public welfare service and market-oriented service. In addition to completing teaching and training, it actively seeks to undertake training, production, and research and development tasks from society. Firstly, it carries out public welfare projects to provide free services and is compensated through government purchase of services. Secondly, it carries out vocational training, skills assessment, product production, training factories, technical services, technology research and development projects, providing paid services and charging reasonable fees based on market principles. On the basis of openness, public welfare, sharing, and service, it establishes a deep integration operation mechanism of service exchange and resource promotion.

In terms of intellectual property rights protection, the construction and operation of the airport operation professional group virtual simulation public training center's hardware and software are the intellectual labor results of all parties involved, and have obvious ownership of knowledge. The center pays attention to the protection of intellectual property rights during the construction and operation process, clarifies the ownership of intellectual property rights, and establishes a systematic intellectual property protection mechanism. It confirms, protects, and allocates the ownership of newly formed intellectual property rights, and protects the existing intellectual property rights invested separately during the collaboration process. Through appropriate confirmation, value assessment, and allocation of intellectual property rights, it effectively protects the interests of all participating entities, strengthens communication, handles intellectual property rights transfer according to laws and regulations, and avoids disputes, striving to maximize the benefits of intellectual property rights in the field of airport operation professional group virtual simulation experimental technology.

3. Achievement Innovation and Specialization

The virtual simulation teaching system for airport operation professionals revolves around the entire process of flight operation support. It deeply integrates practical teaching in the field of airport operation support with virtual simulation technology, strengthening the relationship between the logic and process of flight operation support. Gradually, it has developed distinct characteristics of its own.

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3.1 The concept of "three connections, two integrations, and four support" to cultivate talents in airport operation support

Based on the development of smart airports and the goals of talent cultivation in airport operation support, the virtual simulation practical teaching system for airport operation professionals has been established. Following the principles of talent cultivation, it has gradually formed three levels of experimental teaching: basic practice, comprehensive practice, and research exploration. This system effectively addresses issues that are difficult to tackle in basic operational support core tasks, enhances students' practical abilities, resolves the issues of immovable equipment and high maintenance costs in airport operation support, enriches the resources for experimental teaching in airport operation support, and improves the efficiency of experimental teaching. With this system, more than 3000 talents in airport safety operation support have been trained, with a graduate employment rate consistently above 95%, and a majority of graduates finding employment in the aviation transportation industry. Many of them have become key personnel in various hub airports and the Greater Bay Area Airport Group[5-6].

3.2 Promoting open sharing of resources to enhance the quality of vocational education

Relying on the virtual simulation public training center for airport operation professionals, various types and levels of training are actively provided to the government and industry enterprises. The first flight dispatcher training center in Central and Southern China based on CCAR65 has been established, with a comprehensive and well-designed theoretical and practical teaching system. Training in aviation operations is actively provided to frontline units in civil aviation airports, enhancing their capability in airport operation support services. A shared professional teaching resource has been developed and vocational training for civil aviation security inspection departments is actively conducted to improve their social service capabilities. Through a commissioned agreement with the 007 Validation Station, multiple training and occupational skill assessments for primary, intermediate, and advanced civil aviation security inspectors have been conducted in the airport security VR simulation training room and X-ray image recognition simulation training room, with over 4,200 individuals assessed. A "research base for artificial bird deterrence lawns in airports" has been jointly established with enterprises. Technical support and services related to airport bird strike prevention are provided, conducting ecological surveys and bird control in over 20 domestic civil and military airports. Training programs for in-service personnel on airport bird strike prevention have been formulated, and multiple airport bird strike prevention technology training courses have been conducted. Technical support and services have been provided several times for the Zhuhai Airshow, ensuring its safe operation.

3.3 Strengthening school-enterprise cooperation and promoting mechanism and institutional innovation

The airport operation professional group's virtual simulation public training center strengthens cooperation with the military, civil aviation enterprises, and research institutes, continuously improving the overall research capabilities of the teachers. Cooperation has been established with the Eastern Theater Command of the Air Force to jointly build the "airport bird strike prevention technology joint research center" and the "joint training base for talent", conducting ecological research and bird control at air force airports. Cooperation has also been established with the Shanghai base of the Eastern Theater Command of the Air Force to jointly build the "airport bird strike prevention collaborative innovation center" and the "skill master studio", gathering high-level talents, elevating the level of professional scientific and technological innovation platforms, enhancing research support, and jointly establishing a collaborative innovation center for military-civilian integration development. The joint research center, guided by the idea of "taking research as the guide and seeking quality through research to promote teaching quality", collaboratively trains talent in airport safety operation guarantee with a naval aviation unit, and conducts technical research on airport bird strike prevention and disaster preparedness with an air force unit in the Southern Theater Command, engaging in in-depth discussions on resource sharing and co-construction, deepening and expanding cooperation, and achieving military-civilian integration development.

4. Conclusion

Based on the laws of talent cultivation, our university has established a teaching system with "three Connections, two Integrations, and four Support" for virtual simulation practice in airport operations,

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integrating different types of practical skills in the field of airport operation support with virtual simulation technology, achieving diversified teaching resources. This has supported the dynamic alignment between the airport operation profession and industry development and facilitated the comprehensive integration of supply-side talent cultivation and the structural requirements of industrial demand.

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