

Research and Practice on Curriculum System of Unmanned Aircraft system Engineering Under the Background of Emerging Engineering Education

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Abstract: With the rapid development of new technologies and new industries, the demand for emerging engineering talents is becoming more and more urgent. The core of emerging engineering construction lies in strengthening emerging engineering education and cultivating diversified and high-quality engineering talents. Centering on the emerging engineering strategy and innovative development needs, and integrating the requirements of Engineering Education Accreditation, The Unmanned Aircraft system Engineering specialty of Zhengzhou University of Aeronautics is taken as an example, under the background of emerging engineering, training objectives of specialty, construction ideas of curriculum system, structure of curriculum system, the full coverage of the curriculum system for graduation requirements, and the support for the ability training of complex engineering problems are discussed. The curriculum system structure that strengthens the characteristics of autonomous flight control and focuses on the ability training of solving complex engineering problems is constructed. It creates conditions for cultivating talents with emerging engineering characteristics, and has certain reference significance for the construction of the curriculum system of other aerospace majors.

Keywords: Unmanned aircraft systems engineering; Emerging engineering; Curriculum system; Graduation requirements; Complex engineering problem.

1. Introduction

Modern society and economy have increasingly urgent demand for emerging engineering talents. With the upgrading and transformation of traditional industries, as well as the rapid development of new technologies and emerging industries such as artificial intelligence technology, autonomous driving and intelligent aircraft. Since 2017, the Ministry of Education has actively promoted the construction of emerging engineering. In the "Fudan Consensus, Tianda Action and Beijing Guide", the connotation and characteristics of emerging engineering and the path selection of emerging engineering construction and development have been pointed out respectively, the action route of "emerging engineering" construction has been formulated and the guidelines for emerging engineering construction have been given [1-3]. Emerging engineering education is the core content of emerging engineering construction. The purpose of emerging engineering education is to cultivate diversified and innovative outstanding engineering talents in the future and meet the demand for innovative engineering talents in the development of new industries and new economy [4]. Therefore, the emerging engineering is the direction of our engineering education reform and represents the new thinking and new ways of our engineering education development [5].

The construction of emerging engineering is a complex systematic engineering, including education concept, talent training, information teaching reform, discipline and specialty, innovation and entrepreneurship, practice platform, quality standard system, etc. The exploration of interdisciplinary integration of engineering talent training model and the curriculum model for complex engineering problems has

been specially proposed in the "Beijing Guide" [3]. The construction of curriculum system, adjustment and optimization of curriculum teaching content are the fundamental guarantee for the realization of talent training objectives, and belong to the key link of talent training model design [6]. Therefore, the construction of professional curriculum system is also one of the key contents in the construction of emerging engineering. Taking the unmanned aircraft system engineering major of Zhengzhou University of Aeronautics as an example, a curriculum system with the characteristics of emerging engineering has been constructed, and high-quality engineering talents with emerging engineering literacy and ability can be cultivated, which is of great significance for the construction of talent training mode for aerospace majors under the background of emerging engineering.

2. The status quo of professional construction of unmanned aircraft system engineering in our university

Zhengzhou University of Aeronautics is the only full-time general undergraduate university with distinctive aviation characteristics in Henan Province, which has formed the characteristics of "aviation-oriented, combined with management and engineering". In combination with its own characteristics and the development needs of the UAV industry, the university applied for the major of unmanned Aircraft Systems Engineering in 2020, which was approved and recorded by the Ministry of Education in February 2021. In order to support the construction of the unmanned aircraft system engineering major, the first phase of the construction

fund of more than 2 million yuan was invested by the university in that year. The UAV training room, UAV flight control development laboratory and multi-intelligent cooperative control laboratory were built, industry-university-research agreements were signed, and the school-enterprise cooperative education mechanism was explored with a number of local UAV technology enterprises.

The UAV industry is an emerging field, and the traditional curriculum system and teaching methods cannot well support the UAV industry's demand for talents. Therefore, it is necessary to build a curriculum system with emerging engineering characteristics and high standards to effectively support the training objectives and graduation requirements of the unmanned aircraft systems engineering major. Therefore, adhering to the responsibility of building the major with high standards, centering on the requirements of emerging engineering construction, guided by the National Standards for Teaching Quality of Aeronautics and Astronautics (hereinafter referred to as the "quality standards"), the "Certification Standards for Engineering Education" (hereinafter referred to as the "certification standards") and the "Requirements of the University on the revision of undergraduate Talents Training Program" (hereinafter referred to as the "requirements of the University"), Focusing on the social demand of training high-quality engineering talents, the university aims to improve the training quality, professional strength and competitiveness of unmanned aircraft talents in the field of unmanned aircraft by building a curriculum system of unmanned aircraft systems engineering with emerging engineering features. It has the significance of guiding teachers' curriculum teaching and professional construction, and providing reference for the curriculum system construction of other aerospace majors.

3. The new requirement of emerging engineering to the construction of professional curriculum system

The knowledge structure system and educational concept of traditional engineering talents training are no longer adapted to the requirements of emerging engineering construction, while the emerging engineering education integrates traditional engineering majors with new technologies and new disciplines to cultivate diversified and high-quality engineering and technical talents in line with the development of new economy. Therefore, new requirements are put forward for the construction of professional curriculum system. Literature [7] summarizes the problems that should be paid attention to in the construction of the curriculum system of emerging engineering majors from three aspects: the orientation of talent training, the "new structure" of the curriculum system, and the "new quality" that emerging engineering talents should have. Literature [8] summarizes the characteristics of training talents in emerging engineering education from four aspects: application of training objectives, interdisciplinarity of curriculum system, engineering and comprehensiveness of teaching content, and practicality of teaching process. Literature [9] summarizes the problems to be solved in the construction of the emerging engineering major curriculum system from several aspects, such as the cross-integration of general education and professional education, the cultivation of the ability to solve complex engineering problems oriented to the future industry, the cultivation of students' personalized development, and the

reasonable modular structure of the curriculum system.

In summary, under the background of emerging engineering, the requirements of curriculum system construction of unmanned aerial system engineering should be reflected in the following aspects: (1) The demand of UAV industry is the guidance of training goal setting. (2) "New structure" and interdisciplinarity should be reflected in the curriculum system. (3) The training elements of "new literacy and new ability" should be integrated into the curriculum system. In other words, "new literacy" includes not only traditional professional literacy and skills, but also national feelings, systematic engineering thinking, multidisciplinary collaboration, project management and so on. "New capability" mainly refers to the ability of engineering innovation design and practice oriented to solve complex engineering problems. (4) The output-oriented concept should run through the whole curriculum system.

4. Optimize the top-level design of curriculum system based on industrial demand and learning output

4.1. Conduct in-depth research, compare standards, and ensure that the curriculum system is based on evidence

The social demand research report was formed, and the research was carried out from several dimensions, such as the development status of the UAV industry, the demand for UAV talents in social development, the situation of similar colleges and universities, the position demand of unmanned aircraft systems engineering and the position professional ability. The construction of curriculum system has a supporting foundation. At the same time, "Emerging engineering Research and Practice Project Guide", "Quality Standards", "Certification Standards", "University requirements", "University Curriculum Ideological and Political construction Plan" and other documents have been carried out to ensure that the construction of the curriculum system has a correct basis.

4.2. The construction of training objectives is oriented to serve the national strategy, industrial needs and the future

Guided by the needs of the latest technical talents in the field of UAV, guided by the "14th Five-Year" Aviation Economic Development Plan of Henan Province", taking the construction of civil unmanned aviation pilot zone as an opportunity, combined with the school's educational positioning and characteristics, based on Henan Province and facing the needs of the Central Plains regional economic development, The Unmanned Aircraft Systems Engineering program trains flight control system engineers to meet the urgent needs of the UAV industry. Professional service orientation, basic professional accomplishment, professional characteristics and talent positioning are included in the description of training objectives. The professional quality and ability that students should achieve about 5 years after graduation are subdivided, from the four aspects of professional quality, engineering knowledge, engineering ability, career development, so as to form the goal connotation.

4.3. Construct graduation requirements based on student learning outputs

According to the engineering education certification standards, graduation requirements are constructed, from the application of knowledge, general ability, ability to solve complex engineering problems and attitude and concept, based on the overall goal positioning of talent training and the professional quality and ability that should be acquired within 5 years after graduation. Professional training objectives can be effectively supported by graduation requirements. In terms of breadth, the content involved in 'certification standards' is completely covered by graduation requirements. In depth, the basic requirements of the 12 criteria are completely exceeded. Students' literacy and abilities were subdivided according to measurable and evaluable requirements, based on which graduation requirement index points were formed.

5. Construct curriculum system around "new structure, new accomplishment and new ability"

Two key issues, such as how to reflect the characteristics of emerging engineering in the curriculum system and whether the graduation requirements can be fully supported, need to be taken into account when constructing the curriculum system of unmanned aircraft systems engineering.

5.1. The construction idea of curriculum system

The idea of "1553" curriculum system construction as shown in Figure 1 is adopted according to the requirements of emerging engineering education for the construction of curriculum system of unmanned aerial system engineering and the goal of training flight control system engineers. That is, one crossing point is complex engineering problems; The five changes include the transformation from curriculum orientation to output orientation, from teaching and solving doubts to educating talents, from traditional disciplines to comprehensive and cross-disciplinary transformation, from basic theory to engineering practice, and from knowledge acquisition to engineering thinking. Five integration, including the integration of course content with industrial demand, ideological and political education, engineering knowledge, engineering innovation, and complex engineering problems; Three improvements, including the improvement of students' talent character, engineering knowledge, engineering ability.

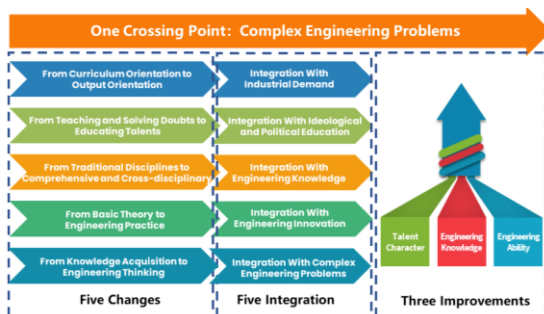


Fig. 1 The construction idea of curriculum system of unmanned aircraft system engineering

5.2. The structure of the curriculum system

As shown in Figure 2, the course architecture of "three

aspects, four levels and multiple modules" has been constructed, based on the construction idea of the course system.

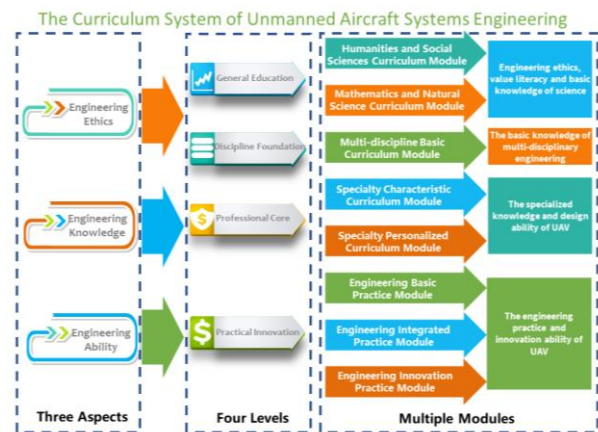


Fig. 2 The curriculum architecture of "three aspects, four levels and multiple modules"

Aiming at cultivating students' engineering literacy and ability, the curriculum system of unmanned aircraft systems engineering is divided into three aspects, namely, cultivating students' engineering ethics, engineering knowledge and engineering ability. The three aspects are further subdivided into four levels, namely the general education level, the discipline foundation level, the professional core level and the practical innovation level. The four levels of the curriculum system are divided into a number of curriculum modules, including humanities and social sciences curriculum module, mathematics and natural science curriculum module, multi-discipline basic curriculum module, specialty characteristic curriculum module, specialty personalized curriculum module, engineering basic practice module, engineering integrated practice module and engineering innovation practice module.

Engineering ethics, value literacy and basic knowledge of science are mainly cultivated by humanities and social sciences, mathematics and natural sciences curriculum module as part of general education. The basic knowledge of multi-disciplinary engineering, such as machinery, mechanics, electronics and control, is mainly cultivated by the multi-discipline basic curriculum module as the basic part of the major. The specialized knowledge and design ability of flight intelligent perception, autonomous control, and new energy power are mainly cultivated by the specialized characteristic curriculum module and personalized curriculum module, which are the core parts of the major. The training of engineering practice and innovation ability is mainly completed by the training of engineering basic practice, engineering comprehensive practice and engineering innovation practice modules in the practice innovation part.

An interlocking, closely supported, complete and three-dimensional curriculum system has been formed, from the top level of literacy and ability design, to the middle of the curriculum level design, and the bottom of the curriculum group module design.

5.3. Graduation requirements are fully covered by the curriculum

The method of "Three optimizations and one addition" as shown in Figure 3 has been adopted. In order to realize the comprehensive coverage of graduation requirements by the

curriculum system, it is based on the construction idea of the curriculum system.



Fig. 3 The implementation method of "three optimizations and one addition"

5.3.1. The course architecture and proportions are optimized to meet the standard requirements

The structure and proportion of mathematics and natural science courses, humanities and social sciences and general education courses, basic engineering courses, basic professional courses and professional courses, engineering practice and graduation design (thesis) course modules have been optimized, adjusted and designed according to the "certification standards" and "quality standards", combined with the "school requirements".

5.3.2. Flight control features are highlighted through the optimization of the subject basis and specialty features of the curriculum

Based on the training objectives set for flight control system engineers, the proportion of systems engineering, control technology, navigation technology, electronic technology and unmanned aerial vehicle system courses has been increased in the multi-disciplinary basic course module and subject characteristic course module. The course features of training UAV autonomous flight control direction are formed.

5.3.3. The promotion of professional engineering ability has been emphasized by optimizing the practice teaching link

Three types of practice modules, including basic practice of engineering, comprehensive practice of engineering and practice of engineering innovation, have been set up based on the requirements of cultivating high-quality engineering talents in line with the characteristics of emerging engineering. The three practice links gradually progress and connect with each other, and correspond with the basic course of the subject, professional characteristics and personalized courses.

Students' engineering consciousness, basic skills and other practical abilities can be cultivated through basic engineering practice, which mainly includes cognition, engineering training, practical training of control, etc. Students' practical abilities such as engineering design and comprehensive application can be cultivated through comprehensive engineering practice, which mainly includes curriculum design, assembly and debugging, system modeling and simulation, and professional practice. Students' ability to solve complex engineering problems and their awareness of innovation and entrepreneurship can be cultivated through engineering innovation practice, which mainly includes professional comprehensive practice, innovation and entrepreneurship practice, graduation practice, graduation thesis (design), etc.

5.3.4. The latest technology and cross-disciplinary features of the subject are reflected through the addition of artificial intelligence and new energy courses.

In order to adapt to the development of intelligence and reflect the characteristics of emerging engineering, courses such as "Intelligent perception and Information Processing", "machine learning", "Fundamentals of Visual SLAM" and "new energy UAV" have been added to the personalized course module, taking into account the development of the latest technologies in the industry such as intelligent aircraft, intelligent unmanned systems and new energy UAV. At the same time, two directions of UAV flight control design and overall UAV design are set to meet students' personalized study needs.

6. Summary

The Unmanned Aircraft Systems Engineering major is a characteristic undergraduate major set under the background of emerging engineering construction in response to the development trend of new technologies and new industries in the field of aviation and astronautics. The construction of its curriculum system is still in the exploratory stage.

Based on the newly established major, adhering to the responsibility of building the major with high standards, guided by the goal of training high-quality aircraft control engineers and focusing on the need to improve the training quality and professional competitiveness of aerospace talents, this paper takes the construction of curriculum system under the background of emerging engineering and professional certification as the content. Based on the course system construction idea of "one penetration point, five transformation, five combination and three promotion", the course system structure of "three aspects, four levels and multiple modules" has been formed. The three aspects include engineering ethics, engineering knowledge and engineering ability. The four layers include the general education layer, the discipline foundation layer, the professional core layer and the practical innovation layer. Multiple modules include humanities and social Sciences, Mathematics and Natural Sciences, multi-discipline basis, specialty characteristics, specialty individuation, engineering foundation practice, engineering integrated practice and engineering innovation practice, etc. In order to complete the full coverage of the curriculum system for graduation requirements, the methods of "optimizing the structure and proportion of the curriculum system", "optimizing the subject basis and specialty characteristic courses", "optimizing the practice teaching links" and "increasing the new technology and cross-disciplinary personalized courses" have been adopted.

The training objectives and graduation requirements of the major have been effectively supported, the quality of professional talent training has been improved, the strength and competitiveness of the major has been enhanced, through the construction of the curriculum system in this paper. This course system is the characteristic course system of unmanned aircraft system engineering under the background of emerging engineering. Not only can teachers get guidance in curriculum teaching, but also in professional construction, from the aspects of teaching staff and support conditions.

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