

Research on the Construction and Application of Post Competency Model for Unmanned Systems Majors Oriented to Practical Combat Requirements

Yawei Li, Tao Tong*, Qiwu Wu

School of Equipment Management and Support, Engineering University of PAP, Xi'an, 710086, China

*Corresponding author: 584000415@qq.com

ABSTRACT

With the in-depth penetration of unmanned systems technology in military and civilian fields, undergraduate majors such as Unmanned Systems Engineering and Unmanned Systems Command and Control have been established in recent years, marking that talent cultivation has entered a new stage of specialization. Aiming at the existing problems in the current education of unmanned systems majors, including ambiguous post requirements, generalized competency indicators, and disconnection between theory and practice, this paper constructs a scientific, dynamic and quantifiable post competency model. Based on in-depth investigations into typical posts such as unmanned equipment operators and mission planners, this study adopts the Iceberg Model and Critical Incident Technique to extract key competency dimensions covering professional knowledge, practical operational skills, decision-making in complex scenarios and professional literacy. On this basis, a three-tier progressive competency model of “basic competency – post core competency – future development competency” is constructed, and an application strategy for talent cultivation featuring “demand-oriented and competency-based” is proposed. Empirical analysis shows that the model can effectively guide the reconstruction of curriculum systems and the optimization of practical training systems, and significantly improve students’ post adaptability and competency. This research provides theoretical basis and practical paths for the standardization and precision of the talent cultivation system for unmanned systems majors in the new era.

KEYWORDS

Unmanned systems majors; Post competency model; Three-tier model; Talent cultivation.

1. INTRODUCTION

As core equipment of the new-generation information warfare and intelligent social infrastructure, unmanned systems are undergoing profound transformation in operation and control technology from “automation” toward “intelligence”. With the further advancement of “Emerging Engineering Education” construction, dramatic adjustments are taking place in the disciplinary structure of universities. The newly launched undergraduate majors related to unmanned systems in recent years not only reflect the optimization of disciplinary layout, but also serve as an important measure to respond to national strategic talent demands [1][2]. Nevertheless, the construction of emerging majors is often trapped in the dilemma of “valuing knowledge transmission while neglecting competency development”. The traditional curriculum system dominated by disciplinary logic cannot directly map the complex and changeable job requirements of unmanned systems, which prolongs the adaptation

period of graduates after employment and leads to the mismatch between what they learn and what they need on the job.

Post competency refers to the deep personal characteristics that distinguish high performers from ordinary employees in a certain job, including knowledge, skills, self-concept, traits and motives [3]. For unmanned systems majors, posts require not only hard knowledge such as control theory and communication protocols, but also soft skills including real-time decision-making, system integration and human-machine collaboration under high-confrontation and highly uncertain environments. Studies by Wang Jijun et al. demonstrate that the post-competency-based talent cultivation model can effectively resolve the structural contradiction between education and employment [4]. Therefore, constructing a competency model based on real post requirements has become a critical bridge connecting university education with employment standards of troops and industries.

Focusing on the actual talent cultivation of newly established undergraduate majors related to unmanned systems, this paper takes students majoring in Unmanned Systems Engineering and Unmanned Systems Command and Control as research objects. By sorting out competency elements of typical posts, a three-tier competency model of “basic competency – post core competency – future development competency” is built, and its specific application in talent cultivation is discussed, so as to provide solutions for enhancing the core competitiveness of talents majoring in unmanned systems.

2. ANALYSIS OF POST COMPETENCY REQUIREMENTS FOR UNMANNED SYSTEMS MAJORS

2.1 Identification of Typical Posts and Deconstruction of Job Responsibilities

To guarantee the representativeness and applicability of the model, this study conducts in-depth analysis on two typical posts with the highest employment proportion of graduates from unmanned systems majors. Referring to the research on the training system for unmanned system operators by Yang Guang et al. [5], two core posts are identified:

Unmanned Equipment Operator: Mainly responsible for real-time monitoring of unmanned platforms (UAV/USV/UGV), data link maintenance, mission execution and emergency response to sudden faults. Its work features high-frequency interaction, real-time response and high risk tolerance.

Mission Planner: Mainly in charge of environmental perception before missions, route planning, payload configuration, risk assessment and preplan formulation. Its work features global perspective, rigorous logic and forward-looking prediction.

Through interviews with personnel from multiple military industrial groups, research institutes and troop support units, core responsibilities of the two posts are extracted: operators focus on “execution and monitoring”, while planners focus on “design and evaluation”. Together they constitute key links in the closed-loop combat/operation chain of unmanned systems.

2.2 Extraction Method of Competency Elements

This study combines Behavioral Event Interview (BEI) and Critical Incident Technique (CIT). First, semi-structured interviews are carried out with 10 high-performance technical backbones of unmanned systems majors with more than 5 years of working experience. Second, 15 typical cases of human errors are collected for reverse analysis. Finally, the Delphi method is adopted to invite experts to screen the preliminary competency indicators and assign weights. In terms of technical background, command and control of unmanned swarms involves complex multi-agent cooperative algorithms, which impose extremely high requirements on planners’ understanding of algorithms [6]. Meanwhile, according to IEEE standards for artificial intelligence systems, intelligent interaction and

human-machine trust mechanism also serve as important reference dimensions for post competency assessment [7].

3. CONSTRUCTION OF THE THREE-TIER POST COMPETENCY MODEL FOR UNMANNED SYSTEMS MAJORS

Based on survey results, drawing on Spencer's Iceberg Model theory [3] and combining technical characteristics of unmanned systems, this paper constructs a three-tier competency model of "basic competency – post core competency – future development competency". The model adopts a pyramid structure: the bottom layer serves as the foundation, the upper layer represents development, and the core layer contains key variables distinguishing high performers. The evaluation indicator system for engineering students proposed by Li Qiang et al. provides methodological support for such hierarchical construction [8].

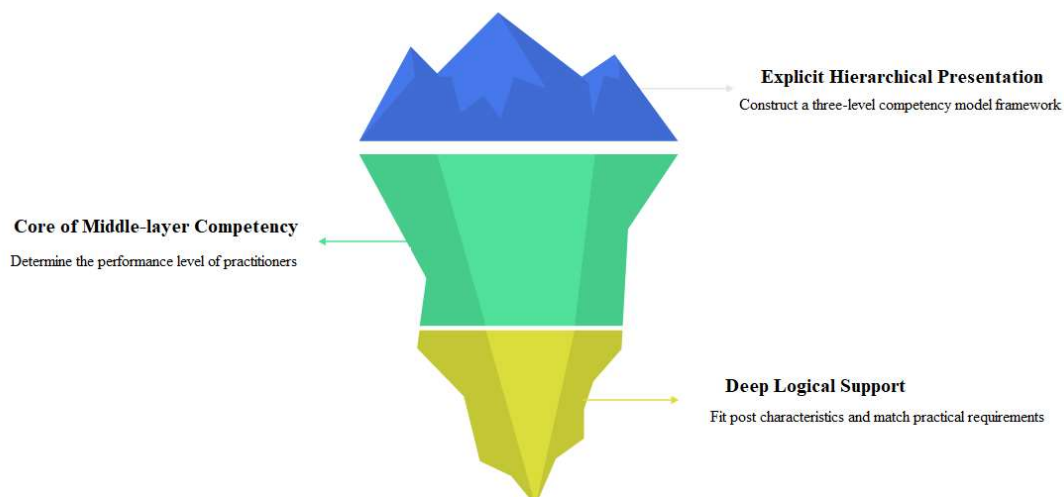


Figure 1. Analysis of Competency Model Construction

3.1 Basic Competency Layer: Cornerstone of Job Qualification

Basic competency is the threshold requirement for engaging in jobs related to unmanned systems majors, including explicit knowledge reserve and implicit basic qualities.

Professional Knowledge Dimension:

Control and Power Systems: Master basic principles of flight mechanics, navigation, guidance and control (GNC).

Information Fusion Technology: Be familiar with data processing and fusion algorithms of multi-sensors (radar, electro-optics, infrared).

Communication and Networks: Understand tactical data links, low-latency high-bandwidth communication protocols and fundamentals of network security.

Basic Literacy Dimension:

Logical Thinking Ability: Rigorously analyze system status and fault codes.

Engineering Ethics and Confidentiality Awareness: Possess a strong sense of national security responsibility and data security awareness.

3.2 Post Core Competency Layer: Key to Distinguishing High Performers

As the core part of the competency model, this layer directly corresponds to high-performance behaviors on posts and is the key focus of this research. Liu Qiang et al. pointed out that in the education of unmanned aerial vehicle majors, it is necessary to strengthen the integration of “Post-Course-Competition-Certificate” oriented toward core competencies [9].

Real-time Decision-Making Ability under Complex Scenarios:

Target Recognition and Classification: Rapidly and accurately identify target attributes under low visibility and strong interference.

Dynamic Route Replanning: Replan optimal routes instantly according to real-time meteorology, no-fly zones and changing threats.

Emergency Response: Execute pre-set or temporary strategies such as return, hover and self-destruction within seconds under emergencies including communication interruption and power failure.

Human-Machine Collaboration and Information Integration Ability:

Situation Awareness Synthesis: Convert discrete multi-source data into a unified battlefield/operational situation map.

Human-Machine Interaction Efficiency: Efficiently parse information on UI interfaces and send rapid commands to unmanned platforms via natural interaction modes such as voice and gestures.

Systems Engineering Thinking:

System Boundary Awareness: Understand interfaces and dependencies between unmanned platforms, manned command posts and other collaborative nodes.

Full-Link Risk Assessment: Identify single-point failure risks throughout the mission and formulate redundant backup schemes.

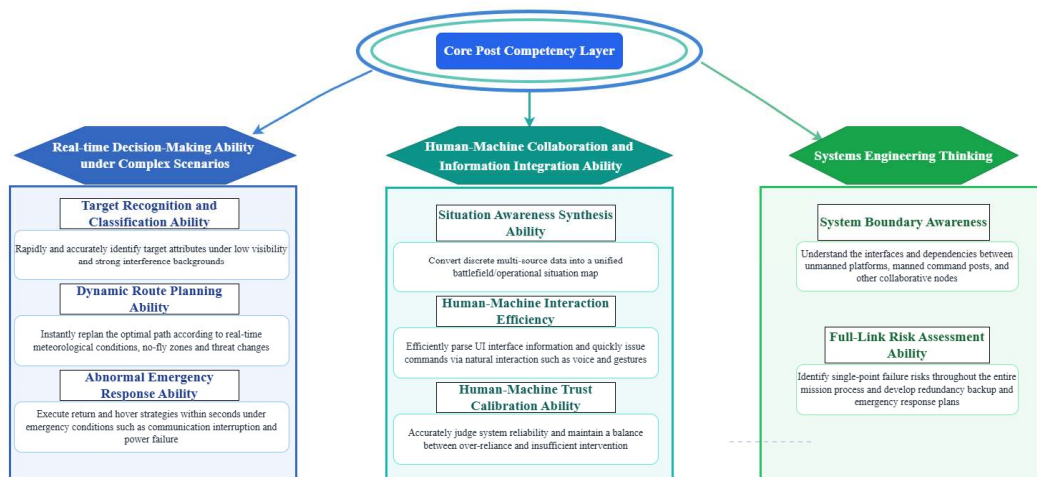


Figure 2. Post Core Competency Layer

3.3 Future Development Competency Layer: Potential for Sustained Growth

Given the rapid iteration of unmanned systems technology, this layer determines professionals' career longevity and promotion potential.

Technology Transfer and Innovative Learning Ability: Rapidly master new AI algorithms (e.g., application of reinforcement learning in path planning), properties of new materials and operation specifications of new platforms.

Cross-Domain Collaborative Command Ability: Capable of transitioning from single-platform operation to multi-domain (air, sea, land, space, cyber) joint combat/operation command.

Team Leadership and Resource Coordination Ability: Coordinate software and hardware development teams, test teams and end-users in complex projects with project management potential.

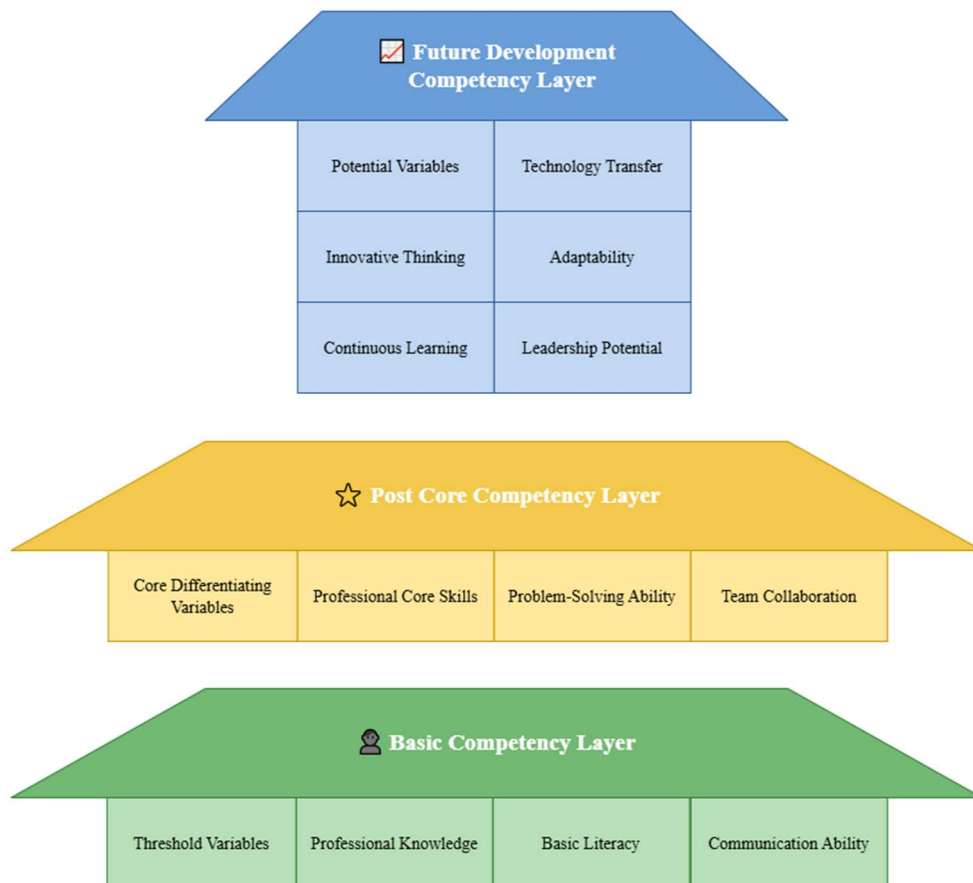


Figure 3. Structure Diagram of the Three-Tier Progressive Post Competency Model for Unmanned Systems Majors

Note for Figure 3: The model demonstrates the logical progressive relationship from the bottom basic competency, through the middle core competency, to the top development competency. The yellow area represents core distinguishing variables, the blue area represents potential variables, and the green area represents threshold variables.

4. APPLICATION OF THE COMPETENCY MODEL IN TALENT CULTIVATION SYSTEM

Model construction is not the end; the key lies in translating it into specific standards for teaching and training. This paper proposes a “demand-oriented, competency-based” mapping mechanism to integrate the three-tier competency model into the whole process of talent cultivation.

4.1 Reconstruction of Curriculum System: From Disciplinary Logic to Competency Logic

Traditional curriculum systems are mostly arranged linearly as “theory – experiment – internship”, which is mismatched with the competency model. Based on the model, modular curriculum reorganization is implemented to strengthen the integration mechanism of “Post-Course-Competition-Certificate” [9].

Basic Competency Curriculum Module: Retain core courses including Advanced Mathematics, Principles of Automatic Control, Signals and Systems, and Principles of Computer Composition, while reinforcing application cases in unmanned system scenarios. For example, add cases of PID parameter tuning under strong interference in “Principles of Automatic Control”, directly matching operators’ basic troubleshooting competency.

Post Core Competency Curriculum Module: Set up the course “Situation Awareness and Information Processing” to focus on cultivating information integration capability. Offer “System Modeling and Simulation Technology”, combining Python/C++ programming to simulate and verify dynamic route planning algorithms. Add practical training course “Equipment Testing Technology and Application”, where random faults are injected via high-fidelity simulation to train students’ real-time decision-making ability.

Future Development Competency Curriculum Module: Introduce general and interdisciplinary courses such as “Artificial Intelligence and Future Combat” and “Countermeasure Technology and Application of Unmanned Systems”. Encourage students to participate in scientific research projects to foster innovative thinking.

4.2 Upgrade of Practical Training System: Scenario-Based Training Combining Virtual and Physical Elements

In view of the fact that “emergency response” and “dynamic planning” in post core competencies are difficult to train frequently in real environments, a “virtual-physical integrated and progressively graded” practical training system is constructed. Research by Zhang Xiaodong et al. indicates that the military intelligent simulation training system based on digital twin can effectively reduce training costs and improve training fidelity [10]. Accordingly, the system is designed as follows:

L1 Basic Virtual Training: With digital twin platforms, students practice basic control commands in virtual environments. Assessment focuses on knowledge mastery in the basic competency layer.

L2 Hardware-in-the-Loop Joint Training: Adopt hardware-in-the-loop (HIL) simulators or small tethered UAVs to conduct mission planning and execution under simulated communication delay and electromagnetic interference. Assessment focuses on collaboration and planning competencies in the post core competency layer.

L3 Full-Element Confrontation Drill: Carry out full-process red-blue confrontation in field training grounds with manned command posts, UAV swarms and adversarial targets. Assessment focuses on comprehensive command and technological innovation competencies in the future development competency layer.

4.3 Reform of Evaluation System: Multi-Dimensional Competency Profiling

Abandon evaluation relying solely on exam scores, and establish a “360-degree + big data” evaluation system based on the competency model. Following the logic of engineering evaluation indicators constructed by Li Qiang et al. [8], the following evaluation strategies are implemented:

Process Data Collection: Embed log interfaces in practical training platforms to automatically record quantitative indicators such as students’ operation time, path deviation and fault response duration.

Competency Radar Chart Generation: Generate personalized “competency radar charts” for each student based on assessment data, intuitively showing strengths and weaknesses across basic, core and development tiers.

Targeted Teaching Feedback: The system automatically pushes targeted micro-course resources or extra training tasks according to weak points on radar charts. For instance, if a student scores low in “dynamic planning”, the system will push tutorials on reinforcement learning path planning algorithms and special simulation training packages.

Table 1. Mapping Table of Typical Post Competency Indicators and Courses / Practical Training for Unmanned Systems Majors

Competency Tier	Key Competency Indicators	Corresponding Main Courses/ Modules	Main Practical Training Items	Evaluation Methods
Basic Competency	Mastery of Control Theory	Principles of Automatic Control, Flight Mechanics	Basic UAV Takeoff and Landing Operations	Written Test + Basic Operation Compliance Check
	Sensor Principles	Computer Hardware and Embedded Technology	Multi-source Data Visualization Analysis	Case Analysis + Experiment Report
Post Core Competency	Target Recognition and Classification	Fundamentals of Computer Information Technology	Simulation of Target Capture under Strong Interference	Simulation Score + Recognition Accuracy
	Dynamic Route Planning	Unmanned Systems Mission Planning and Decision-Making	Practical Obstacle Avoidance and Route Planning	Path Optimality + Time Efficiency
	Emergency Response	Equipment Testing and Application	Emergency Subjects of Communication Interruption/ Power Failure	Response Time + Decision Accuracy
Future Development Competency	Cross-Domain Collaborative Command	Collaborative Application and Defense of Unmanned Systems	Collaborative Missions of Multi-UAV Swarms	Peer Review + Comprehensive Mission Score
	Technological Innovation Ability	Artificial Intelligence and Future Combat	Self-Exploratory Algorithm Design	Patent / Paper + Project Defense

5. CONCLUSION AND PROSPECT

Aiming at the practical talent cultivation demands of newly established majors related to unmanned systems, this paper constructs a three-tier post competency model of “basic competency – post core competency – future development competency”. The model clearly defines core competency elements of typical posts such as unmanned equipment operators and mission planners, including complex scenario decision-making, human-machine collaborative integration and system risk prediction. Moreover, it materializes these abstract competencies into teachable, trainable and evaluable curriculum and practical training indicators.

The research shows that the talent cultivation system reconstructed based on this model can effectively solve the problems of generalized competency indicators and single training scenarios in

traditional education, and significantly improve the matching degree between students and post requirements. Future research will further focus on deep mining of students' practical training data using artificial intelligence technology to realize dynamic prediction of competency and automatic generation of adaptive teaching strategies, promoting the intelligent and personalized development of education for unmanned systems majors.

REFERENCES

- [1] Wu, Y. (2017). Emerging engineering education: University transformation in new era. *Research in Higher Education of Engineering*, (2), 1–6.
- [2] Ministry of Education of PRC. (2023). *Catalogue of undergraduate majors in general institutions of higher education (Revised 2023)*. Ministry of Education of the People's Republic of China.
- [3] Spencer, L. M., & Spencer, S. M. (1993). *Competence at work: Models for superior performance*. Wiley.
- [4] Wang, J., Zhang, M., & Li, H. (2022). Research on talent cultivation model reform in higher vocational colleges based on post competency. *Chinese Vocational and Technical Education*, (15), 58–63.
- [5] Yang, G., & Zhu, M. (2022). Design of skill training system for operators and maintenance personnel of unmanned systems. *Equipment Environmental Engineering*, 19(5), 88–94.
- [6] Chen, W., Wang, F., & Li, N. (2022). Review on key technologies of command and control for unmanned swarms oriented to complex systems. *Systems Engineering and Electronics*, 44(9), 2105–2115.
- [7] IEEE. (2020). *IEEE Std 6175-2020: IEEE standard for artificial intelligence lexicon*. IEEE.
- [8] Li, Q., & Zhou, T. (2021). Research on post competency evaluation indicator system for engineering students under the background of emerging engineering education. *Research in Higher Education of Engineering*, (3), 102–108.
- [9] Liu, Q., & Zhao, G. (2023). Exploration on the cultivation model of integrating “post-course-competition-certificate” for UAV major in military academies. *Aviation Education Research*, 40(4), 12–17.
- [10] Zhang, X., & Liu, Y. (2023). Construction and application of military intelligent simulation training system based on digital twin. *Acta Armamentarii*, 44(6), 1582–1590.