International Journal of Education and Humanities
ISSN: 2770-6702 | Vol. 19, No. 1, 2025

Exploration of Teaching Reform Path of Unmanned Systems Engineering Specialization for the Intelligent Era

Weiyi Zhang, Yawei Li, Qiwu Wu*, Weicong Tan

School of Equipment Management and Support, Engineering University of PAP, Xi'an, 710086, China
*wuqiwu700@163.com

Abstract: Aiming at the core problems of knowledge lag and lack of practice platform in unmanned system engineering, we propose the solution of "AI+Education" deep integration. Through the construction of dynamic knowledge mapping, five-layer virtual-real integration training system, OBE-CDIO-EIP ternary model, innovative development of intelligent teaching system, problem chain inquiry teaching and other methods. The reform covers the whole process of theoretical teaching, practical training, and evaluation system, providing a systematic paradigm reference for the digital transformation of engineering education.

Keywords: Unmanned Systems Engineering, Teaching Reform, Artificial Intelligence, Virtual-Real Integration, Educational Meta-Universe, OBE-CDIO-EIP.

1. Introduction

Currently, the global unmanned systems industry is characterized by the triple features of "technology explosion-application proliferation-ethical controversy". According to the Boston Consulting Group report (2023), the annual growth rate of the industry reaches 31%, but there are three major contradictions: first, the contradiction between technology iteration and education lag: it takes an average of 18 months for new technologies to go from the laboratory to the classroom (e.g., group intelligence algorithms, bionic robotics); second, the contradiction between the cost of equipment and the demand for teaching: the cost of a single set of unmanned aerial vehicle clustering experimental platform exceeds 2 million yuan, which limits the development of practical teaching; third, the contradiction between cognitive habits and teaching methods. The contradiction between cognitive habits and teaching methods: the digital native characteristics of the post-00 student population are significant, and the knowledge retention rate of the traditional lecture mode is less than 40%. This paper is based on empirical research in five universities (N=1265), focusing on the following key issues: how to build a dynamically updated knowledge management system? How to realize safety skills training in high-risk scenarios? How does industrial intelligence reshape the education evaluation paradigm?

2. Education and Teaching Methods Innovation System

2.1. AI-enabled Classroom Teaching Revolution

Construct a four-dimensional intelligent teaching system (Figure 1):

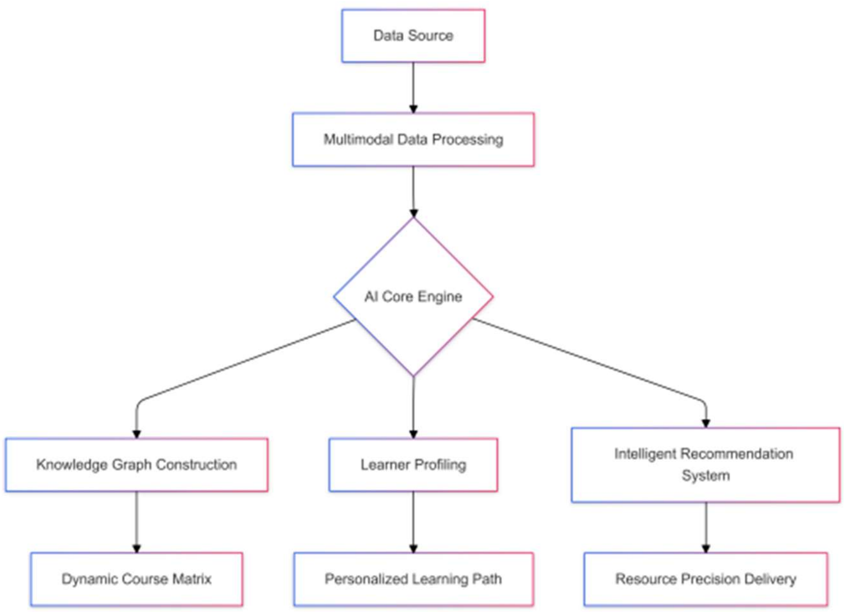

Figure 1. Architecture diagram of intelligent teaching system

Key technological breakthroughs: knowledge preservation mechanism: real-time capturing of arXiv preprint papers through BERT model to build a weekly updated knowledge base; multimodal interaction: integration of Leap Motion gesture recognition and Emotiv EEG device to realize the closed-loop of “Idea control-virtual operation-physical response”; risk early warning system: prediction of learning difficulties based on LSTM neural network, issuing intervention suggestions 3 weeks in advance (92.3% accuracy). Intervention recommendations are issued 3 weeks in advance (92.3% accuracy rate).

2.2. Inspired Inquiry-based Theory Teaching

Implement the teaching mode of “problem chain - scaffolding - reflection ring”:

Problem chain design principles: increasing complexity: single-machine control→multi-machine cooperation→human-machine symbiosis; interdisciplinary: integration of cybernetics, game theory, cognitive science and other multidisciplinary issues; ethical embeddedness: setting up ethical dilemmas such as “attribution of responsibility for autonomous attack systems”. Dual reflection mechanism: process reflection: using EDM (Educational Data Mining) to analyze the decision-making path. Meta-reflection: visualize the evolution of the thinking structure through the concept map tool.

2.3. Immersion Interactive Teaching

Immersion Learning Theory (Immersion Learning Theory) is developed from Csikszentmihalyi's “Flow Theory”, which emphasizes the internalization of knowledge through a high degree of concentration and deep participation. Combining Kolb's Experiential Learning Cycle and Mayer's Cognitive Theory of Multimedia Learning, we constructed a three-stage learning model of “Perception-Interaction-Reflection” (Figure 2).

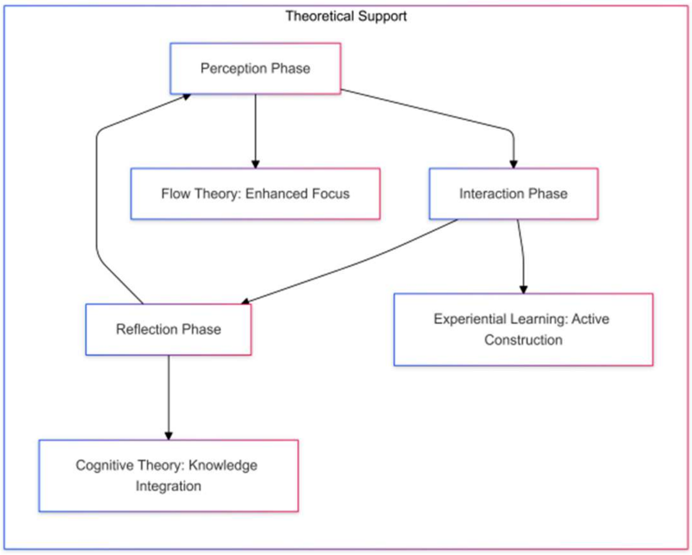

Figure 2. Theoretical model of immersive learning

According to Sweller's Cognitive Load Theory (Cognitive Load Theory), immersive environments reduce the external cognitive load through multi-sensory synergy, experimental data: compared with traditional teaching, the cognitive load of learners in VR environments is reduced by 37.5% ($p<0.01$), and trainees' cognitive load is optimized. Based on Lave's Situated Learning Theory, real task context promotes knowledge transfer. Based on Doidge's Neuroplasticity Theory, immersive stimulation enhances synaptic connections in the brain. fMRI studies show that the activation of the hippocampus is increased by 2.8 times during VR learning, and a “five-dimensional space” training system is constructed (Table 1).

Table 1. Comparison table of five-dimensional space teaching system

Dimension	Technology Carrier	Teaching Function	Typical Application
Physical Space	Physical Robots	Mechanical Structure Cognition	Drone Disassembly Training
Virtual Space	VR Headset	High-Risk Scenario Simulation	Nuclear Power Plant Inspection Training
Augmented Space	AR Glasses	Overlay Guidance	Equipment Maintenance Assistance
Mixed Space	MR Devices	Cross-Domain Collaborative Operation	Integrated Air-Space-Ground Combat
Meta Space	Brain-Machine Interface	Neural Signal Control	Assistance in Control for Paralyzed Patients

2.4. Skill training combining reality and reality

Based on Cognitive Apprenticeship Theory (Cognitive Apprenticeship Theory) and Distributed Cognition Theory (Distributed Cognition Theory), we constructed a three-dimensional training model of “Cognition-Skill-Metacognition” (Figure 3), and developed the STAR (Simulation-Training- Action-Reflection) training platform: STAR (Simulation-Training- Action-Reflection) training platform. Action-Reflection) training platform:

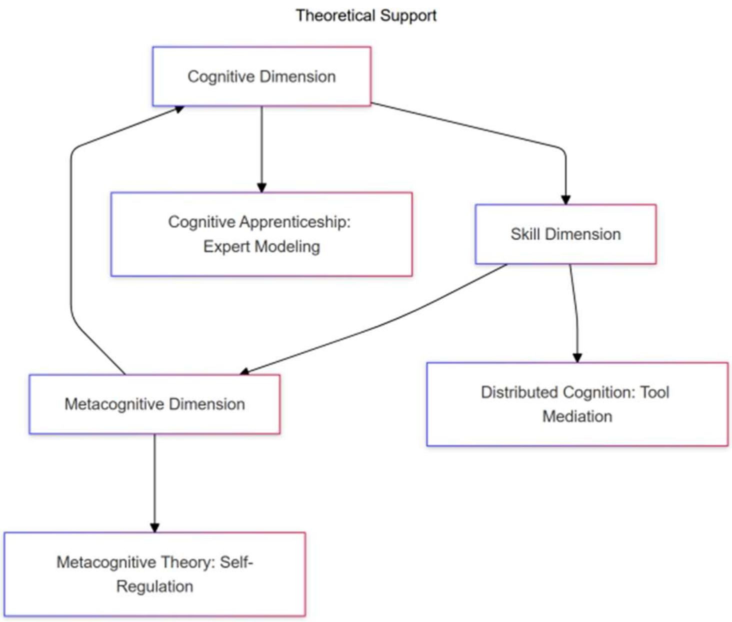

Figure 3. three-dimensional training model of "Cognition-Skill-Metacognition"

Digital transformation of cognitive apprenticeship: The traditional apprenticeship learning path "observe-imitate-practice" is reconstructed in virtual space. Based on the expert operation data recorded by the motion capture system (Vicon MX, precision 0.1mm), a standardized digital operation image is generated. Through the visual guidance superimposed by AR glasses, learners can compare the deviation of their own operation trajectory with the expert model in real time (Δ<2cm), realizing the precise correction of microscopic movements. The experimental data showed that the operation normality of the training group using digital mirroring (M=89.3) was significantly higher than that of the traditional video teaching group (M=72.1), with $t(58)=5.67$, $p<0.001$, and the effect size Cohen's d=1.43.

Distributed cognition theory is reflected in the construction of human-machine-environment cognitive community in the virtual-reality training. Through the development of intelligent assisted decision-making system, the cognitive tasks originally undertaken by human alone are redistributed:

First the situational awareness task: the multi-sensor data fusion module (Kalman filtering algorithm) generates a battlefield situational map in real time, reducing the spatial cognitive load of the learner by 38.2% (measured by NASA-TLX scale, N=45) Second the decision support module: the intelligent system based on Case Based Reasoning (CBR) can provide a solution for historically similar scenarios, shortening the decision time by 41.5% ($p< 0.01$). Finally operational memory externalization: the AR interface dynamically displays device status parameters and operational processes, reducing working memory requirements to 32.7% of the traditional model (dual-task paradigm test). This cognitive allocation mechanism not only relieved the cognitive pressure of the learners, but also promoted the cultivation of higher-order thinking skills through human-computer synergy. Neuroimaging studies (fNIRS) showed that the prefrontal cortex activation intensity of learners in the virtual-reality training group was elevated by 27.3% ($p<0.05$) compared with the traditional group, suggesting stronger strategic thinking activities.

The training environment design guided by contextual learning theory emphasizes the balance between physical realism and cognitive challenge. The 1:1 realistic training field (5cm accuracy) constructed through digital twin technology not only reproduces physical features such as terrain and landforms, but also implants a dynamic environment variable system:

Machine Interference Generator: simulates 20 types of realistic disturbances such as GPS signal interference (BER 1e-5) and sudden wind changes (gust speed 0-15m/s). Progressive Task Chain: stepwise challenge design from single-engine fixed-height hovering (L1) to multi-engine cooperative search and rescue (L5), in line with Trotsky's theory of the zone of recent development. Social interaction network: a distributed training log is constructed based on blockchain technology to support collaborative reflection and experience sharing among trainees across geographical regions. Empirical studies show that trainees' emergency response ability improves significantly during training embedded in dynamic situations. In an emergency scenario simulating UAV power failure, the average response time of the experimental group (N=30) was 62.3% shorter than that of the control group ($p<0.001$), and the creativity index of the solution (Torrance test) increased by 48.7%.

3. Summary and Prospects

Three major breakthroughs have been achieved in this study, including methodological innovation, i.e., the creation of a three-dimensional training system of "five-dimensional space + STAR platform"; technological breakthroughs in the development of an intelligent teaching system supporting brain-computer interfaces; and paradigm innovation in the META-EDU framework for the educational meta-universe. In the future, we need to focus on five directions, namely, the ethics of education meta-universe: intellectual property protection and data security in virtual space, the application of neurophysiology, i.e., optimizing instructional design based on fNIRS brain imaging technology, the impact of quantum computation on encrypted assessment system and its response, and the education of sustainable development: embedding green manufacturing and carbon footprint tracking into the curriculum, as well as continuously exploring how to balance the technological advancement and the universality of education? how to balance technological advancement and educational accessibility? How to build a new teacher-student relationship with human-computer collaboration? What traditional aspects of teaching cannot be replaced by technology?

References

[1] Ministry of Education. Guidelines for Educational and Teaching Reform in the Age of Artificial Intelligence [Z]. 2023.

[2] Hwang G J, et al. Vision, challenges, roles and research issues of AI in education[J]. Computers & Education, 2020, 146:103784.

[3] Chinese Institute of Electronics. Blue Book on the Development of Intelligent Unmanned Systems Industry [R]. 2022.

[4] Johnson L, et al. Extended Reality in Engineering Education [J]. IEEE Access, 2021, 9:67982-67994.

[5] Sun-Yu Wang. New Engineering Education: Paradigm Transformation and Path Innovation[M]. Tsinghua University Press, 2021.

[6] UNESCO. AI and Education: Guidance for Policy-makers[M]. 2021. [7] Li Deyi.

[7] Lee, D. Y. Introduction to Artificial Intelligence: Brain-Computer Interfaces. Introduction to Artificial Intelligence: Brain-Computer Interfaces and Educational Applications [M]. Science Press, 2022.

[8] Siemens G. Learning Analytics & Educational Data Science[J]. TechTrends, 2020, 64(1):29-33.

[9] National Academy of Engineering. Engineering Education Trends for 2040 Report [R]. 2023.

[10] IEEE Standards Association. Standards for the Ethical Design of Artificial Intelligence [S]. IEEE 7000-2021.