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Construction of a "Three Dimensions, Four Stages, Five Enhancements" Innovation and Entrepreneurship Training System for Information Security Majors Under the Background of Emerging Engineering Education

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Abstract: Emerging engineering education prioritizes industry-education integration, interdisciplinary innovation and practical training, which fits the national cybersecurity strategy's need for interdisciplinary information security talents. Nevertheless, the current innovation and entrepreneurship (I&E) training for information security majors in Xinjiang suffers from fragmented procedures, unsystematic progressive design and unclear training goals. Such drawbacks fail to satisfy the talent demands of emerging fields such as zero-trust security and industrial internet security. Guided by emerging engineering education concepts, this study adopts constructivism and competency-based education theories alongside industry-education integration principles to construct a closed-loop I&E training system with three-dimensional linkage, four-stage progression and five-dimensional improvement. It elaborates the system's framework, core connotations and operational mechanisms, and proposes three training paths: expanded knowledge teaching, practice-driven competency enhancement, and project-based I&E cultivation. This paper designs a four-stage training chain of awareness, initiation, practice and incubation, and defines five core objectives covering innovative awareness, thinking, spirit, practical ability and achievement transformation. This research provides theoretical references and a feasible paradigm for the I&E training of information security majors in local universities.

Keywords: Emerging Engineering Education; Information Security Major; Innovation and Entrepreneurship Training; Three Dimensions, Four Stages, Five Enhancements; Talent Training System.

1. Introduction

1.1. Research Background

The ongoing new round of technological and industrial transformation is pushing the cybersecurity industry toward intelligent upgrading, scenario-oriented application and cross-field integration[1]. In response to industrial changes, the national cybersecurity strategy has put forward clear requirements for cultivating interdisciplinary talents who possess solid technical foundations, innovative thinking, practical operational abilities and commercial transformation awareness. As a vital reform direction of higher engineering education, emerging engineering education abandons the traditional engineering training mode that overemphasizes theoretical knowledge while neglecting practical training and innovative cultivation. It constructs a new talent training system featured by interdisciplinary integration, university-enterprise cooperation and competency-oriented cultivation, which offers solid policy basis and theoretical support for the innovation and entrepreneurship (I&E) teaching reform of information security majors.

As a core region of the Silk Road Economic Belt, Xinjiang has witnessed in-depth integration of the digital economy with local energy and manufacturing industries, resulting in a huge talent shortage in industrial control security, cross-border data security and regional network protection fields. Nevertheless, the I&E training system for information security majors in local universities still has obvious drawbacks. First, training dimensions are fragmented. Theoretical teaching, practical training and achievement transformation are poorly connected, which separates professional teaching from I&E cultivation. Second, the training process lacks progressive design. The existing system fails to follow students' cognitive development rules, leading to weak innovative awareness among freshmen and sophomores and insufficient incubation resources for senior students. Third, training objectives are vague. There are no targeted professional competency standards and scientific evaluation systems, making it hard to quantify and assess students' I&E cultivation effects. Under such circumstances, building a targeted I&E training system that adapts to regional industrial demands and emerging engineering education concepts has become a key task for the talent training reform of local information security majors.

1.2. Research Significance

1.2.1. Theoretical Significance

Combining emerging engineering education philosophy with constructivism, competency-based education and industry-education integration theories, this study innovatively establishes a unique I&E training system defined as "Three Dimensions, Four Stages, Five Enhancements" for information security majors. This paper clarifies the internal logical framework, core connotation and practical operational mechanism of the constructed system, which remedies the inadequacy of theoretical research on targeted I&E cultivation for local information security majors. It further improves the theoretical framework of emerging engineering-oriented I&E education for engineering students, and offers a referable theoretical paradigm for talent training reform of relevant majors in regional universities.

1.2.2. Practical Significance

Tailored to the unique industrial characteristics of Xinjiang, the constructed system effectively targets the key bottlenecks existing in current I&E training practices. It sets out phased, multi-dimensional and multi-subject educational paths, which can provide practical guidance for the curriculum optimization, practical platform development and university-industry cooperation of local information security majors. This system facilitates the cultivation of interdisciplinary innovative and entrepreneurial talents matching the development demands of regional cybersecurity industries, and delivers solid talent guarantees for the safe and high-quality development of Xinjiang's digital economy.

1.3. Research Status

1.3.1. International Research

Overseas colleges and institutions have carried out innovation and entrepreneurship (I&E) education for a long time and formed relatively mature training paradigms. Typical representatives include the innovation ecosystem in the United States, the dual vocational education system in Germany, and the practice-oriented innovation training model in Singapore. These international models share common characteristics: in-depth university-industry collaboration, whole-process practical teaching, and high attention to the commercialization of innovative achievements. In the field of information security, foreign universities focus on the integrated cultivation of technological research capabilities and entrepreneurial literacy. They adopt real enterprise projects as core teaching carriers to carry out practical I&E training, so as to improve students' ability of technological innovation and achievement transformation[2]. Nevertheless, most existing studies mainly concentrate on universal I&E training frameworks for engineering majors. Few scholars have constructed targeted and systematic training systems that fit local industrial characteristics and professional scenarios of information security, leaving a research gap in localized talent cultivation schemes.

1.3.2. Domestic Research

Domestic scholars have carried out in-depth explorations on the integration of emerging engineering education with innovation and entrepreneurship education, and relevant studies mainly fall into three categories. First, multiple studies focus on the reform of I&E training modes and have put forward diversified cultivation paths featuring progressive training, industry-education integration, and the combination of professional teaching with innovative education[3]. Second, existing research explores curriculum system optimization, attempting to integrate I&E literacy training into professional course design. Third, many studies concentrate on practical platform construction, aiming to build a sound practical education system through in-depth university-enterprise collaboration. Despite fruitful achievements, current research still has obvious limitations. The existing reforms are usually fragmented and single-dimensional, lacking a complete closed-loop cultivation design covering theoretical learning, practical training and achievement transformation. In addition, most established models are universal and generalized, with few targeted at the operational characteristics of local universities and the professional attributes of information security disciplines[4]. Furthermore, relevant studies prefer to summarize practical experience and operational paths, while paying insufficient attention to systematic theoretical demonstration and logical mechanism interpretation, resulting in insufficient theoretical depth.

1.3.3. Research Commentary

Although existing international and domestic research has laid certain theoretical foundations and practical references, few studies have constructed a targeted I&E training system that fits emerging engineering education requirements, matches the professional traits of information security, and adapts to regional industrial development needs[5]. Specifically, there is a severe lack of in-depth theoretical elaboration on the construction logic, core connotation and operational mechanism of localized training systems. Targeting the above research gaps, this paper constructs a novel I&E training system named "Three Dimensions, Four Stages, Five Enhancements", which integrates theoretical innovation with practical applicability to complement current research deficiencies[6].

2. Core Concept Definition and Theoretical Foundation

2.1. Core Concepts

2.1.1. Emerging Engineering Education

Emerging engineering education serves as a comprehensive educational philosophy and practical system that responds to emerging technologies, new industries, innovative business formats and modern development models. Centering on industry-education integration, interdisciplinary cooperation and innovative empowerment, it commits to cultivating interdisciplinary, innovative and application-oriented engineering talents who can adapt to ongoing technological and industrial transformation. This education model is typically characterized by cross-disciplinary integration, practice-oriented cultivation, industrial adaptability and innovation-driven development.

2.1.2. I&E Training for Information Security Majors

The I&E training for information security majors is a industry-oriented educational activity rooted in the practical demands of the cybersecurity sector. It aims to cultivate students' innovative awareness, polish their creative thinking, and improve their comprehensive entrepreneurial competencies. This training mode organically combines core information security technologies, including network attack and defense, data encryption and industrial control security, with interdisciplinary I&E knowledge such as business planning, market investigation and research, and technological achievement transformation. Relying on systematic theoretical teaching, hands-on practical training and whole-process project incubation, it empowers students with solid technological innovation ability and entrepreneurial practical literacy, with the core goal of realizing the in-depth integration of professional technical skills and innovative entrepreneurial capabilities.

2.1.3. Three Dimensions, Four Stages, Five Enhancements

The overall I&E cultivation framework proposed in this paper consists of three core modules, namely Three Dimensions, Four Stages and Five Enhancements. The three synergistic educational dimensions adopt the collaborative cultivation modes of expanded classroom knowledge teaching, practice-driven competency upgrading, and project-based I&E training, which jointly form a complete closed-loop development path covering theoretical learning,

practical exercise and achievement transformation. The four-stage progressive training system follows students' cognitive growth rules, arranging targeted cultivation tasks for students at different grades: innovation awareness building for freshmen, preliminary exploration and initiation for sophomores, comprehensive practical training for juniors, and achievement incubation and promotion for seniors. In addition, five core capability enhancement goals run through the whole training cycle, including stimulating students' innovative awareness, shaping their professional innovative thinking, cultivating positive innovative and entrepreneurial spirit, improving comprehensive I&E practical abilities, and boosting the effective transformation of innovative academic and technological achievements.

2.2. Theoretical Foundations

2.2.1. Constructivism

Constructivism holds that learning is a proactive knowledge-building process rather than passive knowledge reception, highlighting the contextual, practical and interactive nature of student learning. This theory provides solid cognitive and logical support for the design of the proposed training system. The lecture-plus model builds a systematic theoretical learning context, enabling students to gradually construct integrated knowledge systems that combine professional expertise with I&E literacy. The practice-plus approach adopts real-world industrial scenarios to help students deepen professional cognition and internalize competencies through hands-on operation. Meanwhile, the project-plus mode encourages team-based exploration, which facilitates knowledge migration and innovative application, and effectively conforms to the progressive law of students' autonomous ability development.

2.2.2. Competency-Based Education (CBE)

Different from traditional teaching theories, competency-based education (CBE) takes professional post competency standards as its core orientation. It focuses on fostering students' all-round practical abilities and adheres to the principles of competency guidance, practical dominance and staged progressive cultivation. This theory lays a solid foundation for the objective setting and phased design of the proposed training system. On one hand, the five-dimensional capability enhancement goals are formulated in strict accordance with the actual job competency requirements of the cybersecurity industry. On the other hand, the four-stage progressive training chain is scientifically designed based on the inherent development rules of students' professional competency.

2.2.3. Industry-Education Integration Theory

Industry-education integration theory stresses close collaboration between universities and industries to make talent cultivation adaptable to real industrial demands, with core values covering university-enterprise cooperation, resource sharing and two-way mutual empowerment. This theory effectively underpins the collaborative education mechanism of the designed training system. The three-dimensional cultivation model brings together university teachers, industrial instructors and professional industry experts to build a multi-subject joint training team. Furthermore, the project-plus cultivation mode introduces authentic enterprise projects, ensuring that classroom teaching content is closely connected with cutting-edge industrial technologies and practical industry scenarios.

2.2.4. Closed-Loop Management Theory

Closed-loop management focuses on full-process and full-element systematic control via a cyclic mechanism of goal formulation, implementation execution, effect feedback and iterative optimization, which guarantees standardized and efficient system operation. This theory supports the overall operational logic of the constructed I&E training system from multiple dimensions. The three-dimensional linkage mechanism builds a complete circulating loop covering talent input, competency transformation and ability output. The four-stage progressive training mode forms a gradual growth closed loop that moves students from initial awareness and continuous growth to competency maturity and achievement landing. Meanwhile, the five enhancement objectives constitute a dynamic iterative system, which proceeds with targeted capability cultivation, training effect assessment and continuous scheme optimization throughout the whole training process.

3. Current Dilemmas in I&E Training for Information Security Majors

3.1. Fragmented Training Dimensions, Insufficient Integration of Professional and I&E Education

The prevailing I&E training mode for information security majors simply superposes professional courses with general entrepreneurship lectures, resulting in disjointed and fragmented cultivation dimensions. In terms of lecture-based teaching, the curriculum overly focuses on technical theoretical knowledge, with inadequate integration of innovative and entrepreneurial elements, making it hard to cultivate students' commercial thinking and innovative literacy. For practical training, most tasks are confined to simulated classroom drills and single technical exercises, without embedding real industrial scenarios that match industry demands. In terms of project training, many training projects lack practical value and professional pertinence. Most projects are divorced from information security disciplinary characteristics and actual industrial needs, while the supporting incubation resources are also insufficient, leading to formalized training outcomes. Such separation between professional education and I&E cultivation fails to generate coordinated educational effects, greatly restricting the overall quality of talent training.

3.2. Homogenized Training Stages, Absence of Progressive Design

Most local universities adopt a rigid, one-size-fits-all I&E training mode that fails to align with students' cognitive and growth patterns. In the early learning stage, schools arrange sophisticated I&E projects for lower-grade students who lack solid professional foundations, resulting in poor understanding and low student participation. For upper-grade learners, practical training activities tend to be repetitive and homogeneous, with no tiered capability improvement design, which greatly restricts students' innovative potential. Furthermore, the existing training system suffers from disjointed teaching objectives, inconsistent course content and unsystematic teaching methods across different academic years. It lacks a complete progressive cultivation chain that spans awareness enlightenment, knowledge accumulation, practical exercise and achievement incubation, making it

difficult to support students' continuous innovative and entrepreneurial growth.

3.3. Vague Training Objectives, Absence of Competency Standards and Evaluation Systems

In addition, the current I&E training system has two prominent drawbacks in goal orientation and evaluation mechanisms. First, core competency objectives are ambiguous. Existing training schemes fail to precisely anchor the five key dimensions of awareness cultivation, innovative thinking shaping, entrepreneurial spirit fostering, practical capability improvement and achievement transformation. They also cannot fully match the professional characteristics of information security disciplines and the unique talent demands of regional cybersecurity industries. Second, the evaluation system is unscientific and unreasonable. Most assessment methods lack staged and multi-dimensional quantitative criteria. They overly rely on tangible achievements such as discipline competitions and academic publications, while neglecting comprehensive, process-based evaluation of students' long-term innovative potential and entrepreneurial literacy.

3.4. Loose Collaborative Mechanisms, Insufficient University-Industry Linkage

Local universities also struggle with inadequate and superficial university-industry collaboration in I&E cultivation. Enterprise participation remains limited to basic student internships, with few enterprises deeply involved in core educational links such as curriculum development and achievement incubation. Meanwhile, the teaching team construction faces obvious bottlenecks. Industry experts rarely participate in regular classroom teaching, while most full-time teachers lack front-line industrial practical experience, resulting in a weak dual-qualified teaching team. Furthermore, the sharing of high-quality industrial resources is insufficient. Authentic enterprise cases, technical resources and professional incubation platforms have not been fully integrated into daily teaching, leading to low resource utilization efficiency and restricting the practicality and professionalism of I&E training.

4. Theoretical Construction of the "Three Dimensions, Four Stages, Five Enhancements" System

4.1. Core Principles

Four core design principles are proposed to guide the systematic construction of the I&E training system for information security majors.

First, emerging engineering orientation. The system insists on interdisciplinary border integration, practical teaching empowerment and industrial demand adaptation. It keeps pace with the technological iteration and market upgrading of the cybersecurity industry, so as to achieve precise alignment between talent cultivation and industrial development.

Second, in-depth integration of professional education and I&E cultivation. Centering on professional cybersecurity technical training, the system further expands students' innovative thinking and entrepreneurial practical capabilities. It fundamentally avoids the common problem of disjointed professional teaching and I&E education in traditional training modes.

Third, staged progressive adaptation. Fully respecting students' cognitive rules and ability growth rhythms, the system formulates hierarchical training objectives and layered teaching content at different learning stages. Such progressive design enables students to achieve steady and continuous competency improvement from basic cognition to innovative application.

Fourth, closed-loop collaborative education. The system integrates high-quality resources from universities, enterprises and other social parties to build a multi-subject collaborative cultivation mechanism. It realizes whole-process management, dynamic feedback and iterative optimization, forming a complete closed-loop operation for talent training.

4.2. Logical Framework

Under the guidance of emerging engineering education concepts, the training system takes core competency improvement as its central goal and relies on closed-loop collaborative education as the fundamental support. It establishes a complete logical architecture consisting of one core, three dimensions, four stages, five enhancements and multi-party collaboration.

The "one core" refers to the fundamental training goal of cultivating interdisciplinary innovative and entrepreneurial talents who can meet the development demands of regional cybersecurity industries. The "three dimensions" cover the lecture-plus, practice-plus and project-plus cultivation paths, which correspond to the whole-process training links of theoretical learning, practical training and achievement transformation. The "four stages" include awareness enlightenment, preliminary initiation, practical exercise and achievement incubation, constructing a complete progressive cognitive and ability growth chain for students. The "five enhancements" target the core competency objectives, covering the improvement of innovative awareness, innovative thinking, entrepreneurial spirit, comprehensive I&E capabilities, and achievement transformation ability. In terms of multi-party collaboration, the system integrates diversified resources from universities, enterprises, industries and alumni communities to build a joint training ecosystem.

4.3. Core Connotations

4.3.1. Three-Dimensional Linkage: Theory–Practice–Transformation Closed Loop

(1) Lecture-plus: Knowledge Delivery

This dimension adopts a professional and I&E dual-track teaching mode with grade-specific content and tutors. Freshmen acquire preliminary innovative awareness through senior students' project sharing. Sophomores learn basic I&E knowledge integrated with professional technical courses via faculty teaching. Juniors receive guidance from industry mentors on industrial security cases and project design. Seniors obtain one-on-one alumni guidance on achievement commercialization, intellectual property protection and policy application.

(2) Practice-plus: Competency Improvement

Following the progressive logic of exploration, design, verification and application, this dimension delivers hierarchical scenario-based practice. Freshmen investigate campus and enterprise cybersecurity pain points to build industrial cognition. Sophomores conduct project feasibility analysis, technical design and functional testing. Juniors

finish prototype development and experimental verification in laboratory and simulation environments. Seniors participate in enterprise pilot deployment and operational tracking, connecting professional technologies with industrial practical needs.

(3) Project-plus: I&E Training

Centering on real information security scenarios, this dimension builds a full-cycle project incubation system. Freshmen participate in basic project work under tutor and senior guidance to accumulate experience. Sophomores complete project selection, demonstration and overall planning. Juniors develop and iteratively optimize technical prototypes through interdisciplinary teamwork. Seniors advance project incubation and commercialization, and apply for patents and software copyrights to transform innovative achievements.

4.3.2. Four-Stage Progression: Progressive Training Chain

Table 1. Four-Stage Progression: Progressive Training Chain

Stage	Grade	Core Goal	Key Content	Facilitators
Awareness	Freshman	Spark innovation awareness	Industry cognition, needs survey, mentorship	Outstanding students, faculty
Initiation	Sophomore	Build I&E knowledge	Professional + I&E courses, design, topic selection	Faculty, industry experts
Practice	Junior	Build I&E capabilities	Prototyping, practical training, competitions	Entrepreneurs, industry experts
Incubation	Senior	Boost I&E performance	Optimization, incubation, entrepreneurship guidance	Alumni, enterprise mentors

5. Conclusion and Outlook

Focusing on the context of emerging engineering education transformation and the unique cybersecurity talent needs of Xinjiang's digital industry, this study addresses key shortcomings in the existing I&E training for information security majors. These prevailing problems involve disjointed training modules, uniform and non-progressive training arrangements, undefined competency cultivation objectives, and superficial university-enterprise cooperative mechanisms. Based on constructivism, competency-based education, industry-education integration and closed-loop management theories, this paper develops a customized I&E training system featuring "Three Dimensions, Four Stages, Five Enhancements". Following four practical design principles—emerging engineering orientation, integration of professional and I&E education, graded progressive cultivation, and closed-loop collaborative education—the study systematically expounds the system's overall logical framework, core connotation, and operational mechanism. It also clarifies the three-dimensional linkage paths, four-stage progressive training sequence, and five core capability improvement objectives, offering a practical and targeted theoretical framework for optimizing localized I&E talent training in regional universities. To further verify and improve the system, follow-up research will carry out pilot teaching practice at Xinjiang University of Science and Technology. Combined with practical teaching effects and industrial technology development trends, the training content, implementation approaches and evaluation criteria will be dynamically adjusted and optimized. The constructed system is conducive to cultivating high-quality interdisciplinary talents with solid cybersecurity technology and innovative entrepreneurial literacy, which can effectively support national cybersecurity development and empower the high-quality growth of Xinjiang's regional digital economy.

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