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Exploration and Practice of Building a High-Quality Innovation and Entrepreneurship General Education Course under the CDIO Paradigm

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Abstract: ***Grounded in the Conceive-Design-Implement-Operate (CDIO) engineering education paradigm, this study explores an innovation and entrepreneurship talent cultivation model featuring "one core, two wings, and three drivers," realizing the restructuring and upgrading of the innovation and entrepreneurship education paradigm oriented toward high-quality courses. By adopting a blended online-offline instructional modality and integrating intelligent technologies, a pedagogical platform for high-quality general education courses is constructed. Furthermore, through an organic cyclic mechanism combining teacher-led case instruction with student-collaborative case creation, a high-level case database is synergistically developed to establish an open and ubiquitous case-based teaching environment. Organically integrating ideological and political education with general education, an integrated pedagogical model is proposed for cultivating ideological-political literacy alongside innovation and entrepreneurship competencies. The exploration and practice of developing high-quality general education courses in innovation and entrepreneurship under the CDIO paradigm provide valuable reference points for cultivating well-rounded, interdisciplinary talent and advancing smart teaching and talent cultivation.***

Keywords: General Education Course; Innovation and entrepreneurship practice; Conceive-design-implement-operate; Engineering education.

1. INTRODUCTION

Against the backdrop of the "mass entrepreneurship and innovation" initiative, innovation has emerged as a vital factor steering contemporary economic development; consequently, cultivating high-caliber talent in innovation and entrepreneurship represents a pressing imperative that higher education must confront. Innovation and entrepreneurship education serves as a pivotal breakthrough point for the reform of talent cultivation in higher education. Advancing the reform and practice of university students' innovation and entrepreneurship education to cultivate innovative and entrepreneurial talents aligns closely with national policy orientations and facilitates the development of well-rounded, interdisciplinary talent. As one of the prominent achievements of international engineering education reform, the Conceive-Design-Implement-Operate (CDIO) engineering education model spans the entire spectrum of four educational and practical training stages—conceiving, designing, implementing, and operating—which aligns seamlessly with the market orientation of innovation and entrepreneurship [1]. Against the backdrop of the big data era, general education, which regards the "integration of knowledge" as its supreme objective, is undergoing diversified reforms and evolving toward realizing multifaceted values advocated by the concept of "parallelism" [2]; it not only underscores students' acquisition of broad and comprehensive knowledge, but also demands the enhancement of their applied and practical competencies. General education represents an inevitable trend for Chinese universities to align with international higher education, and higher education reform should advance toward a "parallel" general education direction that places equal emphasis on general education and specialized education. Accordingly, exploring talent cultivation models for innovation and entrepreneurship under the CDIO paradigm, forging "high-quality general education courses" in innovation and entrepreneurship, propelling the restructuring and upgrading of university entrepreneurial education models, and cultivating well-rounded talent equipped with innovative and entrepreneurial capabilities have emerged as a critical issue confronting entrepreneurship education in higher education institutions today.

In recent years, innovation and entrepreneurship education has burgeoned worldwide, with comparatively mature educational paradigms established in Europe and the United States. In the United States, entrepreneurship

education is categorized into focused and universal modalities: the former is offered exclusively in business and management schools and is restricted to their enrolled students, whereas the latter is accessible to students across all academic disciplines. In terms of curriculum design, it dismantles disciplinary boundaries and accentuates experiential pedagogies driven by problems, actions, and contingencies. Through the application of classic case-based teaching methods, university students are encouraged to assume a managerial perspective to confront corporate decision-making dilemmas, thereby cultivating their capacities for insight, discernment, and decision-making regarding entrepreneurial opportunities and challenges through the in-depth dissection of both successful and failed innovation and entrepreneurship cases [3]. Concurrently, practical endeavors anchored by diversified organizational and institutional platforms enable undergraduates to be comprehensively immersed in an atmosphere conducive to innovation and entrepreneurship [4]. In the United Kingdom, innovation and entrepreneurship education places significant emphasis on curricular configuration alongside the construction of educational models spearheaded by entrepreneurial projects. Specifically, curricular offerings encompass two primary categories: courses "for entrepreneurship" and courses "about entrepreneurship." Through instructional activities such as contextualized scenario setting, case studies, and business planning, emphasis is placed on fostering students' core and auxiliary entrepreneurial competencies. Subsequently, driven by entrepreneurial projects, students are guided to deliberate on entrepreneurial strategies in collaboration with entrepreneurs or to establish enterprises directly, thereby achieving an organic integration of theoretical inquiry and practical application in innovation and entrepreneurship [5-6].

From the perspective of the nation and society, high-quality general education courses in innovation and entrepreneurship serve as the principal arena for cultivating applied innovative talent and constitute the cradle for the vanguard of future entrepreneurs. For higher education institutions, developing high-quality general education courses represents a vital link within entrepreneurship education, acting not only as a pivotal component in the top-level design of educational systems, but also as an innovative breakthrough for university brand building [7]. For educators, the development of such high-quality general education courses enhances instructional competence and provides a valuable window for innovative pedagogical practices. For students, engaging in the study of high-quality general education courses enables them to grasp the essence of innovation and entrepreneurship through foundational theories, while cultivating innovative thinking, mastering entrepreneurial dynamics, and honing creative skills within practical endeavors, thereby comprehensively enhancing their overall competence [8]. Consequently, the imperative of constructing high-quality general education courses in innovation and entrepreneurship is self-evident. Accordingly, higher education institutions must undertake a "student-development-centered" restructuring and upgrading of their entrepreneurship education paradigm. This approach aims to transform students' learning attitudes, heighten their awareness of and interest in innovation and entrepreneurship, and cultivate their entrepreneurial character traits and competencies, ultimately fulfilling the objectives of bolstering students' entrepreneurial intentions and propelling their practical entrepreneurial endeavors.

2. EXPLORATION OF THE "ONE CORE, TWO WINGS, AND THREE DRIVERS" INNOVATION AND ENTREPRENEURSHIP TALENT CULTIVATION MODEL UNDER THE CDIO PARADIGM

The essence of the "one core" lies in blended learning, with "extracurricular practice and competition-based enhancement of teaching" serving as an indispensable extension from curricular instruction to extracurricular practice. The "two wings"—scientific research and interaction—safeguard educational quality, leveraging scientific research as the foundation to propel classroom upgrading and utilizing interactive classrooms as the vehicle to foster synergistic co-development. Grounded in a student-centered philosophy, the "three basics" of teaching adhere to forward-looking curriculum development principles, prioritize the cultivation of learners' higher-order thinking skills and learning process evaluation, and facilitate students' well-rounded development. Building upon this talent cultivation paradigm, a CDIO-based blended instructional model and an innovation and entrepreneurship practical training system are constructed to bolster university students' innovative and entrepreneurial capabilities.

Through CDIO blended learning, functionalities such as autonomous knowledge construction, online communication, and project progress tracking are realized, enabling students to effectively manage CDIO projects. By orchestrating instructional content via a "5+4" framework and implementing online-offline flipped classrooms, interactive workflows substantially enhance student engagement. Instructors guide five pivotal stages while students benefit from higher-order learning conditions across four dimensions, balancing collective teamwork with

individual growth and cultivating comprehensive capacities to solve complex engineering problems. Specifically, instructors manage the five-step critical sequence of "task-driven initiation → testing and critique → discussion organization → project presentation → data feedback": 1) Sharing pedagogical materials to facilitate task-driven learning; 2) Utilizing item banks via mobile terminals to conduct in-class quizzes, review student insights, reinforce core curricular knowledge, organize classroom problem discussions, and invigorate classroom dynamics through mobile-based interaction and online "likes"; 3) Bridging knowledge points to shape competencies, facilitating online submission of experimental and practical projects, and conducting competency verification and assessment; 4) Flipping the classroom, recording and reviewing in-class performances in real time, identifying deficiencies, and providing constructive positive encouragement; 5) Generating data profiling to deliver real-time feedback on collective and individual learning analytics, positively stimulating students' learning initiative, and iteratively optimizing classroom instruction. Concurrently, this framework activates four learner states: "ubiquitous learning, team interaction, work presentation, and competency accumulation." Students navigate four systematic steps: 1) Pre-class preparation and uploading reflective insights; 2) Conducting thematic group discussions; 3) Refining deliverables and delivering on-stage presentations; 4) Engaging in outcome feedback and completing assignments. Through seamless online-offline interaction, this approach promotes students' progression from knowledge acquisition and understanding to practical mastery, thereby steadily enhancing their competencies.

Constructing an undergraduate innovation and entrepreneurship practical training system involves selecting and cultivating high-caliber projects while balancing collective teamwork with individualized development. Embedding CDIO practices throughout students' entire university academic journey facilitates the comprehensive, multidimensional enhancement of their overall competence. Through a matrix-based CDIO approach, an organizational architecture is established: 1) Systematically collating relevant policies and specialized competition guidelines, while compiling exemplary CDIO projects, distinguished capstone design projects, high-quality research initiatives, and competition-oriented projects slated for incubation into a repository of exemplary projects and works, thereby delivering targeted, specialized mentorship. 2) Capitalizing on the university's innovation and entrepreneurship association, an operational mechanism is established wherein instructional faculties focus on key project teams, mentors foster student leaders, and student leaders mobilize team members, thereby ensuring universal participation alongside targeted breakthroughs.

The CDIO project framework is refined by adopting student-centered "Curricular CDIO" and "Activity-based CDIO" groups as the foundation, while employing faculty-led "Research CDIO" teams for advanced progression. This approach cultivates university students' scientific research thinking and enhances their innovation and entrepreneurship capabilities, establishing a matrix-based CDIO talent cultivation model. Building upon the curricular, activity-based, and research CDIO project units, student research, innovation, and entrepreneurship teams are assembled to incubate seed cohorts with priority. Simultaneously, elite teams are openly selected and formed to undergo structured, targeted intensive study and hands-on training. Ultimately, improving the overall quality and capabilities of team members drives the qualitative and quantitative growth of scientific research and innovation-entrepreneurship projects, shaping a new landscape for the innovation and entrepreneurship education system.

3. CONSTRUCTION OF A PEDAGOGICAL PLATFORM FOR HIGH-QUALITY GENERAL EDUCATION COURSES BASED ON A BLENDED ONLINE-OFFLINE INSTRUCTIONAL MODALITY

Leveraging introduced or self-developed Massive Open Online Courses (MOOCs), localized adaptations are implemented in accordance with practical institutional contexts in the form of Small Private Online Courses (SPOCs) or alternative online course formats. Relying on intelligent instructional tools provided by public service platforms, diverse application modalities are explored, closely aligning with the characteristics of university students and talent cultivation requirements. Supported by open online course resources and implemented through multifaceted blended online-offline pedagogical applications, this approach achieves classroom teaching reform and methodological innovation, continuously enhancing instructional efficacy and optimizing curriculum resource development. Grounded in the online-offline instructional design of high-quality courses, modern information technologies are integrated to reshape curriculum architectures and reform instructional content and pedagogical methods, thereby facilitating the large-scale dissemination of high-quality course resources under the "Internet+" initiative.

In the development of the blended learning platform, digital case development directly influences the comprehensive cultivation of students' innovative and entrepreneurial competencies; thus, the project team proposes an organic cyclic model combining teacher-led classroom case instruction with student-collaborative case creation. Addressing pivotal scientific and technological challenges derived from research projects and enterprise engineering requirements, the teaching faculty prioritizes the construction of an exemplary case repository to present cases, orchestrate analyses, and synthesize critiques. Concurrently, it systematically elucidates foundational aspects—including case selection principles, case discussion techniques, contextual background elements, and case writing specifications—thereby laying a solid foundation for collaborative case development by students. Building upon the foundation of teacher-led case pedagogy, students engage in collaborative case creation. The essence of this student-collaborative case development process is a problem-oriented learning journey; it constitutes a process wherein students, confronted with authentic challenges within contextualized innovation and entrepreneurship practices, engage in cooperative learning and autonomous inquiry to resolve authentic problems, conduct critical reflection, and achieve deep learning. Consequently, instructors leverage case-based instruction as classroom activities to pave the way for students' case writing; simultaneously, students engage in collaborative case creation anchored by problem-solving, which in turn feeds back instructional cases to the faculty.

4. INTEGRATED PEDAGOGICAL MODEL FOR CULTIVATING IDEOLOGICAL AND POLITICAL EDUCATION ALONGSIDE INNOVATION AND ENTREPRENEURSHIP COMPETENCIES

In light of the distinct characteristics of innovation and entrepreneurship courses, ideological and political elements are organically woven into course objectives, pedagogical methods, and instructional content, seeking subtle and pervasive implementation approaches for ideological and political education to realize its value-guiding function. The six requirements articulated by General Secretary Xi Jinping for youth in the new era—"establishing lofty ideals, cherishing the great motherland, shouldering the responsibilities of the times, daring to struggle tenaciously, honing exceptional skills, and tempering moral character"—are internalized into talent cultivation objectives and ideological-political integration mechanisms. This enables instructors to accurately identify the pivotal leverage points for ideological-political education within innovation and entrepreneurship instruction, thereby accentuating value cognition, reinforcing value identification, and strengthening value practice. By capitalizing on key instructional links such as thematic seminars, core knowledge points, and academic frontier lectures, and through approaches such as enhancing the political literacy of specialized course instructors, forging teacher-student learning communities, reforming teaching methods, applying new media and emerging information technologies, and executing innovation-entrepreneurship training projects, intangible ideological and political elements are infused into tangible pedagogical activities. While conveying the scientific thinking, academic thinking, and engineering thinking inherent in science and engineering disciplines, instructional activities organically permeate patriotism, moral character, ethical values, education on the "three outlooks" (worldview, outlook on life, and values), ideals and convictions, as well as innovation and entrepreneurship education. Consequently, this promotes the deep integration of specialized disciplinary instruction and ideological-political education, ultimately elevating the instructional quality of higher education and the cultivation caliber of high-end innovative talents.

Focusing on curriculum design and instructional activities, elements including "ideals and convictions, patriotism and national commitment, scientific spirit, craftsmanship spirit, and global perspective" are seamlessly integrated into every facet of education and teaching—akin to salt dissolving in water, invisible and intangible, yet omnipresent. In accordance with the progressive trajectory of "innovative thinking → innovation techniques → classic cases → frontier exploration → innovative practice," instructional content is optimized to deepen the integration of ideological and political connotations, allowing students to profoundly grasp the strategic significance of "Made in China 2025." The pedagogical process is structured into four progressive tiers: "Guiding the Path" (Ling Dao) through ideological-political elements, "Inquiring the Path" (Wen Dao) via disciplinary frontiers, "Collaborating on the Path" (Tong Dao) through innovative methods, and "Internalizing the Path" (Wu Dao) through practical inquiry. This establishes a "four-in-one" curriculum-based ideological and political education system for innovation and entrepreneurship, thereby forging an integrated pedagogical model that synergistically cultivates ideological-political literacy and innovative capabilities.

5. CONCLUSION

By constructing a CDIO-based blended instructional model, a matrix-based innovation and entrepreneurship practical training system, and an open case-based learning environment, the CDIO framework is embedded throughout the entire continuum of curricular study, project practice, and innovation-entrepreneurship training, thereby facilitating the organic articulation among students' knowledge acquisition, competency development, and practical application. Concurrently, the cyclic mechanism combining teacher-led case pedagogy with student-collaborative case creation drives the continuous generation and iterative upgrading of high-quality case resources. Furthermore, integrating ideological and political education into instructional links—including innovative thinking, innovation techniques, case studies, and practical inquiry—realizes the synergistic educational integration of value guidance, knowledge impartation, competency development, and innovation-entrepreneurship practice. Grounded in the CDIO paradigm, the development of high-quality general education courses in innovation and entrepreneurship effectively broadens the integrative domain connecting general education with specialized engineering practice, providing a novel pedagogical model and actionable pathway for cultivating well-rounded, interdisciplinary talent endowed with innovative consciousness, practical capabilities, collaborative spirit, and engineering literacy.

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