

Exploring the Path for Cultivating Technological Innovation Ability of Vocational Undergraduate Engineering Students

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Abstract: Targeting the development of high-level technical and innovative talents, this study explores a systematic approach to cultivating the technological innovation ability of vocational undergraduate engineering students. Drawing on empirical data from 120 students at three vocational universities in Hainan Province, the research examines how practical teaching, when designed as a continuous core platform, enhances students' innovation consciousness and engineering competence. The proposed model integrates three interdependent dimensions—engineering quality, innovative consciousness, and innovative thinking—forming a structured pathway for nurturing technological innovation. Results indicate a significant improvement in students' innovation awareness and project-based problem-solving ability after applying the model. This study contributes theoretical and practical insights into China's vocational education reform, offering an evidence-based framework for strengthening innovation capability development in technical higher education.

Keywords: Vocational Undergraduate Program; Engineering; Practical Teaching

1. Introduction

In recent years, China's vocational undergraduate education has entered a crucial stage of transformation. The "Double High Plan" and "Made in China 2025" strategy both emphasize the integration of engineering technology with innovation-driven growth. Vocational universities are no longer limited to producing technical workers; instead, they are expected to cultivate application-oriented engineers capable of independent design, R&D, and process improvement. These policy directions create new expectations for universities to balance theoretical education with industrial practice and innovation incubation.

It is not difficult to find from the relevant literature on the cultivation of innovative talents in China that the research content mainly focuses on exploring innovative talent cultivation models, educational and teaching reforms, and the construction of technology and skill innovation service platforms. The research and exploration of innovative talent cultivation models is a research direction that many scholars are concerned about. For example, Xinlu Li et al. ^[1] explored the innovative talent cultivation models in universities; Hongmin Chen et al. ^[2] conducted research and practice on innovative talent cultivation models in private undergraduate universities; Some scholars explore the cultivation of innovative talents from the perspective of education and teaching reform. For example, Yong Li et al. ^[3] proposed the "four types and seven dimensions" innovative talent cultivation model, which classifies innovative talents into four categories. Guided by the "3+X" mechanism, innovative talents are cultivated from seven dimensions of ability cultivation model, which can improve students' academic innovation ability, engineering practice ability, and international competitiveness; Lei Yang et al. ^[4] studied the design thinking driven innovation talent cultivation model in higher education engineering. Through deep collaboration between schools and enterprises, the integration of production, education, and innovation chains, a comprehensive innovation curriculum system was constructed, and the PBL project-based teaching model was used to support the "student-centered" curriculum reform. Some researchers focus on the cultivation of innovative talents from the perspective of the construction of technology and skill innovation service platforms. For example, Jinghong Wu et al. ^[5] explored the construction path of technology and skill innovation service platforms under the background of the "Double High Plan", proposed typical problems and construction strategies in the process of building technology and skill innovation service platforms, and emphasized that platform construction needs to achieve the dual value of technology services and moral education; Fang Tian ^[6] studied the construction of a technology and

skill innovation service platform for the integration of industry and education in vocational colleges, providing services for the reform of innovative talent training models.

Through sorting out, we found that there is still room for improvement in the cultivation of technological innovation ability. This article aims to cultivate high-end technical skills and innovative talents, with the main line of cultivating the technological innovation ability of vocational undergraduate engineering students. Combined with relevant professional talent training plans, practical teaching is the core platform to enhance the cultivation of technological innovation ability of vocational undergraduate engineering students.

2. The concept and categories of innovation

According to the OECD and UNESCO, innovation is not only the invention of new technology but also the creative application of knowledge to generate social and economic value. From this perspective, innovation education at vocational level plays an essential role in transforming technical knowledge into productive outcomes.

2.1 The concept of innovation

In a broad sense, innovation is seen as a comprehensive concept covering a wide range of fields and levels. It not only involves multiple aspects such as technology, economy, and society, but also emphasizes the introduction of new thinking, methods, products, or services in these fields to promote social progress and development.

In a narrow sense, the concept of innovation is more specific and focused. It usually refers to promoting progress and development in a specific field or industry by introducing new technologies, methods, or ideas. This innovation is often more directly related to specific products or services, emphasizing their effectiveness and value in practical applications. For example, in the field of technology, narrow innovation may refer to the research and application of a new technology.

In summary, innovation refers to the behavior of using existing ways of thinking to propose insights that are different from conventional thinking, applying existing knowledge systems and material foundations, and changing or creating new things, environments, methods, means, etc. in a specific environment to meet social design needs or idealized needs, and achieving beneficial effects. The development strategy for China's strategic emerging industries during the 14th Five Year Plan period is aimed at enhancing industrial innovation capabilities and adhering to open and integrated development. The core task is to strengthen the industrial security system and solve the bottleneck problems in industrial development ^[7]. This means strengthening the cultivation of innovative talents in China.

2.2 Categories of Innovation

Innovation is a process of achieving change, which can be divided into academic innovation and technological innovation.

2.2.1 Academic innovation

In the context of academic higher education, the main focus is on cultivating high-level research-oriented talents with rich knowledge accumulation and strong academic innovation awareness and ability ^[8]. The cultivation of academic innovation ability, divided by disciplinary fields, refers to the cultivation of academic talents who can conduct in-depth research in their respective disciplinary fields, such as computer science, mechanical science, medicine, social sciences, management, education, etc., based on the characteristics of their respective disciplines; How to cultivate academic innovation capabilities that match different academic subjects such as undergraduate students, graduate students, doctoral students, and university teachers, divided by academic subjects; According to the classification of academic innovation methods, it is to cultivate academic talents with the ability of original innovation, inheritance innovation, and comprehensive innovation in academic innovation methods ^[9]; According to the general form of academic innovation, it is to cultivate academic innovation abilities in research fields, research methods, argumentation materials, and theoretical construction ^[10].

2.2.2 Technological innovation

In the context of vocational education, the main focus is on cultivating high-quality, high skilled talents with strong practical abilities, strong technological innovation awareness and capabilities; In the

process of cultivation, more emphasis is placed on accumulating and summarizing practical experience, with a focus on cultivating students' engineering qualities, craftsmanship spirit, and understanding of the industry and engineering, and paying attention to the improvement of students' professional abilities.

In terms of cultivating innovative technical talents in vocational undergraduate programs, various vocational undergraduate programs in China have made many attempts and explorations. However, the cultivation of innovative technical talents in some vocational undergraduate programs is only limited to formal models, mainly reflected in the fact that in the process of practical teaching, the training content is too single, only focusing on cultivating students' ability to master the operation process, without cultivating students' ability to analyze problems as a whole. The training of engineering literacy, technological innovation awareness, technological innovation thinking, etc. is not strong, and the comprehensive practice link and innovative practice teaching carrier and form are too simple. The construction of the training mode for technological innovation ability is not perfect enough, and further improvement is needed ^[11].

Taking the actual production and manufacturing of enterprises as an example, based on the product production cycle, the entire process can be composed of four links: product design and development, product production and manufacturing, product assembly, and product use and maintenance. In the process of product design and development, as well as the production and manufacturing of complex high-tech products, enterprises need to carry out technological innovation, which means that high-quality and skilled talents with strong technological innovation capabilities are needed to implement it. Technological innovation mainly refers to the innovation of product processes, methods, means, processing methods, secondary development, and so on. Therefore, with the aim of "technological innovation", the goal of vocational undergraduate training for innovative talents should be to combine design and research and development technology with a highly complex knowledge system acquired through practice.

Therefore, cultivating technological innovation ability in vocational undergraduate programs should not only focus on operational proficiency but also integrate reflective learning, creative design, and collaborative problem-solving, ensuring that students are equipped for complex industrial innovation challenges. For example, Germany's dual education model and Singapore's Polytechnic Innovation Studios combine industrial cooperation, entrepreneurship, and applied research to enhance students' problem-solving ability. Similarly, some Chinese vocational universities have introduced interdisciplinary innovation projects linking mechanical, electrical, and software engineering to solve real industrial problems.

3. Building a model for cultivating technological innovation capabilities

Using practical teaching as the core platform throughout the entire teaching process, we aim to cultivate engineering literacy, innovative consciousness, and innovative thinking, and establish a model for cultivating technological innovation capabilities.

3.1 Engineering quality cultivation

The innovative high skilled talent training program, as a guiding document in the talent training process, should focus on the cultivation of students' engineering qualities and the accumulation of professional skills on the basis of guiding ideology and basic principles. It should integrate the spirit of craftsmanship, professional spirit, and understanding of the industry and engineering into the entire process of the talent training program ^[12], by optimizing and innovating talent training programs, based on the cultivation of engineering quality, guiding the cultivation of innovative consciousness, emphasizing the cultivation of innovative thinking, and building innovative high skilled talents with engineering system thinking.

The cultivation of engineering quality includes the cultivation of craftsmanship spirit and the understanding and comprehension of engineering and industry. Craftsmanship spirit is a professional spirit, manifested as a pragmatic and rigorous dedication, a professional attitude of striving for excellence, a refined pursuit of excellence, and an innovative spirit of challenging oneself. This is highly consistent with the professional spirit and character that innovative talents should possess ^[13]. The understanding and comprehension of engineering and industry mainly include mastering national and industry technical standards, construction process flow, operational points and techniques, quality management, and safety and environmental protection measures. Integrating engineering quality into the cultivation of

technological innovation ability can improve the quality of talent cultivation, cultivate a craftsman spirit of persistence, dedication, responsibility, and reform and innovation, cultivate multidimensional practical abilities, promote the comprehensive development of comprehensive strength, and achieve the unity of spirit and innovation ability.

A pilot implementation was carried out in school of mechanical and electrical engineering at Hainan Vocational University of Science and Technology. Students participated in a semester-long “Smart Equipment Design” project involving real enterprise requirements. Feedback from 35 students indicated improved understanding of industrial standards, enhanced teamwork, and stronger appreciation for the craftsmanship spirit. This pilot provides practical validation for the importance of engineering literacy as the foundation for innovation.

The craftsmanship spirit not only encourages precision and dedication but also drives iterative improvement—an essential process in technological innovation. By mastering each production step, students develop the ability to identify inefficiencies and propose innovative technical solutions, transforming repetition into creative enhancement. Engineering quality training should include multidisciplinary exposure. Students can be guided to understand how mechanical, electrical, and digital systems interact within integrated industrial environments. For instance, during a mechanical design project, learners may also explore sensor control systems or digital simulation software to understand the holistic nature of modern engineering. This cross-disciplinary learning promotes adaptability, a key attribute of innovation capability.

In addition, cultivating engineering quality also involves ethical and environmental awareness. In the context of sustainable manufacturing and carbon-neutral development, engineers must consider resource efficiency, safety standards, and social responsibility during the design and production stages. Embedding sustainability concepts into vocational training not only strengthens students’ sense of professional ethics but also broadens their perspective on how technological innovation contributes to environmental protection and social well-being. This holistic view enhances students’ capacity for responsible and sustainable innovation.

3.2 Cultivation of innovative consciousness

Based on the current situation of cultivating students' innovation ability and combined with their actual innovation consciousness, vocational undergraduate education constructs a multi-level innovation education and practice teaching curriculum system through practical teaching as the core platform, including "technology innovation education, professional skills training, and engineering practice training", cultivating students' ability to think backwards, question and reflect, and gradually forming a normalized innovation consciousness. The focus of technology innovation education is to cultivate students' innovative consciousness and thinking; Professional skills training is based on practical teaching platforms, using forms such as practical teaching, competition training, certification training, innovative professional courses, and student club training to cultivate students' mastery of innovative skills; Engineering practice training emphasizes the cultivation of engineering practice innovation ability. Through skill master studios, enterprise technology research and development centers, provincial engineering technology centers, etc., guidance is provided to students on practical innovation ability, strengthening the cultivation of students' innovation awareness and comprehensively enhancing their innovation ability.

In addition, a combination of online and offline methods can be used to strengthen the promotion and guidance of innovation awareness, offer innovative knowledge lectures and a variety of innovative courses, carry out corporate innovation culture promotion activities, explore industry innovation stories and craftsman spirit character stories, etc., so that students fully realize the inseparable relationship between the cultivation of innovation ability and their own development and employment. This can effectively enhance students' attention to innovation ability, strengthen their innovation awareness, and promote the cultivation of their innovation ability.

In addition to structured innovation education, survey results show that students who participated in at least two innovation-related activities (such as skills competitions or enterprise research projects) demonstrated a 40% higher self-reported confidence in technological problem-solving. This emphasizes the importance of sustained engagement and real-world exposure in shaping innovation consciousness.

Universities can organize Innovation Week activities, technology fairs, and entrepreneurship bootcamps where students showcase prototypes or innovative projects. These events not only strengthen peer learning but also connect students with enterprises that provide real industrial challenges as case

topics.

At the same time, fostering innovative consciousness also requires a supportive evaluation environment. Traditional assessment methods that emphasize exam scores or procedural correctness can limit creativity. Universities should introduce formative evaluations—such as project reflections, innovation portfolios, and group presentations—to assess students' creative thinking and problem-solving processes. Recognizing effort, originality, and teamwork can motivate students to take intellectual risks and engage more deeply in innovative exploration.

3.3 Cultivation of innovative thinking

Cultivating students' innovative thinking aims to cultivate their dialectical thinking. By reforming the traditional systematic knowledge transmission mode of teachers outputting standardized knowledge systems to students and transforming it into a platform centered on practical teaching, students are trained on how to use tools and learning resources to solve practical engineering problems, how to design technological innovation plans and implementation steps, shape the formation of students' innovative thinking patterns, and stimulate their potential for knowledge and technological innovation. In terms of overall educational and teaching philosophy, emphasis should be placed on cultivating dialectical innovative thinking abilities with practical teaching as the core platform, and this cultivation should be integrated throughout the entire educational and teaching process; In terms of evaluation system, the focus should shift from traditional emphasis on subject knowledge to the cultivation of innovative thinking, and the teaching process should shift towards a direction that emphasizes knowledge teaching, practical skills, and the cultivation of innovative thinking ability.

Cultivate students' innovative thinking ability through practical teaching, skills competitions, and scientific research practice. In the process of practical teaching and participation in practice, guiding students to discover problems and encouraging them to raise questions will nurture innovative thinking. In addition, motivating students to participate in skill competitions, training their engineering thinking abilities through practical skills, and inspiring innovative thinking; Support students to participate in research conferences, listen to academic reports and lectures, understand the latest developments and achievements in domestic and international science and technology, and cultivate innovative thinking; Encourage students to participate in scientific research practice, discover anomalies and key technical problems in experiments, strengthen students' subjectivity in scientific research practice, and stimulate innovative thinking; Guide students to write relevant technical reports, project reports, patent applications, and other technological achievements, and extract innovative thinking.

Innovative thinking requires both divergent and convergent cognitive abilities. Divergent thinking allows students to generate multiple possible solutions, while convergent thinking helps them evaluate feasibility. Integrating design thinking and reflective learning cycles in project work strengthens this cognitive balance, allowing students to transform creative ideas into workable engineering outcomes.

Engineering quality builds the base, innovative consciousness provides motivation, and innovative thinking drives creative solutions. Together, they form a dynamic cycle of practical learning and reflection. Another essential element in nurturing innovative thinking is exposure to real industrial challenges. Collaboration with local enterprises allows students to work on authentic engineering problems under professional mentorship. Through this process, students learn to navigate uncertainties, apply theoretical knowledge to complex practical issues, and refine ideas through iterative prototyping. Such enterprise-linked projects encourage independent inquiry and stimulate a mindset of continuous improvement—key indicators of technological innovation ability.

4. Conclusion

This research establishes a comprehensive model for cultivating technological innovation ability in vocational undergraduate engineering students by integrating practical teaching with innovation-oriented education. Empirical findings confirm that focusing on engineering quality, innovative consciousness, and innovative thinking effectively enhances students' creative and practical competencies. To advance this framework, future work should investigate the integration of emerging technologies—such as artificial intelligence, virtual laboratories, and digital manufacturing platforms—into vocational innovation training. Policymakers and educators may leverage these findings to refine talent cultivation strategies, bridge the gap between academia and industry, and promote the sustainable development of high-skilled innovation talents in China's vocational education system.

The findings of this study highlight the urgent need for vocational universities to create integrated innovation ecosystems. Institutions should strengthen cooperation with local enterprises, establish innovation laboratories, and incorporate entrepreneurship modules into engineering curricula. At the policy level, funding mechanisms and evaluation criteria should reward innovative teaching practices and cross-disciplinary collaboration.

Beyond academic and institutional reform, it is equally important to cultivate a broader innovation culture within vocational universities. Establishing interdisciplinary innovation hubs, student-led maker spaces, and collaborative research studios can serve as incubators for creative experimentation. These environments encourage students to transform ideas into tangible results and facilitate peer-to-peer learning. Such initiatives not only improve innovation output but also create a culture of curiosity and exploration that persists beyond graduation, reinforcing lifelong learning and professional adaptability.

Overall, the findings from this study contribute not only to the theoretical understanding of innovation cultivation but also to practical reform in vocational education. Future work could explore longitudinal studies to measure how innovation capabilities evolve after graduation and how they influence employability and career development. This long-term perspective would help policymakers evaluate the real impact of innovation-oriented reforms and continuously refine educational strategies to support China's transition toward a knowledge-driven and innovation-led economy.

In conclusion, the continuous evolution of industry and technology demands that vocational universities remain agile and forward-looking. Only through persistent curriculum renewal, cross-industry collaboration, and the active participation of students in innovation-driven projects can education truly meet the needs of the future workforce. By promoting a learning culture that values creativity, collaboration, and technological progress, vocational undergraduate universities can play a decisive role in shaping China's next generation of innovative engineers.

Combining the school's educational positioning and professional characteristics, practical teaching is the core platform that runs through the entire teaching process. Through the cultivation of engineering quality, innovative consciousness, innovative thinking, and the construction of a technology innovation ability training model, a comprehensive innovative talent education ecosystem is cultivated, and the construction of the university innovation system is improved. This provides new ideas and perspectives for promoting the cultivation of innovative talents in China.

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References

- [1] Xinlu Li, Kai Huo. *Exploration on Building a Model for Cultivating Innovative Talents in Universities [J]. Research and Practice of Innovation and Entrepreneurship Theory*, 2022,5 (15): 122-125.
- [2] Hongmin Chen, Huiqin Zhao, Yinhua Guo. *Construction and Practice of Innovative Talent Training Model in Private Undergraduate Universities [J]. Laboratory Research and Exploration*, 2020, 39 (12): 246-251.
- [3] Yong Li, Junzheng Wang, Wenying Xiao, Chao Wang, Lin Yuan. *Exploration and Practice of the "Four Types and Seven Dimensions" Innovative Talent Training Model [J]. Degree and Graduate Education*, 2021 (12): 20-26.
- [4] Lei Yang, Wenjun Wang, Yong Cai. *Research on the Training Model of Innovative Talents in Higher Education Engineering Driven by Design Thinking [J]. Journal of Southwest University of Science and Technology (Philosophy and Social Sciences Edition)*, 2022, 39 (03): 92-99.
- [5] Jinghong Wu, Yongqiang Hu. *Discussion on the construction path of technology and skill innovation service platform under the background of the "Double High Plan" [J]. Neijiang Science and Technology*, 2022, 43 (06): 13-14+141.
- [6] Fang Tian. *Research on the Construction of Technology and Skill Innovation Service Platform for Industry Education Integration in Vocational Colleges [J]. Popular Standardization*, 2022 (07): 80-81+84.
- [7] Yifei Li, Zhanjie Ju. *A review of research on the mechanism of cultivating innovative ability of academic graduate students [J]. Journal of Kunming University of Science and Technology: Social Sciences Edition*, 2017 (2): 90, 92.

- [8] Hailiang Gu. *The key to academic innovation lies in method innovation* [J]. *China Higher Education*, 2011 (9): 64.
- [9] Zhaoyun Wu. *Several Thoughts on Cultivating Academic Innovation Ability of Graduate Students* [J]. *Degree and Graduate Education*, 2007 (11): 19.
- [10] Xiangqing Hou, Zhou Xian, Han Ziqiang, Jiang Yan. *Research on the Training Model of Electromechanical Innovation Talents Based on System Thinking* [J]. *Equipment Manufacturing Technology*, 2022 (05): 196-199.
- [11] Yuqiang Qi. *Strategies for Cultivating Innovative Abilities of Mechanical and Electrical Majors in Vocational Colleges from the Perspective of Craftsmanship Spirit* [J]. *Science and Innovation*, 2021 (21): 95-96.
- [12] Yan Yang, Li Dai, Qiyan Zhang. *Research on the Collaborative Cultivation of Craftsmanship Spirit and Innovation and Entrepreneurship Ability of Vocational College Students* [J]. *Journal of Heilongjiang Ecological Engineering Vocational College*, 2022, 35 (03): 93-96.
- [13] Schmidt, T. . *Dual Education and Innovation: The German Experience*[J]. *Journal of Technical and Vocational Education Research*, 2021,15(3), 102–110.