Research on Innovation of Engineering Training Project Teaching Mode in Ordinary Colleges and Universities

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Abstract. Under the construction requirements of "Double First-Class" universities, disciplines, and majors, engineering training courses, as an important comprehensive training segment in practical education, play a vital role. By establishing a full-cycle mentoring system for engineering training practices, we can integrate the training projects of various work types into a large-scale training project, breaking the problems of low integration and insufficient innovation among individual work types and smaller training projects. After the implementation of the reform plan, student performance, scientific research competitions, and student evaluations of teaching have improved by 12.6%, 34.12%, and 26.6% respectively, continuously improving and enhancing the quality of training teaching.

Keywords: Double First-Class, Engineering Training, Practical Training Projects, Cross-Integration, Continuous Improvement

1 Introduction

1.1 Engineering training is a practical course offered by universities to all students, characterized by its broad professional coverage, large number of participants, substantial class hours, and intensive instruction. The course primarily aims to cultivate students' practical skills, engineering professionalism, and innovative abilities. In traditional practical teaching, the teaching projects for various trades were separated, and students only superficially grasped the practical key points and techniques of each task. Digital teaching methods were rarely applied, resulting in low participation and lack of interest in the practical training projects. Each project was guided by different practical training instructors, leading to students' insufficient understanding of the specific roles of each trade in the processing of specific products, and preventing the formation of an integrated and cross-integrated concept of the connections between various trades in students' minds[2].

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1.2 Currently, the teaching objectives of engineering training courses in universities should include cultivating students' abilities in interdisciplinary integration and collaborative innovation. Their practical training projects should be closely linked to industrial development, social needs, and the forefront of technology, with a focus on collaborative innovation among practical training projects [1]. Based on the current teaching objectives of the course, by establishing a full-cycle responsibility system for engineering training practical instructors, the practical training projects for various trades in engineering training are integrated into one large practical training project. Preliminary theoretical knowledge is structured into online courses on the Chaoxing Learning Platform, with various engineering training competitions serving as entry points. Actual products and challenging problems from leading-edge enterprises are used as problem-solving cases in course instruction. Through a series of teaching reforms and continuous updates and improvements, the educational quality of engineering training courses is enhanced. Students have seen significant improvements in their internal motivation and interest in the course's practical training projects, the integration of interdisciplinary knowledge, learning outcomes, and teaching evaluations.

2 The Pathway to Innovative Integration and Construction of Engineering Training Projects

2.1 Constructing the "One Core, Five Pillars" Innovation System for Engineering Training Projects to Enhance Students' Practical and Innovative Abilities. Innovation stems from practice, and innovation enhances practice. Practice and innovation are inseparable and mutually reinforcing, improving together. Under the integrated engineering training innovation system of "practice-innovation," a "Five Pillars" curriculum integration system is implemented, encompassing basic practical training, project research training, competition-driven training, intelligent guided training, and school-enterprise collaborative training.

2.2 Establishing an Open Online Practical Teaching Platform for Engineering Training Courses to Strengthen Student Learning Outcomes in the Era of Big Data. By seizing the learning interests of students in the new era and effectively utilizing big data teaching measures through modern integrated media, a reasonable time matrix is constructed to encircle students and make full use of their fragmented time for practical training [3]. Through the effective opening of laboratory resources, a series of all-weather, open-book style practical training projects are established, allowing students to independently learn various practical methods and seek solutions to problems. This continuously enriches teaching methods with modern information technology, comprehensively improving the ways of teaching and learning, and significantly broadening students' educational pathways.

2.3 Establishing a Full-Spectrum Industry-Academia Integrated Training Faculty to Enhance the Competency Level of Engineering Training Teaching. The improvement of the training faculty's competency level is a fundamental prerequisite for students to acquire professional knowledge and enhance their innovative practical abilities in engineering training courses. Training instructors must continuously update the practicality, foresight, and innovation of teaching knowledge points, closely link with cutting-edge advanced technologies, and collaborate with leading industry enterprises to build a full-spectrum training instructor team, achieving a consistent integration of production, learning, research, and teaching [4]. This breaks away from the traditional model where each training project has a single instructor responsible for teaching guidance, establishing a coherent mentorship system that spans from the moment students enter the training center until the course conclusion. From the moment students select their courses to choosing practical products, integrating products into practical teaching, instructing all relevant knowledge points across various types of work, completing product creation, and even handling product upgrades and improvements, all these stages are under the fixed guidance of one training mentor [5], constructing a "Dual Core, Five Pillars" innovative teaching model for engineering training, as illustrated in Figure 1.

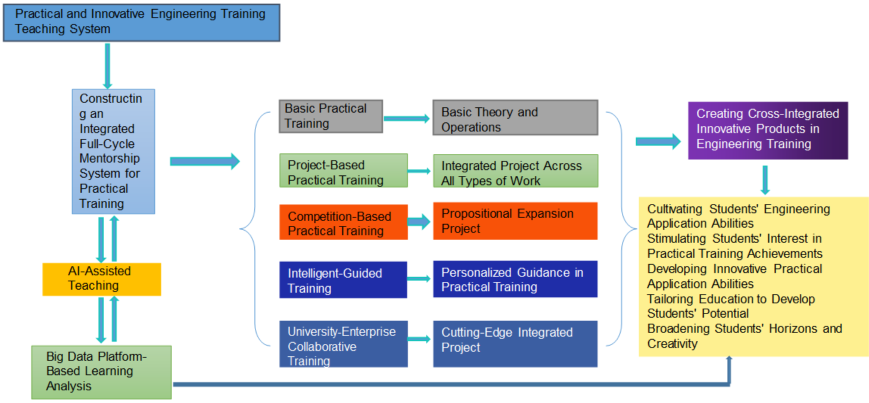

Fig. 1. "Dual Core, Five Pillars" Innovative Teaching Model for Engineering Training

3 Construction of the "One Core, Five Pillars" Innovative Teaching Model for Engineering Training

3.1 Integration of Full-Spectrum Engineering Training Projects under a Mentorship System. Throughout the entire engineering training course, students integrate practical training projects from various types of work, guided by a fixed mentor who leads them through basic theoretical operations, selection and reflection on practical projects, integration of cutting-edge technology and interdisciplinary approaches into practical projects, culminating in the creation of a comprehensive innovative integrated practical project product. This approach immerses and engages students fully in the process[6].

3.2 Construction of Innovative Teams through Interdisciplinary Integration. By establishing an integrated large-scale practical training project, students are encouraged to combine their own and their team's professional strengths and abilities with the characteristics of various types of work they are familiar with. This helps them understand team collaboration before processing products and consider the practical application of workpiece processing skills as well as problem identification and solving. Consequently, they can identify issues during hands-on processing, inspire solutions through continuous reflection, and innovate ideas throughout the practical training process.

3.3 Design and Construction of Real Products from Cutting-Edge Enterprises. Under a comprehensive practical training product concept, creating and processing a tangible product requires not only understanding and mastering the processing skills of various engineering training types but also a clear comprehension of the characteristics and interconnections between them[7]. While integrating all practical training types, it is also essential to incorporate the professional characteristics of the student team to conceive an innovative, integrated practical training product.

3.4 Integrated Thinking on the Relevance of Implementing All Types of Work. Under the fragmented engineering training projects, fostering students' understanding and cultivation of the spirit of craftsmanship can be challenging due to the lack of connectivity between individual projects, which does not sufficiently reflect the precision and rigor required in product processing. This makes it difficult for students to fully appreciate the critical importance of the craftsmanship spirit in product manufacturing[8].

Addressing the above issues enables students to truly achieve: using both hands and brain for diligent thinking, solidifying sentiments through labor and craftsmanship, perceiving problems innovatively, significantly increasing interest and proactive learning, and enhancing abilities comprehensively. Thus, constructing the "One Core, Five Pillars" innovative teaching path for engineering training, as shown in Figure 2.

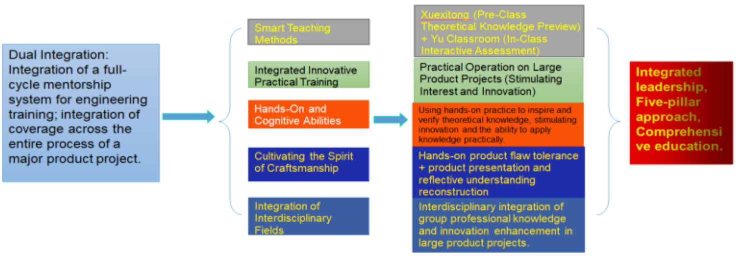

Fig. 2. Implementation Diagram of the "One Core, Five Pillars" Innovative Teaching Path for Engineering Training

4 Engineering Training Teaching Implementation Plan

4.1 Integrated Practice and Innovation in Basic Training. Basic training focuses on the development of fundamental skills and basic technological methods, such as machining (lathe, milling, planer, grinding, bench work), electrical and electronics technology, intelligent manufacturing production lines, laser engraving, 3D printing, and training in innovative thinking and methods, etc. By "modularizing" the training content according to professional needs, a teaching project implementation scheme for an integrated training product is constructed based on the knowledge points of all types of engineering training courses, combined with different professional talent training programs to guide the classification and construction of integrated training products for various majors. Through carefully designed products as guidance and outcomes as orientation, students are prompted to reflect on the training knowledge points that should be mastered in product making and their integration with the major. From initially mastering knowledge in separate segments to mastering knowledge throughout the entire process, from having no outcome goals for knowledge acquisition to product-oriented source mining learning, this approach makes students have stronger intrinsic motivation for acquiring knowledge, clearer goals, and greater coherence in knowledge[9].

4.2 Integrated Practice and Innovation in Project Research and Training. By constructing a teaching resource library for research and training projects of training products, seminar-style teaching is conducted in a tiered and categorized manner[10]. The resource library for research and training projects is built through three modes, namely: the basic creative product research and training project resource library — jointly constructed by training teachers and cutting-edge enterprises; the subject integration product research and training project resource library — jointly developed by training teachers and professional subject teachers, integrating engineering training knowledge with professional subject knowledge; the innovation integration product research and training project resource library — students design products based on their grasp of basic engineering training knowledge and personal learning insights, guided teachers review and improve products considering factors such as the comprehensiveness and relevance of the training knowledge involved in the product making process, ultimately allowing students' independently designed products to integrate throughout the teaching of all training knowledge points during practical training, achieving a fusion of knowledge and innovation. Thus, a "menu-style" selection is made for rectifying basic training projects, enhancing the knowledge coherence of training ability cultivation.

4.3 Integrated Practice and Innovation in Competition-Driven Training. Through competition resources and mechanisms, with multidisciplinary cross-integration competition research and training projects as carriers, combined with student engineering training clubs, continuously explore students' practical application abilities of engineering training course knowledge, enhancing innovation and improvement in training product design and construction[11]. Increase students' interest and enthusiasm for engineering practice. Leveraging the various advantages of competitions to stimulate students' interest in learning and internal motivation, transforming passive learning into active learning.

4.4 Integrated Practice and Innovation in Intelligent Guidance Training. Intelligent guidance training centers around products, according to industry frontier demands and technologies, combining training projects with actual product manufacturing, allowing students to enter the actual production scenes of today's cutting-edge enterprises, to debug and arrange the intelligent production line equipment within the training platform[12]. For example, completing tasks like robotic arm clamping and communication with CNC machine tools, and learning key technologies in various aspects of the production link, the diversified training content aims to integrate different subjects, enabling students to reconstruct different fields of knowledge during the training process, gain a macro overall understanding of the intelligent manufacturing system, and enhance students' comprehensive practical abilities.

4.5 Integrated Practice and Innovation in School-Enterprise Joint Training. Collaborate with enterprises for joint education, integrating enterprise needs and standards into engineering practice, ensuring that talent cultivation meets the demands of industries and sectors. Transforming actual enterprise needs into topics for project research and training, and enterprise work standards into labor disciplines for student training, thus sublimating engineering training projects in school-enterprise joint training.

4.6 Integration of Big Data Information Technology in Teaching Reform. Utilize the theoretical knowledge and practical demonstration videos produced by Superstar Learning Pass to allow students to preview in advance, and use Rain Classroom teaching aid tools in class to enhance classroom interaction atmosphere and teaching effectiveness, building an online and offline hybrid engineering training course teaching model. Basic theoretical knowledge is learned online by students, and key and difficult points suitable for virtual simulation software explanations are displayed online. By leveraging the big data analysis advantages of online learning, effectively analyze various aspects of student learning conditions to improve students' learning outcomes and interests[13]. Activate the atmosphere of online learning exchanges among students, stimulating the driving force for solid knowledge mastery.

4.7 School-Enterprise Joint Construction of Full-Cycle Training Instructors. Collaborate with cutting-edge enterprises to cultivate a group of high-level, innovative practice teaching teams. The key to engineering training reform lies in faculty, and the difficulty and breakthrough are also in faculty. Without high-quality faculty, even the best designs are castles in the air[14]. Cutting-edge enterprises and schools jointly build a dual-qualified teacher team, with training teachers going to cutting-edge enterprises in batches to learn about current intelligent manufacturing production technologies, and enterprise technical personnel coming to schools to explain the developments in today's industry fields for students, jointly building a training teacher faculty team and cooperating in scientific research and teaching for education together.

5 Data Analysis of the Effectiveness of Teaching Reform in Engineering Training

Through the implementation of the comprehensive engineering training teaching mode reform, we have integrated the learning resources of the online courses on Chaoxing Learning Tong platform and the timely teaching methods provided by AI intelligent study partners. In offline practical training, practical training projects are integrated with competition projects and enterprise product projects, allowing students to collaboratively participate in the independent setting of products. Under the guidance and optimized explanation of teachers, a final integrated practical training product scheme is formed. By teaching large-scale project products, we adopt a mode that combines theory, conception, competition, enterprise mentors, enterprise products, practical training guidance, whole-process assessment, project product assessment, evaluation feedback, data analysis, and continuous updating and improvement. After implementing the reform, while maintaining the consistency of course evaluation standards, students' performances are comprehensively evaluated from multiple dimensions such as processing accuracy, operational skills, hands-on abilities, theoretical knowledge, and innovative capabilities. By extracting the engineering training course grades before and after the reform from the school's educational administration management system, the grades show a normal distribution. After the reform, students' average exam scores increased by 12.6% (see Figure 3). During the course assessment, it was found that students' abilities to solve problems innovatively, practical hands-on abilities, and team collaboration abilities have been significantly improved. Additionally, comparing students' evaluations of teachers' teaching before and after the reform, the overall score increased by 26.6% (see Figure 4). Among them, students' interest in the reformed teaching has increased significantly, their driving force has been continuously strengthened, and they highly recognize the teaching methods and modes adopted in the course, which has improved their overall engineering ability level. Furthermore, the number of awards won by students in provincial and above-level competitions related to engineering training has increased by 34.12% (see Figure 5). By adopting the teaching method of promoting teaching through competition and combining competition projects with enterprise products, students' innovative abilities in competitions have been enhanced, making the projects they participate in more competitive in competitions, and the number of award-winning projects has continued to increase. Finally, to continuously and comprehensively understand the effectiveness of the engineering training curriculum reform among students, we have conducted multi-dimensional surveys of students using the Wenjuanxing platform. The survey results show that students' satisfaction has been significantly improved before and after the reform (see Figure 6) [15]. Through a series of curriculum reforms, it has been fully verified that the reform of the engineering training teaching mode has achieved the expected goals. This mode also has good reference value for subsequent continuous improvement and serves as a good reference for other engineering practice courses.

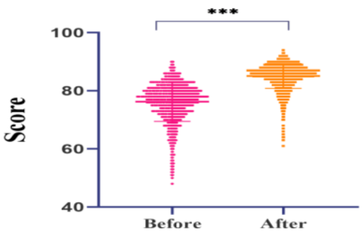

Fig. 3. Analysis of Student Performance in Engineering Training Courses

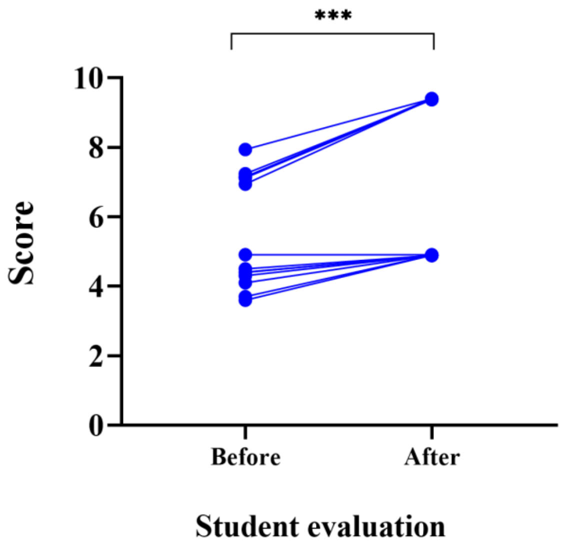

Fig. 4. Data Analysis of Student Evaluation Scores

Category	Competition projects related to engineering training	National level	Provincial level	Count
Before	China Undergraduate Engineering Practice and Innovation Ability Competitions China Undergraduate Mechanical Engineering Innovation and Creativity Competitions China University Intelligent Robot Creativity Competitions ... and other 8 categories	48	37	85
After	China Undergraduate Engineering Practice and Innovation Ability Competitions China Undergraduate Mechanical Engineering Innovation and Creativity Competitions China University Intelligent Robot Creativity Competitions ... and other 8 categories	62	52	114
effect		29.17%	40.54%	34.12%

Fig. 5. Analysis Chart of Award-Winning Data of Student Engineering Training-Related Competitions

——Before, the questionnaire survey was conducted among 2000 students, with 860 questionnaires collected and 300 of them selected through cluster sampling.

——After, the questionnaire survey was conducted among 2000 students, with 1800 questionnaires collected and 300 of them selected through cluster sampling.

	Category	Satisfaction with engineering training practical projects				Satisfaction with basic training projects				Satisfaction with advanced manufacturing projects				Satisfaction with electrical and electronic training projects				Satisfaction with smart production line training projects			
Before	Score	10	8	5	2	10	8	5	2	10	8	5	2	10	8	5	2	10	8	5	2
	Number	86	114	55	45	121	86	67	26	110	72	78	40	102	154	34	10	105	123	45	27
	Percentage	28.70%	38.00%	18.30%	15.00%	40.30%	28.70%	22.30%	8.70%	36.70%	24.00%	26.00%	13.30%	34.00%	51.30%	11.30%	3.30%	35.00%	41.00%	15.00%	9.00%
After	Category	Satisfaction with engineering training practical projects				Satisfaction with the integrated reform of basic training programs				Satisfaction with the integrated reform of project-based research and training				Satisfaction with the integrated reform of competition-driven training programs				Satisfaction with the integrated reform of intelligent guidance-based training programs			
	Score	10	8	5	2	10	8	5	2	10	8	5	2	10	8	5	2	10	8	5	2
	Number	286	13	1	0	278	15	7	0	280	16	4		260	30	10	0	288	11	1	0
	Percentage	95.30%	4.30%	0.30%	0.00%	92.70%	5.00%	2.30%	0.00%	93.30%	5.30%	1.30%	0.00%	86.70%	10.00%	3.30%	0.00%	96.00%	3.70%	0.30%	0.00%
	Category	Satisfaction with the integrated reform of school-enterprise collaborative training programs				Satisfaction with the reform of big data-based information technology in teaching				Satisfaction with full-cycle training mentors				/				/			
	Score	10	8	5	2	10	8	5	2	10	8	5	2	/	/	/	/	/	/	/	/
	Number	258	32	10	0	291	8	1	0	286	12	2	0	/	/	/	/	/	/	/	/
	Percentage	86.00%	10.70%	3.30%	0.00%	97.00%	2.70%	0.30%	0.00%	95.30%	4.00%	0.70%	0.00%	/	/	/	/	/	/	/	/

Fig. 6. Analysis of student survey data on course evaluations

6 Conclusion

Research on the "One Body, Five Wings" Engineering Training Teaching Model and Path from the Perspective of "Double First-Class" Construction. The first point is to reconstruct the original engineering training courses, which were dispersed in various trades and projects, as well as the model where each trade was guided by different training teachers, into a format where all trades in the engineering training course are guided by a group of teachers[16]. This poses higher requirements for training instructors, demanding that all training instructors be proficient in the teaching objectives and content of each training trade, thereby forming an all-cycle through-trained tutor responsibility system. The second point is to integrate the contents of multiple training projects through students' professional cross-integration and the operational skill characteristics between trades, creating an integrated large project product training. This allows students to utilize their hands-on and intellectual abilities through the organic integration of profession and trade, stimulating students' thinking training and innovative creativity. It profoundly understands the importance of craftsmanship spirit in practical labor, thus educating people comprehensively in terms of talent, mind, aspiration, and soul[17][18].

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