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SCHOOL-ENTERPRISE COLLABORATIVE EVALUATION AND CONTINUOUS IMPROVEMENT STRATEGIES FOR OUTSTANDING ENGINEERS ORIENTED TO ENGINEERING PRACTICE ABILITY

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Abstract: The cultivation of outstanding engineers is an important lever for the construction of new engineering disciplines and the upgrading of industrial talent. Engineering practice ability is the core competency of outstanding engineers. At present, the cultivation of outstanding engineers in universities faces practical problems such as a single evaluation subject, vague practical evaluation standards, emphasis on assessment over improvement, and school-enterprise collaborative evaluation becoming a mere formality, making it difficult to meet the industry's demand for engineering talent capabilities. Guided by the goal of enhancing students' engineering practice ability, this paper conducts research on four aspects: the construction of a school-enterprise collaborative evaluation mechanism, the development of an engineering practice ability evaluation rubric, a closed-loop mechanism for continuous improvement of cultivation quality, and pilot application verification of the evaluation system. It constructs a multi-party participatory school-enterprise collaborative evaluation mechanism, develops a tiered and categorized engineering practice ability evaluation rubric, establishes a full-process closed-loop improvement system of "evaluation—analysis—rectification—feedback—optimization," and tests the feasibility of the system through professional pilot programs. This research can provide theoretical reference and practical basis for improving the quality of outstanding engineer cultivation and reforming school-enterprise collaborative education under the background of new engineering disciplines.
Keywords: Outstanding engineers; Engineering practice ability; School-enterprise collaboration; Evaluation mechanism; Continuous improvement; Rubric development

1 INTRODUCTION

Recent technological advances and industrial developments are contributing to rapid innovation and transformation in fields such as intelligent manufacturing and new energy. The industry is placing higher demands on engineering talent in terms of engineering practice, complex problem-solving, and job adaptability. The Outstanding Engineer Education and Training Program, as an important measure in China's higher engineering education reform, aims to cultivate a large number of high-level engineering and technical talents who meet the needs of industrial development and possess both engineering practical skills and innovative literacy. Engineering practice ability includes engineering cognition, practical application, engineering problem-solving, teamwork, innovative practice, and engineering professional literacy. It is a core indicator for measuring the quality of outstanding engineer cultivation[1-2].

After long-term development, engineering education in Europe and America has formed relatively mature school-enterprise collaborative evaluation models. The ABET engineering education accreditation in the United States lists engineering practice ability and industrial adaptability as core indicators, requiring enterprises to participate in the entire process of curriculum design, practical teaching, and quality evaluation, forming an education model led by industry standards, jointly evaluated by schools and enterprises, and dynamically and continuously improved. The German dual system takes enterprise practice as its core, implementing a dual evaluation model that combines school theoretical assessment with enterprise practical evaluation[3-5]. Evaluation standards directly align with job requirements, achieving matching between talent cultivation and industrial needs. The United Kingdom and Japan rely on industry associations and leading enterprises to establish tiered evaluation standards for engineering talent, emphasizing the use of evaluation results to reversely adjust talent cultivation plans and form a normalized improvement mechanism. However, foreign evaluation systems are rooted in their own educational and industrial environments and cannot be directly copied for the localized cultivation of outstanding engineers in China[6-7].

Domestic academia has conducted extensive research on school-enterprise collaborative education and practical ability evaluation for outstanding engineers. Existing achievements focus on exploring education models such as school-enterprise co-built bases, jointly developed courses, and dual-teacher team building[8]. Some studies have constructed evaluation indicators including practical operation, innovation, and professional literacy. However, existing research still has shortcomings. First, most studies focus on education models, with relatively little institutionalized and systematic research on school-enterprise collaborative evaluation, and there is a lack of standardized design for the rights and responsibilities of evaluation subjects and implementation processes[9]. Second, practical ability evaluation mostly uses

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general indicator scoring, lacking refined evaluation rubrics, and evaluation is highly subjective. Third, there is emphasis on evaluation results but neglect of quality improvement, and a closed-loop improvement mechanism covering the entire talent cultivation process has not yet been established, making it difficult to translate evaluation results into teaching reform measures[10]. Fourth, there is too much theoretical research and a lack of complete pilot application and effect verification, resulting in insufficient system implementation. In response to the above shortcomings, this paper conducts research on four core aspects to fill the gaps in existing research.

2 CORE RESEARCH CONTENT AND IMPLEMENTATION PATH

2.1 The Construction of a School-Enterprise Collaborative Evaluation Mechanism

A school-enterprise collaborative evaluation mechanism is the institutional foundation for ensuring that evaluation is objective and aligned with industrial needs. To address pain points such as a single evaluation subject, unclear rights and responsibilities, and poor collaboration, this paper constructs a school-enterprise collaborative evaluation mechanism featuring "multi-subject collaboration, whole-process coverage, clear rights and responsibilities, and unified standards," and clarifies the evaluation subjects, boundaries of rights and responsibilities, implementation process, and collaboration model.

A four-in-one evaluation subject structure of "universities + enterprises + industry associations + students" is constructed. Universities assume the leading role, coordinate the organization and implementation of evaluation, and are responsible for evaluating theoretical literacy and on-campus teaching processes. Enterprises, as the core subject of practical evaluation, rely on real job scenarios, with enterprise mentors assessing students' practical operation level, project execution, and job adaptability. Industry associations, as a third party, guide indicator optimization based on industry technical standards and calibrate the evaluation orientation. Students participate in the evaluation process through self-evaluation and peer evaluation, achieving self-reflection and awareness of their own abilities[11].

An institutionalized collaborative evaluation process is established. In the early stage, universities and enterprises jointly formulate evaluation standards and assessment plans based on job requirements[12]. In the middle stage, staged evaluation is implemented: universities complete on-campus course practice assessment, while enterprises are responsible for internship and engineering project practical operation evaluation, with both sides synchronizing evaluation information in real time. In the later stage, the four subjects jointly conduct comprehensive assessment and compile a comprehensive student evaluation report[13]. Supporting systems are also established for evaluator appointment, data sharing, responsibility assessment, and review of disputed results, so as to break down the separation of school and enterprise evaluation and the shifting of responsibility, and realize the transformation from single on-campus evaluation to full-domain school-enterprise collaborative evaluation[14].

In terms of evaluation dimensions, collaboration is achieved among theory and practice, process and results, and ability and literacy. Universities focus on assessing engineering theoretical foundations and on-campus practical performance. Enterprises focus on assessing practical skills, engineering problem-solving ability, and professional ethics[15]. Industry associations judge the degree of match between students' abilities and industry standards, forming a three-dimensional evaluation pattern.

2.2 The Development of an Engineering Practice Ability Evaluation Rubric

An evaluation rubric is a tool for achieving refined evaluation of engineering practice ability and can alleviate the vagueness and subjectivity of traditional practical evaluation. Based on the cultivation objectives of outstanding engineers and the requirements of industrial positions, and following the principles of scientificity, operability, and tiered categorization, this study develops engineering practice ability evaluation rubrics for outstanding engineers at different levels, namely undergraduate and master's levels.

Through literature review, enterprise visits, expert interviews, and teaching seminars, five major evaluation dimensions are determined: basic engineering practical operation ability, engineering problem-solving ability, engineering project practice ability, engineering innovation and application ability, and comprehensive engineering professional literacy. Basic engineering practical operation ability includes equipment operation, drawing reading, and experimental practice. Engineering problem-solving ability includes problem identification, data analysis, scheme design, and troubleshooting. Engineering project practice ability focuses on teamwork, process control, and deliverable delivery. Engineering innovation and application ability covers process optimization, application of new technologies, and innovative scheme design. Comprehensive engineering professional literacy includes engineering ethics, sense of responsibility, awareness of norms, and job adaptability.

Each dimension is set with four levels: excellent, good, qualified, and unqualified, with clear judgment criteria and observation points for each level. Differentiated standards are set for different learning stages. Lower grades focus on basic practical operation, while higher grades and enterprise internship stages emphasize project practice, innovation, and job ability. Evaluation weights are differentiated between undergraduate and master's levels, with the master's level strengthening assessment of complex engineering problem-solving and technology transformation and innovation ability.

Verification and optimization of the rubric's reliability and validity are completed. University teachers, senior enterprise engineers, and industry experts are organized to discuss and validate the indicators. Small-scale pre-evaluation is used to test the reliability of the rubric, and vague and unreasonable items are revised, forming a standardized evaluation tool with clear indicators, distinct levels, and ease of use by both universities and enterprises.

2.3 The Closed-Loop Mechanism for Continuous Improvement of Cultivation Quality

The fundamental purpose of evaluation is to improve cultivation quality. To address the problem of "emphasis on assessment but neglect of improvement," a six-step closed-loop continuous improvement mechanism of "data collection—comprehensive evaluation—problem diagnosis—rectification and optimization—feedback implementation—dynamic iteration" is built to promote long-term improvement of cultivation quality.

First, data collection. Relying on school-enterprise collaborative evaluation channels, multi-source data such as course practice, practical training, enterprise internships, project outcomes, competitions, and professional literacy are gathered, and student cultivation files are established to provide a data foundation for quality assessment. Second, comprehensive evaluation. Using the developed evaluation rubric, multi-party evaluation results are integrated to produce individual student ability reports and class and program cultivation quality reports, objectively presenting the current state of cultivation. Third, problem diagnosis. Problems are traced from three levels: individual students, teaching and cultivation, and school-enterprise collaboration. This includes identifying shortcomings in students' practical ability, investigating deficiencies in the curriculum system and practical teaching, and examining problems in enterprise job matching, fulfillment of duties by enterprise mentors, and implementation of collaborative evaluation, forming a problem list and cause analysis. Fourth, rectification and optimization. Countermeasures are formulated for different types of problems: personalized improvement plans are developed for individual student shortcomings; course content is optimized and real enterprise engineering projects are added; the school-enterprise cooperation system is improved, internship positions are optimized, and incentive and assessment mechanisms for enterprise mentors are implemented. Fifth, feedback implementation. Universities implement revisions to cultivation plans and updates to teaching content, enterprises adjust practical training projects, and rectification measures are aligned with evaluation standards. Sixth, dynamic iteration. Closed-loop cycles are carried out on a semester or academic-year basis, comparing quality data before and after improvement, tracking newly emerging problems, and continuously iterating and optimizing, thus changing the traditional model of terminal evaluation.

2.4 Pilot Application and Verification of the Evaluation System

To test the effectiveness of the collaborative evaluation mechanism, evaluation rubric, and closed-loop improvement mechanism, two outstanding engineer pilot programs at this university—Intelligent Mining Engineering and Resource Exploration Engineering—were selected for a one-academic-year pilot.

In the early stage of the pilot, a special working group was established to review the current state of program cultivation, connect with industry partner enterprises, form a joint school-enterprise evaluation team, conduct special training on evaluation processes and rubric use, and build a school-enterprise data sharing platform to ensure the exchange of evaluation information.

During the implementation stage of the pilot, the evaluation system constructed in this study was fully applied. Whole-process dynamic evaluation was carried out for pilot students, various types of cultivation data were collected simultaneously, and staged quality diagnosis was conducted. In response to problems exposed during the pilot, such as disconnection between course content and enterprise positions, weak innovative practice among some students, and untimely feedback from enterprise evaluation, the closed-loop improvement process was launched. Practical course modules were optimized, real enterprise projects were introduced, personalized improvement plans for students were established, and the assessment mechanism for enterprise mentors was improved. At the same time, in response to problems such as cumbersome evaluation processes and insufficient standard adaptation for niche practical projects, processes were simplified, evaluation rules were supplemented and refined, and the operability of the system was improved. After the pilot operation, this evaluation system showed good applicability, was able to identify problems in the cultivation process, and provided support for teaching reform.

3 IMPLEMENTATION STRATEGIES FOR CULTIVATION OPTIMIZATION

Combining prior theoretical research and practical experience from pilot programs, and in order to effectively improve the cultivation quality of outstanding engineers and promote the real implementation and effectiveness of the engineering practice ability evaluation system, we propose the following five implementation strategies. These strategies focus on both institutional design and operational execution, striving to form a scalable and replicable path for cultivation optimization.

3.1 Deepen School-Enterprise Collaboration and Eliminate Formalistic Cooperation

Deepen school-enterprise collaboration. School-enterprise cooperation cannot remain merely at the level of signing agreements, putting up plaques, and holding seminars; it must truly implement the cooperation model of co-construction, co-governance, co-evaluation, and sharing. Specifically, industrial standards and enterprise evaluation should be embedded into the entire talent cultivation process, from curriculum design and practical teaching to assessment and evaluation, allowing enterprises to participate substantively. For example, in the curriculum design stage, enterprise technical experts should be invited to participate in revising teaching syllabi and translating real job requirements into teaching objectives; in the practical teaching stage, enterprise mentors should directly guide students' engineering projects and on-the-job internships; in the assessment and evaluation stage, enterprise evaluation results should serve as an

important basis for students' practical performance scores. Only in this way can collaborative education avoid becoming a mere formality and truly achieve precise alignment between talent cultivation and industrial needs.

3.2 Promote the Application of Evaluation Rubrics to Achieve Precise Whole-Process Evaluation

Promote the implementation of evaluation rubrics. Evaluation rubrics are important tools for achieving refined evaluation of engineering practice ability. The already developed engineering practice ability evaluation rubric should be applied to course practical training, enterprise internships, innovative projects, and other links, so that evaluation has a basis to follow. Specifically, in course practical training, teachers can use the rubric to conduct graded evaluation of students' experimental operations, problem analysis, teamwork, and other dimensions; in enterprise internships, enterprise mentors can use the rubric to record students' job performance, awareness of engineering norms, and problem-solving ability; in innovative projects, the rubric can help judge students' innovative thinking, scheme design, and deliverable delivery levels. Through the widespread application of rubrics, precise evaluation throughout the whole process is achieved, subjective arbitrariness is reduced, and both schools and enterprises reach consensus on evaluation standards.

3.3 Improve the Closed-Loop Improvement Mechanism to Drive Continuous Quality Enhancement

Improve the guarantee for closed-loop improvement. The purpose of evaluation is not to end with a score, but to identify problems and drive improvement through evaluation. To this end, quality supervision organizations should be established at both the university and college levels, data management and rectification supervision systems should be implemented, and responsible persons and time nodes should be clearly defined, ensuring that the "evaluation—diagnosis—rectification—feedback" closed loop operates on a normalized basis rather than as a one-off activity. Specifically, the university level is responsible for overall coordination, institutional design, and data platform construction; the college level is responsible for specific implementation, problem diagnosis, and rectification. A complete closed-loop cycle should be carried out each semester or academic year, comparing quality data before and after improvement, tracking newly emerging problems, continuously iterating and optimizing, and forming a long-term improvement mechanism.

3.4 Strengthen the Dual-Teacher Team to Build a Professional Evaluation Team

Strengthen the building of the dual-teacher team. The quality of evaluation and cultivation depends to a large extent on the professional level of the evaluation team. An evaluation and education team composed jointly of on-campus teachers and enterprise engineers should be formed, with regular teaching seminars and industrial surveys carried out. On the one hand, on-campus teachers should gain an in-depth understanding of frontier industrial technologies, enterprise job requirements, and engineering practice standards, so as to make up for the shortcomings of insufficient frontline engineering experience. On the other hand, enterprise engineers should become familiar with university education objectives, evaluation methods, and teaching standards, enhancing their professionalism in educational evaluation. At the same time, a mechanism for mutual appointment and two-way exchange between university and enterprise personnel should be established, promoting on-campus teachers to participate in enterprise practice and enterprise engineers to teach on campus, creating a professional team with both theoretical grounding and engineering experience.

3.5 Advance Digital Construction to Empower Smart Evaluation and Improvement

Advance digital construction. Information technology can greatly improve the efficiency of evaluation and quality improvement. A smart evaluation platform should be built, and big data should be used to complete data collection, ability assessment, and problem tracking, realizing intelligent evaluation and quality improvement. The platform should have functions such as process recording, real-time evaluation, result uploading, feedback push, data statistics, and issue warnings. Enterprise mentors can record students' job performance and ability weaknesses in real time, while on-campus teachers can synchronously track students' enterprise practice situations. Through big data analysis, individual students' ability weaknesses and common shortcomings in the cultivation process can be precisely identified, providing technical support for continuous optimization and improving the efficiency of evaluation and improvement.

In short, the above five strategies support each other and are indispensable. Only by truly implementing school-enterprise collaboration, rubric application, closed-loop improvement, team building, and digital platforms can we continuously improve the cultivation quality of outstanding engineers and deliver more high-quality engineering talent to industrial development.

4 RESEARCH INNOVATION POINTS

Targeting the real pain points in the cultivation of outstanding engineers under the background of new engineering disciplines, this study forms innovations in three aspects. First, it constructs a four-in-one school-enterprise collaborative evaluation mechanism, clarifies the rights and responsibilities of multiple subjects, designs a complete collaborative evaluation process, breaks through the limitation of single on-campus evaluation, and achieves alignment between evaluation and industrial needs. Second, it develops a tiered and categorized engineering practice ability evaluation rubric, addresses the problem of strong subjectivity in practical evaluation, and provides a standardized tool for schools and enterprises to carry out practical assessment. Third, it establishes a complete six-step closed-loop mechanism for

continuous quality improvement, realizes dynamic iteration of evaluation, diagnosis, and rectification, overcomes the drawback of emphasizing results over improvement, and completes practical testing through professional pilots, possessing both theoretical value and application value.

5 CONCLUSION AND OUTLOOK

The improvement of engineering practice ability is the core task in cultivating outstanding engineers, and the school-enterprise collaborative evaluation and continuous improvement mechanism is the key to ensuring cultivation quality. This paper completes four research tasks: the construction of a school-enterprise collaborative evaluation mechanism, the development of an evaluation rubric, the design of a continuous improvement closed loop, and pilot verification, forming a set of evaluation and quality improvement systems that adapt to the requirements of new engineering disciplines and can be iterated. The pilot shows that this system can alleviate problems such as a single evaluation subject, vague standards, and disconnection between schools and enterprises, and help improve students' engineering practice ability and job adaptability.

Follow-up research will further refine professional evaluation rubrics according to the characteristics of different engineering majors; expand the pilot scope, attract more cooperative enterprises to participate, and continuously optimize the collaborative evaluation process; and improve the digital smart evaluation platform to achieve refined management and control of cultivation quality, providing support for the construction of China's outstanding engineer talent team and the high-quality development of higher engineering education.

COMPETING INTERESTS

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