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RESEARCH ON THE EVALUATION SYSTEM FOR TRAINING FIELD ENGINEERS IN THE MANUFACTURING INDUSTRY OF VOCATIONAL EDUCATION UNDER THE BACKGROUND OF NEW INDUSTRIALIZATION

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ABSTRACT

In the process of promoting new industrialization, it is particularly crucial to build a high-level team of engineers. Although China has established the world's largest engineering education system, it still faces a talent gap of over 20 million, especially the scarcity of high-quality technical and skilled engineers, which has become a bottleneck restricting the sustainable development of China's industry. In this context, the on-site engineer special training program has emerged, with the first phase focusing on the advanced manufacturing industry, aiming to jointly cultivate at least 200000 on-site engineers through deep cooperation between vocational colleges and enterprises. In view of this, this article starts from the demand for talents in the manufacturing industry in China's new industrialization process, and deeply analyzes the problems and shortcomings of the current evaluation system for engineer training. On this basis, we actively explored and constructed a training and evaluation system and implementation path for vocational undergraduate on-site engineers in the manufacturing field, aiming to provide solid talent support for the transformation and upgrading of China's manufacturing industry towards high-end, digital, intelligent, and green directions, and also provide strong theoretical support for building a high-level engineering team for new industrialization.

Keywords: On Site Engineer, New Industrialization, Evaluation System, Vocational Education, Manufacturing Industry

1. INTRODUCTION

1.1. URGENT NEED TO CULTIVATE UNDERGRADUATE LEVEL VOCATIONAL EDUCATION ON-SITE ENGINEERS IN THE CONTEXT OF NEW INDUSTRIALIZATION

In the process of promoting new industrialization, the cultivation of high-level engineering teams is particularly important. Although China has the world's largest

engineering education system and a total of over 20 million engineers, it is noteworthy that we still face a talent gap of over 20 million, especially the shortage of high-quality technical and skilled engineers, which has become a bottleneck restricting development. To this end, the Ministry of Education, the Ministry of Industry and Information Technology, and other five departments have jointly implemented a special training plan for on-site engineers since 2022. This plan aims to mobilize no less than 500 vocational colleges and 1000 enterprises to participate by 2025, and jointly cultivate at least 200000 on-site engineers. In the context of new industrialization, vocational colleges at the undergraduate level have more advantages in cultivating on-site engineers in the advanced manufacturing industry compared to colleges at the intermediate and vocational levels. They are more in line with the needs of the new industrialization process driven by technological innovation, and can provide strong talent support for the transformation and upgrading of the manufacturing industry towards high-end, digital, intelligent, and green directions, thereby promoting the effective improvement of quality and reasonable growth of quantity in the manufacturing industry Donovan et al. (2022), Lampon & Rivo-Lopez (2022), Sarbu (2022).

Starting from the demand for manufacturing talents in China's new industrialization process, this article analyzes the current situation and problems of the engineer training evaluation system, explores and constructs a training evaluation system and implementation path for vocational undergraduate on-site engineers, in order to provide guidance for building a high-level engineering team in new industrialization.

2. CURRENT SITUATION AND PROBLEMS IN THE EVALUATION OF ON-SITE ENGINEER TRAINING

1) Current status of research on training methods and paths for on-site engineers

The key to cultivating on-site engineers is "on-site". No less than scholars have explored the training of on-site engineers from the perspective of standardized training modes Mostow & Wohlers (2022), Kuang & Li (2022), Djuniardi et al. (2022), Braglia et al. (2024), such as constructing a standardized training mode for on-site engineers in vocational colleges, proposing the construction of training standards for "professional certification+vocational qualification certificates", and proposing the reconstruction of a standardized system for integrating theory and practice courses; In terms of training paths, we discussed the training of on-site engineers from the perspectives of value implications and paths, and explored effective paths for cultivating talents through the collaborative mode of industry and education from the perspective of improving the quality of talent training; Analyze the practical experience of on-site engineer training from the perspective of industries such as elevators, molds, and steel; Analyzed the value, challenges, and paths of on-site engineer training from the perspective of the skills development framework of the International Labour Organization.

2) Current Status and Shortcomings of Research on the Training of Field Engineers in Undergraduate Vocational Education

Since its launch in 2019, undergraduate vocational education has received widespread attention from various sectors, including academia Teixeira & Tavares-Lehmann (2023), Ramos-Maldonado & Aguilera-Carrasco (2022), Brown (2022), Wang et al. (2024). How to carry out on-site engineer training in undergraduate

vocational colleges has also become a hot research topic. Many scholars have proposed new ideas, models, and methods, such as systematically constructing a "one main line, two supports, three directions, and six key" undergraduate level vocational education on-site engineer training path; Positioning the training standards for vocational undergraduate on-site engineers as engineering technology oriented, ability composite oriented, and practical innovation oriented; The proposal of the on-site engineer plan will promote the development of vocational undergraduate majors towards matching, distinctive, and high-quality directions; Taking 321 engineering related professional talent training programs from the first batch of 32 vocational undergraduate colleges in China as samples, this paper analyzes the logical dimension, practical difficulties, and path optimization of on-site engineer training in vocational undergraduate colleges. These studies provide effective theoretical support for vocational undergraduate colleges to carry out on-site engineer training, but there is still a lack of systematic research in the evaluation of training effectiveness Kahyarara & Teal (2022), Mao et al. (2024), Kuang & Li (2022), Paek (2023).

3. EVALUATION PRINCIPLES FOR ON-SITE ENGINEER TRAINING IN UNDERGRADUATE VOCATIONAL EDUCATION

1) The requirements of new industrialization for on-site engineers in undergraduate vocational education

The flourishing new round of technological revolution and industrial transformation has built an immensely broad growth stage for new industrialization and endowed it with enormous development potential. The new industrialization, with its distinctive characteristics of high-end, digitalization, intelligence, and greenization, is gradually shaping a new appearance of modern industry. High end development not only means the optimization and upgrading of industrial structure, but also represents the outstanding improvement of product quality. It requires us to continuously pursue excellence in technology and management, and promote the extension of the industry to the high-end of the value chain. Digitalization represents the deep integration of industry and digital technology. Industry digitization drives the transformation and upgrading of traditional industries, while digital industrialization gives birth to new economic growth points. Intelligence is the deep integration of artificial intelligence and manufacturing industry. Through the application of intelligent technology, the automation and intelligence of the production process are achieved, improving production efficiency and quality. Greenization emphasizes the harmonious coexistence between industrial development and environmental protection, promotes low-carbon industrial development, and achieves sustainable development.

Therefore, the new industrialization has put forward clear and urgent requirements for the training of on-site engineers in undergraduate vocational education. We need to cultivate on-site engineers with high professional competence, innovative spirit, and practical ability. They should not only have profound theoretical knowledge, but also have practical operation ability, be able to proficiently master and apply new technologies and processes, and promote the rapid development of new industrialization. At the same time, they should also have a high sense of responsibility and mission, actively engage in the practice of new industrialization, and contribute their own strength to promoting the modernization process of China's industry.

2) Principles of on-site engineer evaluation

- **Strengthen the evaluation of craftsmanship spirit**

To guide enterprises to form their own unique comparative advantages, promote the spirit of craftsmanship, strengthen brand building, cultivate more "century old stores", and enhance product competitiveness. When evaluating on-site engineers, it is important to highlight and strengthen the assessment and evaluation of apprentices in terms of finely crafted products and pursuit of ultimate quality. This means that we expect apprentices to demonstrate a spirit of striving for excellence and perfection in every process of production and every detail of products, in order to promote the continuous improvement of industrial manufacturing level.

- **Highlight the "on-site" attribute of evaluation**

The most prominent feature of on-site engineers compared to other types of engineers is their "on-site" nature. Specifically, this includes a precise assessment of their on-site operational capabilities to verify their proficiency and accuracy in actual operations; Conduct an in-depth assessment of their on-site process knowledge to verify whether they have rich practical experience and a solid theoretical foundation; A comprehensive examination of their on-site management capabilities to determine whether they can effectively organize and coordinate on-site work; A detailed observation of their on-site collaboration ability to evaluate their communication and collaboration abilities in team collaboration; And conduct a survey on the satisfaction of their on-site service recipients to understand their performance and effectiveness in serving customers.

- **Evaluation should follow the rules of project and task implementation**

The manufacturing industry, especially high-end manufacturing projects, has its unique and inherent operating rules. When evaluating on-site engineers, it is important to ensure that the evaluation process is closely linked to the actual operational logic of the manufacturing industry. Specifically, evaluation should closely consider the progress of the project and the specific requirements of the task, comprehensively and comprehensively from multiple dimensions, including the engineer's actual operational ability, process application level, management and coordination ability, and service effectiveness. Through this evaluation method, not only can it ensure that the evaluation process conforms to the actual situation of the manufacturing industry, but it can also accurately reflect the professional ability and comprehensive quality of engineers, providing strong talent support for the sustainable development of the manufacturing industry.

- **Reflect the innovative orientation of evaluation results**

Technological innovation is the core driving force in the process of new industrialization, injecting a continuous stream of vitality into industrial development. When evaluating on-site engineers, attention should be paid not only to their professional abilities in technical implementation and problem-solving, but also to their innovative thinking and outstanding achievements demonstrated in on-site practice. This evaluation method aims to motivate engineers to continuously explore new technologies and methods, drive the sustainable development of the manufacturing industry through innovation, and promote the industry to achieve higher levels of innovation and upgrading.

Figure 1

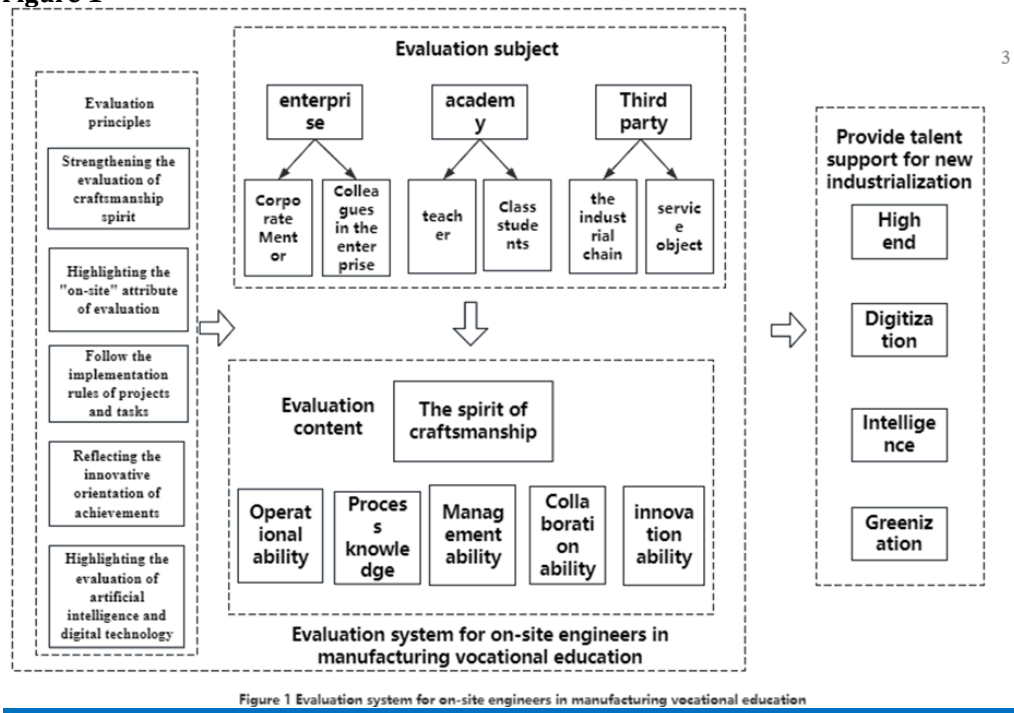

Figure 1 Evaluation system for on-site engineers in manufacturing vocational education

Figure 1 Evaluation System for on Site Engineers in Manufacturing Vocational Education

- **Highlighting the evaluation of artificial intelligence and digital technology**

Digitization and intelligence, as significant symbols of new industrialization, have brought unprecedented changes to modern manufacturing industry. It is necessary to focus on assessing the professional competence and application ability of engineers in the fields of intelligence and digitization, and deeply explore their technological innovation and practical achievements in modern manufacturing environments. Through this evaluation, the aim is to emphasize the important role of engineers in promoting the transformation and upgrading of the manufacturing industry in the digital age, in order to better meet the urgent needs of manufacturing development.

4. EVALUATION SYSTEM FOR ON-SITE ENGINEER TRAINING IN UNDERGRADUATE VOCATIONAL EDUCATION

1) Evaluation system framework

Based on the principles of strengthening the spirit of craftsmanship and highlighting the "on-site" attribute of evaluation, a undergraduate level on-site engineer evaluation system for manufacturing vocational education is established, with enterprises (enterprise mentors and colleagues), universities (teachers and students), and third parties (upstream and downstream of the industry chain, service objects, etc.) as the evaluation subjects (as shown in Figure 1), to provide high skilled talent support for the high-end, digitalization, intelligence, and greening of new industrialization.

2) Evaluation Content Framework

The evaluation content of on-site engineers in undergraduate vocational education mainly includes six dimensions: craftsmanship spirit, operational ability,

process knowledge, management ability, collaboration ability, and innovation ability (as shown in Figure 2).

- **Evaluation of craftsmanship spirit**

The evaluation of the spirit of craftsmanship should comprehensively consider their performance in persistence, excellence, meticulousness, and pursuit of excellence. Through these evaluation contents, we can more accurately grasp their level of craftsmanship quality and literacy.

- **Evaluation of operational ability**

The evaluation of operational ability should be based on the specific operational performance of the apprentice in specific positions such as production and manufacturing, testing and assembly, trial production, and equipment operation and maintenance. The evaluation of operational ability should pay more attention to the reflection of on-site ability.

Figure 2

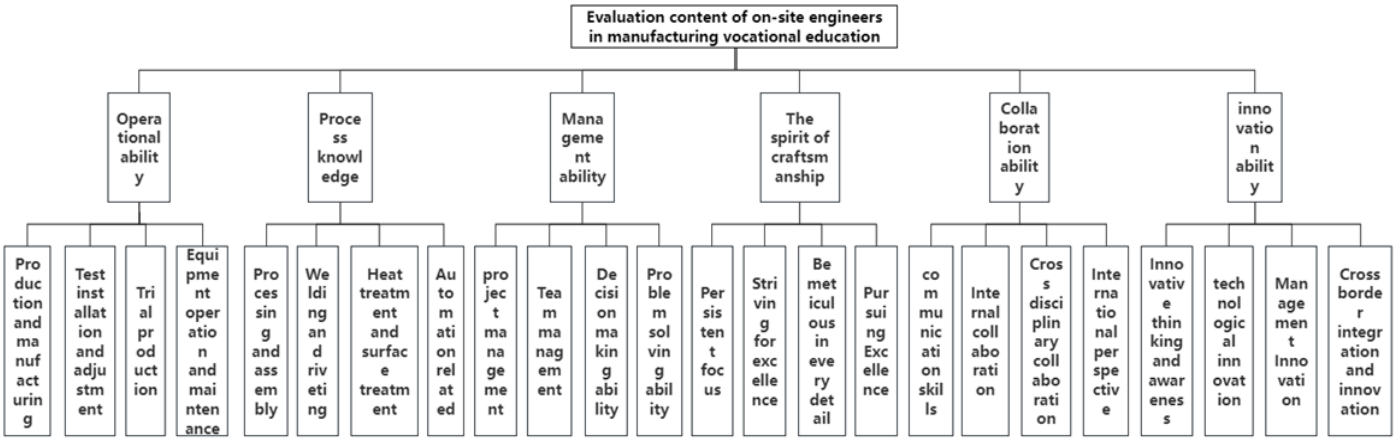

Figure 2 Evaluation content of on-site engineers in manufacturing vocational education

Figure 2 Evalution Content of On-Site Engineers in Manufacturing Vocational Education

- **Evaluation of process knowledge**

The evaluation of process knowledge should include related process knowledge such as processing and assembly, welding and riveting, heat treatment and surface treatment, automation, etc. The evaluation of process knowledge should place greater emphasis on the depth and breadth of knowledge.

- **Management capability evaluation**

The evaluation of management ability should include project management, team management, decision-making ability, and problem-solving ability. The main body for evaluating management capabilities should be corporate executives or direct responsible persons.

- **Collaboration ability evaluation**

The evaluation of collaborative ability should include communication skills, internal collaboration, cross disciplinary collaboration, and an international perspective. The evaluation of collaborative ability should focus on the performance of apprentices in communicating and collaborating with external enterprises and organizations.

- **Evaluation of Innovation Capability**

The evaluation of innovation capability should include innovative thinking and awareness, technological innovation, management innovation, cross-border integration and innovation. The evaluation of innovation capability should be guided by achievement innovation, such as the formation of invention patents, papers, etc.

5. REFORM MEASURES AND TYPICAL CASES

The trend of evaluation reform for field engineers in the manufacturing industry can be summarized as follows:

1) Classification management and scientific evaluation

Emphasis on classified management, and develop a more scientific evaluation system based on the professional ability, performance and contribution of professional and technical personnel, as well as the innovation, achievement transformation and market application of enterprise technical personnel. Such adjustments not only make the evaluation more realistic, but also give every engineer a chance to show their unique value.

2) Break the "four-only" and focus on practical ability

In the past, academic qualifications, qualifications, papers, and awards often became the "hard bars" for professional title evaluation, which restricted the development of many talented and capable engineers. The reform explicitly breaks this tendency of "only", no longer using these factors as the only criteria for evaluation, but paying more attention to the actual work ability of engineers.

3) Strengthen supervision to ensure fairness and justice

By establishing a system of integrity files and blacklists for professional title evaluation, we will strictly deal with units and individuals who violate regulations to ensure fairness and impartiality in professional title evaluation.

4) The evaluation criteria are more strict and comprehensive

The new evaluation criteria not only require applicants to have a solid theoretical foundation, but also require them to have rich practical experience and innovative capabilities. Emphasize the importance of transforming and applying research results, encourage applicants to combine theoretical knowledge with practice, and promote scientific and technological innovation and industrial development.

5) Establish a diversified qualification certification system

Considering factors such as education, work experience, project experience, and professional skills, and focusing on practical abilities, we aim to improve the accuracy of engineer qualification certification.

6) Improve the career evaluation system

Include factors such as performance results, innovation ability, and professional ethics into evaluation indicators to achieve a comprehensive, objective, and fair evaluation of engineers' careers. Strengthen the application of the evaluation results of engineers' professionalism, link them with salary and promotion, and stimulate the enthusiasm and creativity of engineers.

7) Enhance the development of the engineering team

We focus on cultivating engineers with innovative spirit, practical ability and international vision. We will increase support for training, communication, and introduction of engineers, and improve the overall quality of the engineer team.

8) Promote mutual recognition of international certification for engineers

Strengthen cooperation with international engineer certification organizations, promote mutual recognition of international engineer certification, and improve the competitiveness of Chinese engineers in the international market.

In summary, the trend of evaluation reform for on-site engineers in the manufacturing industry is moving towards a more scientific, fair, comprehensive, diverse, and international direction. Through reform measures such as classified management, breaking down the "four-only" approach, strengthening supervision, setting strict standards, establishing a diverse system, and improving the professional evaluation system, it will help cultivate more outstanding on-site engineers and promote the sustainable development and innovation of China's manufacturing industry.

Shenzhen Polytechnic University actively promotes the reform of the diversified talent training model, deepens the integration of industry and education, and school enterprise cooperation, laying a solid foundation for the training of on-site engineers. Among them, the innovation and practice of the automation technology application talent training model led by the Huichuan Industrial Alliance began in 2017, and 7 consecutive order classes have been held. Through the reform of the training evaluation system, more than 170 automation technology high skilled talents that meet the actual needs of Huichuan Technology Industry Alliance enterprises have been delivered, and Huichuan technology innovation has been transformed into new courses, new skills, and new vocational qualification standards of the school, forming a replicable and promotable "Deep Vocational Huichuan" model.

6. CONCLUSION

In the context of new industrialization, the training of on-site engineers in undergraduate vocational education has become a key measure to promote the growth of high skilled talents. This article is based on the current demand for talents in the manufacturing industry in China's new industrialization process, and conducts in-depth research and construction of a systematic evaluation system for on-site engineers in undergraduate vocational education in the manufacturing industry. The construction of this system aims to provide strong guidance and support for the construction of a new type of industrialized engineering team with high-level skills and qualities, thereby injecting new impetus into the transformation, upgrading, and sustainable development of China's manufacturing industry.

CONFLICT OF INTERESTS

None.

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