Cultivation of Highly Skilled Talents at the Bachelor degree of Vocational Education in Major Iron and Steel Metallurgy --Exploration Under the Background of New-Quality Productive Forces From the Perspective of Industry-Education Integration and School-Enterprise Cooperation

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Abstract: *In the era of Industry 4.0, the global metallurgy industry is undergoing technological and industrial upgrades. This paper analyzes the current situation and development trends of the metallurgy industry, aiming to provide a reference for the cultivation of high-skilled talent in China. The industry is developing towards intelligence, sustainability, informatization, and service-oriented growth. Developed countries such as the United States and Japan have achieved technological breakthroughs. Developing countries like China are accelerating industrial transformation through the "Made in China 2025" initiative, improving technology levels and product quality, and promoting green production. Future development will place more emphasis on the efficient use of resources and environmental protection, such as the development of technologies for utilizing low-grade iron resources, improving energy efficiency, while also advancing informatization and service-oriented approaches. In the context of new productivity, undergraduate metallurgy education in China needs to follow industry trends by optimizing courses and teaching through school-enterprise cooperation, integration of industry, academia, and research, and strengthening students' practical skills.*

Keywords: *New productivity; vocational undergraduate; industry-education integration; school-enterprise cooperation; high-skilled talent cultivation.*

1. Introduction

In the current economic and technological context, the integration of industry and education is a key direction for higher education reform. For vocational undergraduate education in metallurgy and steel, the key is to cultivate high-skilled talent capable of meeting the rapid demands of industry. This study explores how to deepen the education of this major through school-enterprise cooperation, with the main goal of constructing an effective training pathway that combines theory and practice, providing abundant practical opportunities and high-quality educational resources.

2. Industrial Transformation in the Context of New Productivity

In the context of new productivity, industrial transformation presents new challenges to the education system, particularly regarding the specialties, curricula, and talent cultivation in higher education. Metallurgical and steel-related programs must adapt to the development of sustainability, intelligence, and high-end technology[2].Traditional educational models are no longer applicable. The integration of educational innovation with industrial upgrading is key to higher education reform. Industrial transformation demands new requirements for talent in terms of knowledge, skills, and innovation capabilities. The digitalization, networking, and intelligent production methods in the metallurgy industry require students to possess interdisciplinary competence, innovative awareness, and technical application skills[3].The educational training system must align with the needs of enterprises to achieve resource integration. School-enterprise cooperation helps enhance the practicality of talent training, enabling students to better adapt to professional positions, while also providing enterprises with a stable supply of high-quality talent. Reforming the educational model requires strengthening students' practical abilities and problem-solving skills. The deep integration of education and technology can drive the fusion of educational resources with research resources, promoting the conversion of scientific research achievements and technological innovation, thereby supporting technological progress and product upgrades for enterprises. Industrial transformation has raised new requirements for talent cultivation in metallurgical programs at vocational colleges. Through paths such as school-enterprise cooperation, educational model reform, and the deep integration of education and technology, the quality of talent cultivation can be improved, and the sustainable development and upgrading of industries can be promoted.

3. The Increasing Demand for High-Skilled Talent

The steel industry is currently undergoing a critical period of transformation and upgrading, which not only requires technological innovation but also the cultivation of a high-skilled workforce capable of adapting to the new environment and challenges. The rise of "new productivity" has led to a growing demand for high-skilled talent. The modernization of the steel industry plays a vital role in national infrastructure construction, manufacturing upgrades, and the development of strategic emerging industries. The acceleration of global infrastructure construction will drive the growth of demand for steel and related materials, while also requiring technological advancement, improved production efficiency, ensured product quality, and the realization of green and low-carbon production processes. This necessitates high-skilled talent with expertise in modern steel manufacturing technologies, new material applications, engineering design, and management capabilities. Emerging technologies, such as intelligent manufacturing, digital management, and big data analysis, have become key drivers of industry transformation and upgrading. The talent cultivation model must also evolve to keep pace with these changes. It should not only encompass traditional metallurgical knowledge and skills but also foster interdisciplinary learning, innovative thinking, and the ability to apply technology and make management decisions in the context of digitalization and intelligence. In the context of a global economy and the global layout of industrial chains, high-skilled talent must also possess an international perspective, cross-cultural communication skills, and global competitiveness. Therefore, constructing a talent cultivation system that aligns with "new productivity" and deepening the training of high-skilled talent in steel metallurgy programs through industry-education integration and school-enterprise cooperation is an important area of research and practice, requiring joint efforts from all parties involved.

4. Theoretical Analysis of Industry-Education Integration and School-Enterprise Cooperation

The theoretical foundation of industry-education integration includes the interaction between education and industry, as well as the connotation and characteristics of industry-education integration. Interaction is crucial for the cultivation of high-skilled talents, while the industry-education integration model promotes educational reform and innovation to meet industry demands. The connotation refers to the combination of the industrial and educational sectors, while the characteristics include demand-oriented curricula, integration of theory and practice, dual-profession teachers, modern teaching content, diverse teaching methods, school-enterprise cooperation, and continuous teaching evaluation[5]. In conclusion, higher education institutions need to collaborate closely with industry, explore practices, and develop a talent cultivation model that produces high-skilled talents adaptable to future society[8]. Under the context of new productivity, school-enterprise cooperation is an important pathway for cultivating high-skilled talents in professional vocational undergraduate programs. Cooperation includes the co-construction of majors, curricula, training bases, "dual-subject" teaching, modern apprenticeship systems, industry colleges, technology research and development transformation platforms, dual-profession teacher teams, training and continuing education systems, and more. This cooperation aims to achieve resource sharing, complementary advantages, joint cultivation of technical and skilled talents, promote the industrialization of education and the educationalization of industry, and realize win-win development[1].

4.1 Knowledge Structure and Skill Requirements for Steel Metallurgy Majors

Under the current context of new productivity and within the framework of industry-education integration and school-enterprise cooperation, the cultivation of high-skilled undergraduate talents in steel metallurgy majors requires not only a solid theoretical foundation but also strong practical and innovative capabilities. The focus will be on optimizing and enhancing students' professional knowledge structure and skill requirements[5]. The optimization of the professional knowledge structure first requires students to master the basic theories of metallurgy, including but not limited to fields such as physical chemistry of metallurgy, so that students can integrate theory with practical problem-solving. Regarding skill requirements, emphasis is placed on the cultivation of practical operational abilities and experimental analysis capabilities, including but not limited to practice activities such as experimental teaching and internships, to ensure that students can continuously improve themselves through hands-on experience[9]. Moreover, given the driving forces of green development and digital upgrading in steel enterprises, students are also required to master green intelligent metallurgy technologies to meet future development needs. Based on these factors, we propose the following professional knowledge structure and skill requirements: a solid foundation in metallurgy theory and related professional knowledge, practical operational abilities in metallurgy engineering design, production technology, and process design, practical skills in experimental analysis, equipment maintenance, etc., the ability to apply green intelligent metallurgy technologies, and the cultivation of innovation and entrepreneurship capabilities, covering key skills such as problem-solving, project management, and teamwork[7]. Through this training system, we believe that students will not only meet current industry demands but also continue to innovate and create value in their future career development, making positive contributions to the development of society and industry.

4.2 Industry Development Trends and Professional Development Positioning

In the context of new productivity, vocational undergraduate education in steel metallurgy majors must closely follow industry development trends and adjust professional positioning. Currently, the steel industry is undergoing transformation and upgrading, emphasizing technological advancement, greening, intelligence, and high added value. Therefore, the educational goals and content must be updated to meet new requirements. The curriculum should integrate new technologies such as automation, intelligent manufacturing, and digital management, and strengthen education in low-carbon metallurgy technologies to cultivate skills in environmental protection and intelligent production[5]. School-enterprise cooperation should be strengthened to promote the construction of intelligent teaching facilities, and students should be encouraged to participate in new product design to enhance their innovation capabilities. In summary, various approaches should be employed to improve students' technical skills, innovation abilities, and green production capabilities, to meet the new industry demands and cultivate high-skilled talents adaptable to future development[6].

5. Current Status and Issues in the Cultivation of High-Skilled Talents in Steel Metallurgy Majors

Teaching teams and "dual-profession" teacher training under educational reform and industry upgrading: Universities need to establish "dual-profession" teaching teams that combine theoretical and practical experience. Teacher capabilities should be enhanced through school-enterprise cooperation and continuing education to meet the talent needs of the steel metallurgy industry. Characteristics of curriculum design and implementation: The course content of steel metallurgy majors emphasizes an employment-oriented approach, adopting modular and integrated teaching designs, along with a diversified dynamic evaluation system to cultivate students' professional skills. Major issues and challenges include the singularity of traditional teaching models, insufficient teacher-student interaction, a disconnect between teaching content and industry demands, and the inadequacy of high-skilled talent cultivation. It is recommended to reform the existing teaching model, strengthen school-enterprise cooperation, update course content, enhance practical teaching, and improve the practical abilities of both teachers and students[1].

6. Exploration of High-Skilled Talent Cultivation Paths Based on Industry-Education Integration

6.1 Establishing a Joint Cultivation System for School-Enterprise Cooperation

In terms of the organizational model and operational mechanism of school-enterprise cooperation, it is important to explore the cultivation path for high-skilled talents in steel metallurgy majors. The focus should be on the significance of the organizational model and operational mechanism of school-enterprise cooperation, including the establishment of professional development committees, curriculum systems, training bases, dual-mentor systems, and evaluation systems. The operational mechanism covers decision-making, management, incentives and constraints, and continuous improvement. These measures help enhance the quality and effectiveness of talent cultivation, promote in-depth cooperation between schools and enterprises, and provide support for the cultivation of high-skilled talents.

Regarding the co-built and shared practical education bases and training platforms, under the context of education-industry integration, co-built and shared practical education bases and training platforms are crucial for improving the quality of higher education and cultivating applied talents. In the cultivation of talents in steel metallurgy majors, they not only provide real work environments and practical experience but also play a key role in promoting educational reform and enhancing employment competitiveness. These platforms are significant for raising the level of higher education in China and accelerating talent cultivation.

6.2 Optimizing Curriculum Design and Teaching Methods

6.2.1 Establishing Employment-Oriented Curriculum Standards

In the current economic and technological environment, industry-education integration is crucial for higher education and industrial development. For steel metallurgy majors, establishing employment-oriented curriculum standards is key to improving educational quality and meeting industry demands [4]. This study explores how to define curriculum positioning within the framework of industry-education integration. By establishing employment-oriented curriculum standards, the core content of the courses can be clarified, modular teaching can be adopted, and a coherent knowledge system and teaching content can be constructed. Establishing employment-oriented curriculum standards not only ensures educational quality but also serves as an effective way to match talent demand with industry needs[5]. Curriculum standards should closely align with industry demands, considering students' career development paths, including theoretical learning and practical skill development, and incorporating new-generation information technologies such as big data, mobile internet, and virtual reality to cultivate students' innovative thinking and problem-solving abilities[8]. Finally, curriculum standards should incorporate national strategies such as the "dual-carbon" goals and the "strong steel nation" initiative, cultivating high-quality, application-oriented talents that meet national needs and ensuring effective alignment with industry demands.

6.2.2 Deep Integration of Information Technology and Teaching

In the process of industry-education integration, the deep integration of information technology and teaching is crucial for improving educational quality and cultivating high-skilled talents. In undergraduate education for steel metallurgy majors, this integration can enhance teaching efficiency and improve students' practical skills and innovative thinking[5]. Information technology provides new tools for teaching, such as online platforms, VR, and AR, breaking spatial limitations, offering flexible learning methods, and enabling students to safely learn operational skills by simulating metallurgical engineering scenarios. Meanwhile, information technology promotes the sharing and optimal configuration of teaching resources, supports personalized teaching and teaching management, and improves teaching effectiveness. With the advancement of information technology, its application in education will become more widespread, promoting the modernization of education and improving the quality of higher education[10].

6.3 Strengthening the Cultivation of Practical and Innovative Abilities

6.3.1 Cultivating Innovation Ability through Project-Driven Teaching

Against the backdrop of educational reform and industrial development, the talent cultivation models of higher education, particularly vocational undergraduate education, face challenges and opportunities[5]. The cultivation of innovation abilities in students majoring in steel metallurgy is a key issue in educational reform[13]. This section focuses on methods to enhance students' innovation capabilities through project-driven teaching. This includes establishing a school-enterprise cooperation project database, constructing a project-driven curriculum system, implementing interdisciplinary project-based learning models, creating effective evaluation systems, and promoting the transformation of the teacher's role. These measures contribute to enhancing students' innovation abilities and laying a foundation for their future development in the steel metallurgy industry[10].

6.3.2 Integrating Steel Enterprise Culture into Activities and Teaching

In the context of industry-education integration, the cultivation of high-skilled talents requires not only that students in steel metallurgy majors possess professional knowledge and operational skills but also that they understand and integrate into enterprise culture[12]. This integrated educational approach not only strengthens students' identification with enterprise culture but also enhances their comprehensive quality, laying the groundwork for their future careers. The implementation steps include: co-building cultural courses with enterprises and offering various activities to help students deeply understand enterprise culture. Integrating enterprise culture into practical activities such as internships and training, combining theory with practice, and including enterprise case studies in teaching to deepen students' understanding of enterprise culture. Embedding elements of enterprise operations and culture into the curriculum, comparing and analyzing different enterprise cultures[11]. Establishing an incentive mechanism based on enterprise culture as an evaluation criterion to encourage students to integrate into enterprise culture. These measures not only enrich the learning experience but also enhance students' comprehensive abilities, laying the foundation for career success.

7. Conclusion and Recommendations

In the context of rapid developments in both education and industry, vocational education reform is crucial for promoting social progress, especially for steel metallurgy majors. Industry-education integration and school-enterprise cooperation are key to improving educational quality and meeting industry needs. Currently, reforms in metallurgical programs at vocational colleges have yielded results, such as curriculum upgrades that have enhanced students' practical experience and cross-job mobility skills. Graduates are widely employed, meeting the needs of multiple industries. In the future, continuous reform of teaching models should be implemented, incorporating blended learning and simulated practice. Additionally, talent cultivation pathways should be further developed, with a stronger emphasis on school-enterprise cooperation, to align with industry development and national strategies such as "dual-carbon" goals. This will foster the cultivation of more high-skilled talents, enhance students' comprehensive qualities, and improve their employability and competitiveness.

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