DEVELOPING AND PRACTICE AN APPLIED TALENT TRAINING SYSTEM FOR ENVIRONMENTAL ENGINEERING MAJORS IN LOCAL UNIVERSITIES BASED ON THE BACKGROUND OF NEW ENGINEERING DISCIPLINES

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ABSTRACT

In accordance with the requirements of the National Standards for Teaching Quality of Environmental Science and Engineering and the Standards for Certification of Engineering Education, and in harmony with the construction of new engineering disciplines, it is essential to connect with local development needs, identify the intersection between talent cultivation and local industrial production practices, and focus on the core element of "curriculum and curriculum system construction". The environmental engineering curriculum system should be developed by considering curriculum system construction ideas, structural composition, teaching processes, and teaching quality assurance. The primary focus should be on addressing issues such as the widespread commonality in curriculum design, deficiencies in curriculum infrastructure, and the imbalance between theoretical and practical elements in both curriculum setup and the teaching process. The ultimate aim is to truly integrate talent cultivation with the development of local industries and enterprises, thereby improving the quality of professional personnel training. This will help achieve the objective of new engineering discipline talents training, ensuring that the curriculum system supports students' graduation requirements as outlined in the talent training program. This approach also provides a valuable reference for the construction of environmental engineering in local universities.

Key words: New engineering disciplines; Environmental engineering; Curriculum system; Dual attributes and difficulty level; Applied talent

1. INTRODUCTION

The construction of new engineering disciplines has become a driving force for the high-quality development of higher engineering education (Fu et al., 2023). Local colleges and universities should build on their unique characteristics, leverage regional advantages, closely conform to industry innovations, and explore diversified and personalized talent training models based on the deep integration of industry, education, research, and learning. The aim is to cultivate engineering talents with innovation and entrepreneurial abilities, and sustainable competitiveness to meet the requirements of local new industries for graduate abilities. However, since most local colleges and universities are located in economically underdeveloped areas, the development of professional education conditions and teaching staff tends to lag behind, making it difficult to meet social needs and creating a gap with the requirements of new engineering discipline construction. Environmental engineering is a multidisciplinary field that includes chemistry, biology, geology, fluid mechanics, and engineering, and is dedicated to researching and developing methods and technologies to solve environmental pollution problems in order to protect and restore environmental quality (Haque and Sharif, 2021). Establishing environmental engineering programs in universities can promote the integration of these disciplines, foster scientific research innovation and technological progress, and provide high-quality talent for national strategies such as “Made in China”, “One Belt, One Road”, and “Beautiful China”.

2. CHALLENGES IN TRAINING ENVIRONMENTAL ENGINEERING PROFESSIONALS AT LOCAL UNIVERSITIES

After graduation, students majoring in environmental engineering typically pursue the following career paths: First, they engage in management and scientific research within government environmental protection departments, planning institutes, or research institutions. Second, they enter enterprises to operate their environmental protection facilities or develop related technologies. Third, they work in environmental protection services within environmental technology companies, environmental assessment agencies, or consulting firms. In the case of local colleges and universities, aside from pursuing postgraduate studies, most graduates tend to engage in the third type of work after graduation. A continuous follow-up survey of graduates from Jinggangshan University, Ji’an, China, also indicates that the majority of its graduates join the third category of organizations, engaging in technical service work closely related to environmental engineering. The survey results on the employment units of these graduates reveal a common issue: insufficient engineering skills among environmental engineering recent graduates from local universities.

The construction of a talent training system is a crucial aspect of developing the environmental engineering disciplines (Zhao et al., 2020). It serves as the core component in cultivating students' quality and professional abilities, playing an indispensable foundational role in talent development.

Addressing the challenge of how to train high-quality professionals who meet the demands of new engineering discipline construction is a significant concern in the development of environmental engineering programs. The most fundamental solution to this issue lies in the scientific and reasonable construction of a curriculum system for talent training within the professional construction process. This ensures that students' knowledge and skill development align with societal demands for graduates' competencies. Therefore, building a curriculum system for environmental engineering talent training is imperative.

The curriculum system is an essential foundation for colleges and universities to achieve their talent training objectives. Reforming the curriculum system and optimizing teaching content are necessary steps to achieve the goal of cultivating high-quality, innovative professional and technical talent in environmental engineering (Southworth et al., 2023). This is also an inevitable requirement for new engineering construction and engineering professional education certification. Currently, there are several issues with the curriculum system of environmental engineering at Jinggangshan University: (1) The curriculum is overly generalized, disconnected from societal needs, lacks clear construction concepts, and does not exhibit distinctive features; (2) The curriculum infrastructure is flawed, making the construction of a coherent knowledge system challenging; (3) There is a significant issue of "emphasizing theory over practice", which has hindered the effective implementation of professional skills training, leading to an urgent need to improve the quality of talent cultivation. In response to these issues, and in accordance with the requirements of the National Standards for Teaching Quality of Environmental Science and Engineering and the Standards for Engineering Education Certification, this paper proposes to construct the curriculum system for environmental engineering based on the OBE (Outcome-Based Education) concept (Qiao and Fu, 2022). This construction will focus on curriculum system ideas, structure, teaching process, teaching evaluation, and other relevant aspects.

3. CONSTRUCTING THE CURRICULUM SYSTEM FOR ENVIRONMENTAL ENGINEERING PROFESSIONAL TRAINING

3.1. Clarifying Curriculum System Construction Ideas Guided by Social Needs

Following the professional talent training service orientation of "based in Jiangxi, radiating across the country", this approach is rooted in research and analysis of regional environmental protection talent requirements. The focus and foothold are on the training of practical skills and innovative abilities, respectively, fully consider the key points and aspects of talent training that are central to the curriculum (**Fig. 1**). The emphasis is placed on strengthening students' professional skills and innovative capabilities while improving the basic structure of the curriculum system (Li et al., 2022). Through refining the professional characteristics and introducing a "forced mechanism"

for continuous optimization, professional quality, and skills training, as well as innovation ability development, are integrated throughout the whole university education process.

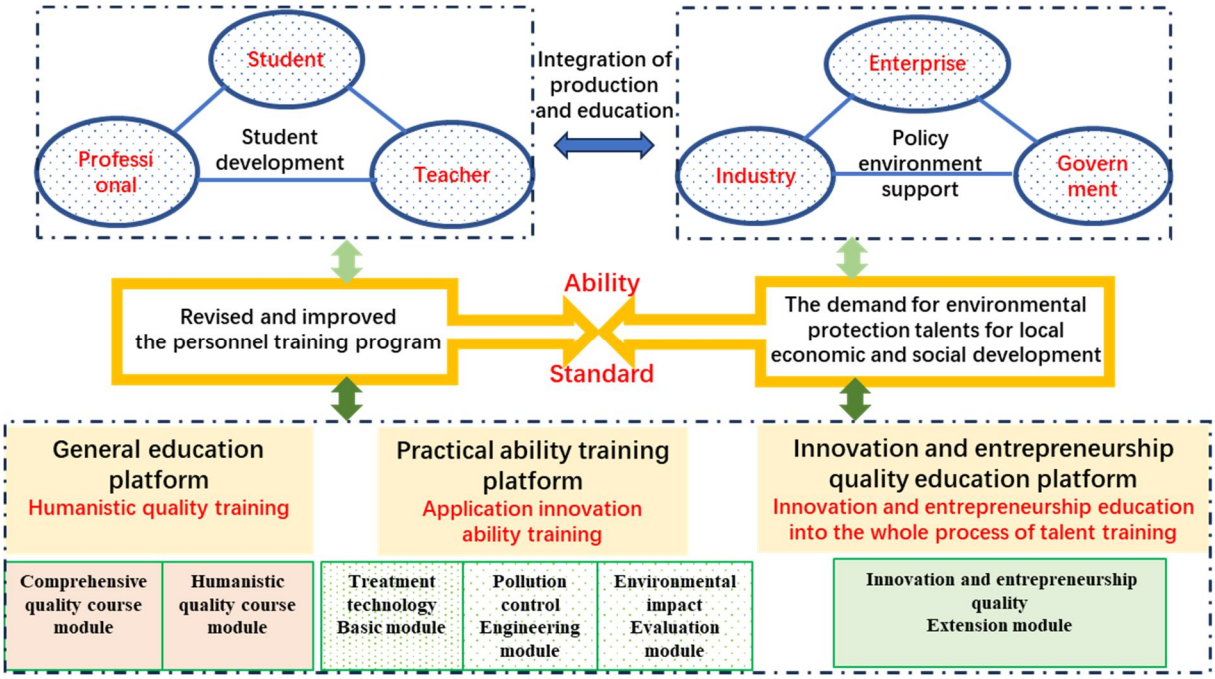

Fig. 1. The construction map of the environmental engineering curriculum system, which includes the integration of production and education and the development of various platforms, runs through the entire process of university learning.

Focus on student development, and the curriculum is gradually intensified according to students' understanding, progressing from general education to practical ability training and then to innovative ability training, moving from lower to higher levels. This approach aims to build a complete professional knowledge system that aligns with the rules of talent training and meets societal demands for high-quality environmental protection professionals. (i) Optimize the composition of public basic courses, improve the platform for public elective courses. Strengthening the comprehensive quality training of application-oriented talents to increase the proportion of humanities, arts, and social science courses within the public basic courses, and add social practice components as per the Ministry of Education's requirements. Broaden the subject coverage of public elective courses, strengthen the auditing, process control, and quality evaluation systems for these courses based on completing the credits of public elective courses, and improve their overall quality. This expansion will help broaden students' knowledge and improve their comprehensive quality. (ii) Reduce and accurately select professional skills courses, increase the hours dedicated to core courses, enabling students to better digest and master key professional knowledge while reinforcing the development of professional core skills. (iii) Select professional basic courses and increase the knowledge coverage of professional skills courses to enhance the subject knowledge base of the professional skills system. In addition to strong engineering design

capabilities, students should receive additional courses on pollution control and design foundations to ensure comprehensive coverage of professional skills. This will aid in building a complete professional knowledge system. (iv) Streamline practical classes within the professional basic course group. Integrate course practices into a curriculum practice group, and allocate the surplus hours to strengthen professional skills. The number of supporting practical training courses for professional basic courses should be reduced, with a focus on integration and concentration rather than dispersion. (v) Increase comprehensive practical training in professional skills courses. Comprehensive practical training courses for professional skills are offered based on course categories and ability objectives. Comprehensive practice is conducted by focusing on several specialized courses with the same ability objectives, simulating productive practice scenarios, and completing practical training projects with real-world production elements. This approach aims to improve students' practical abilities and enhance their employability.

3.2. Reconstructing the Curriculum Structure with a Focus on Ability Training

Following the concept of curriculum system construction, a 3+3 course group system based on ability cultivation has been initially developed. This system includes three professional direction modules and a three-tiered innovation and entrepreneurship course group system. The curriculum group system is structured according to the logic of mastering knowledge and skills (cognition) → applying knowledge and skills (method) → solving professional problems (ability). The emphasis is on ability cultivation, creating a systematic and interconnected course organic cluster.

(i) Three-tiered innovation and entrepreneurship course group system: First level is to add an innovation and entrepreneurship module to general courses. This includes two compulsory courses on general knowledge of innovation and entrepreneurship, as well as an innovation and entrepreneurship concentrated practice component in professional practice. Examples include "university students' innovation and entrepreneurship foundation (theory + extracurricular practice)", "university career planning and employment guidance", and "university students' innovation and entrepreneurship training". Second level is to offer an entrepreneurial guidance courses on the discipline platform, such as "environmental engineering special report," which are integrated with professional introduction courses and taught by professional experts or industry and enterprise specialists. Third level is built on the practical education activities of the students' self-selected second classroom, practical training courses such as "Internet +", business model design, and entrepreneurial sandbox simulations are provided for a select group of students with entrepreneurial intentions.

(ii) Three professional direction module course group system. Leveraging the advantages of interdisciplinarity and emphasizing the characteristics of water and soil governance, the university

offers three specialized module courses: the basic module of treatment technology, the pollution control engineering module, and the engineering practice evaluation module. The primary courses in the basic module of treatment technology include environmental engineering microbiology (the basis of biological treatment technology in pollution control engineering), environmental chemistry (the basis of chemical treatment technology in pollution control engineering), and chemical engineering principles (the basis of physical treatment technology and engineering design in pollution control engineering). The main courses in the pollution control engineering module include water pollution control engineering, air pollution control engineering, and soil pollution control engineering. The core courses in the engineering practice evaluation module include course experiments, course design, graduation design, and graduation practice (Zheng et al., 2016).

3.3. Reforming the Curriculum Teaching System with a Focus on Student Development

The optimization of the curriculum and curriculum structure, as well as the achievement of student ability cultivation goals, must be realized through an effective teaching process. As a key element in developing professional skills and practical abilities, student development should remain the central focus (Shore and Dinning, 2023). However, traditional teaching content and methods are insufficient to meet the training goals for applied talents, necessitating in-depth reform and innovation. Starting from the fundamental rules of undergraduate education, it is essential to continuously update teaching content in accordance with the evolution of disciplines and majors. This involves closely tracking the latest trends and frontiers associated with discipline and professional development, and ensuring that the own newest research findings and educational advancements are promptly translated into teaching contents. Enhancing the applied research element of teaching content is also of great significance, particularly by conforming to the specific requirements of local colleges and universities. This includes reducing the proportion of theoretical courses and increasing the overall credit hour of practical courses to better support the training of application-oriented talents. Additionally, emphasis should be placed on cultivating “double-qualified” teachers—those with both academic and industry experience—and actively exploring long-term mechanisms for school-enterprise cooperation (Wang and Wang, 2021). Pay attention to the integration of courses across different disciplines, actively promoting the merging of course content. This approach ensures that, while consolidating existing disciplinary knowledge, the curriculum also absorbs relevant knowledge from similar and related disciplines, thereby enhancing the breadth of curriculum content to meet students’ needs for broader knowledge and to foster innovative thinking. Actively implement the reform of teaching methods by exploring various approaches such as research-based, inquiry-based, interactive, and heuristic teaching. Encourage students to excel in practical applications, challenge established “paradigms”, and actively engage in innovation. Make full use of digital teaching tools, gradually establishing a comprehensive

knowledge system that integrates knowledge, skills, quality, and wisdom. Focus on the holistic and sustainable development of students, and strive to achieve the “golden course” teaching standard of “dual attributes and difficulty level”, thereby significantly improving the quality of education and teaching (Jing, 2019).

3.4. Innovative Teaching Quality Security System to Enhance Talent Training Quality

Guided by industry development needs, evaluation standards for application-oriented personnel training courses are established through collaboration between schools and enterprises (Chu, 2022). These standards emphasize the inherent requirements of “dual attributes and difficulty level”, creating feedback and improvement mechanisms, and ensuring continuous monitoring of the teaching process and outcomes. By analyzing the results of students’ ability evaluations, the reasons for any gaps between students’ skills and employer expectations are identified (Rikala et al., 2024). This allows for a reassessment of the alignment between student training and societal needs, leading to adjustments in teaching practices to further standardize and improve the teaching system and to promote educational reform. A comprehensive quality security system is established, consisting of the following components: (1) Formulating professional quality standards; (2) Monitoring key links of the education and teaching process (internal feedback); (3) Tracking the quality opinions of graduates and employers (external demand feedback); and (4) Continuously improving professional teaching quality based on quality information feedback (third-party supervision). This system operates at multiple levels, including objective level, content level, and implementation level. The establishment of a six-tier integrated teaching management model—comprising “school → college → program leader → teaching and research section director → course instructor (including industry mentors) → students”—ensures the seamless combination of the objective level and content level. Through the effective completion of these content levels, the model guarantees teaching quality and the achievement of teaching management objectives.

4. ACHIEVEMENTS IN THE REFORM OF THE CURRICULUM SYSTEM FOR TRAINING ENVIRONMENTAL ENGINEERING PROFESSIONALS

4.1. Remarkable Achievements in Talent Training and Student Development

In the past five years, students have undertaken 103 innovation and entrepreneurship projects, accounting for 21% of projects at or above the provincial level. In various discipline competitions, they have won 37 awards at or above the provincial level, including 1 national gold award, 1 provincial gold award, and 1 silver award in the Internet + university students innovation and entrepreneurship competition. In the “Challenge cup” university student entrepreneurship competition, they earned 2 national bronze awards and 1 provincial silver award. In the 5th national

university student's municipal environment innovation and practice ability competition, they secured 5 second prizes. Additionally, students participated in the publication of 48 papers, with 26 indexed in SCI, applied for 12 patents, and were granted 6 invention patents. The average annual postgraduate entrance examination rate is 28.6%, demonstrating a significant improvement in students' innovation abilities.

Alumnus Wentao Dong founded Hubei Yanghua Group and donated the school motto stone in celebration of the university's 60th anniversary. Alumnus Yankuan Zhao organized a student team to support national precision poverty alleviation efforts, earning the title of "Chinese college students self-improvement star" in 2018. He also led the Centennial Good team to win a gold medal on the Internet + university students' innovation and entrepreneurship competition in 2021. His public welfare entrepreneurship story has been widely reported by national mainstream media such as CCTV news, Morning news, People's daily, People's daily overseas edition, Guangming daily, and learning, generating significant social impact and serving as a powerful promotion for this achievement.

4.2. Significant Achievements in Professional Development with Broad Impact

Professional construction has yielded significant results, with the program being recognized with 2 Jiangxi high-level teaching team approvals, 8 provincial double-qualified teachers, 1 provincial virtual teaching and research room, 1 provincial experimental teaching demonstration center, 2 provincial key laboratories, 1 provincial engineering research center, 2 new national talents, and 3 provincial talents. Additionally, the college has received 1 third prize in natural science from Jiangxi Province. Over the past five years, 22 national projects and more than 30 provincial and ministerial projects have been approved, with total funding amounting to 35.79 million RMB. More than 70 academic papers have been published in professional authoritative journals such as Environmental Science & Technology. The college has completed more than 10 provincial teaching reform projects, including "Construction and practice of the curriculum system for environmental engineering talent training in local universities under the background of new engineering disciplines". The course "Environmental engineering microbiology" was recognized as a national first-class course, a provincial ideological and political demonstration course, an education sharing course, and a provincial first-class course. Additionally, "Air pollution control engineering" was approved as a first-class offline course in Jiangxi Province. The "Virtual simulation system for typical urban sewage treatment process scenario simulation" was established as a provincial virtual simulation experiment project and has been launched on the provincial shared service platform. More than 20 teaching and research papers have been published in educational journals, covering various aspects such as professional construction, curriculum development, and teacher team building. These efforts have greatly advanced the level of professional construction and improved

the quality of talent training. The college's success has provided valuable experience for the construction and reform of environmental programs in local undergraduate universities. As a result, more than 10 universities, including Guangzhou University, Jiangxi University of Science and Technology, and Southwest University of Science and Technology, have visited the college for exchanges.

4.3. Deep Integration of Schools, Localities, and Enterprises with Positive Social Impact

Deepen multi-party cooperation among the government, schools, and industries (enterprises), and implement an education model that integrates production with education, learning with research, and training with competition (Zhang, 2024). A "Two mountains transformation" center has been established in collaboration with the local government, alongside stable off-campus practice bases with over 10 enterprises, including Beijing Enterprises Water Group Limited, Jiangxi Tingjin Environmental Protection Technology Co., LTD., and Hunan Dingli Technology. A modern industrial college of ecological environment has also been established.

Cooperation with enterprises has led to the establishment of a dual-tutorial system, enhancing students' practical innovation abilities through industry-based scenarios and project-driven teaching reforms (Yan, 2024). Over 30 industry professionals have been employed as teachers, with 10 courses jointly conducted by schools and enterprises, 10 research projects initiated, more than 2,000 students mentored, and 8 teachers taking temporary positions within industrial enterprises. The professional personnel training model and its educational outcomes have been widely recognized by employers and reported by Xinhua New Media, Jiangxi News, and other media. In 2022, the environmental engineering major at our school ranked second among local universities (outside the Nanchang).

5. CONCLUSION

Based on the national engineering education certification standards, the training objectives and requirements for the environmental engineering major at Jinggangshan University were formulated. Meanwhile, focusing on the construction of the curriculum system, the problems existing in professional talent training were analyzed. Considering the problems identified, ideas for the construction of the curriculum system were proposed. Through the implementation of these reforms, significant achievements have been made in talent training, leading to a substantial improvement in the level of professional development and social influence. This experience also provides a valuable reference for the construction of environmental engineering at other local universities.

ETHICAL APPROVAL

No applicable.

CONSENT TO PARTICIPATE

No applicable.

CONSENT TO PUBLISH

All authors agree to publication.

AUTHORS CONTRIBUTIONS

Genhe He: Conceptualization, Data curation, Investigation, Funding acquisition, Writing – original draft, review & editing. **Yian Wang:** Investigation, Funding acquisition, Writing – original draft, review & editing.

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CONFLICTS OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available within the article and/or its supplementary materials.

REFERENCES

Chu, H., (2022). Research on a new mode of integration of production and education for applied undergraduates. *International Journal of New Developments in Education*, 4(16), 68-72.

Fu, J., Hu, D.X., Wang, S.Y., (2023). Empowering the future of engineering education discipline with chinese characteristics: motivation, formation, and promotion. *Engineering Education Review*, 1(1), 27-39.

Haque, M.S., Sharif, S., (2021). The need for an effective environmental engineering education to meet the growing environmental pollution in Bangladesh. *Cleaner Engineering and Technology*, 4, 100114.

Jing, Z.H., (2019). Exploring the path and method of creating the "golden course" of vocational education. *1st International Symposium on Education, Culture and Social Sciences (ECSS 2019)*, 311, 64-68.

Li, X., Pu, R.H., Liao, H., (2022). The impacts of innovation capability and social adaptability on undergraduates' employability: The role of self-efficacy. *Frontiers in Psychology*, 13, 954828.

Qiao, Y., Fu, H.M., (2022). Study on OBE teaching concept in the context of deep learning for the construction of university mathematics microcourses. *Computational Intelligence and Neuroscience*, 2022(1), 6860842.

Rikala, P., Braun, G., Järvinen, M., Stahre, J., Hämäläinen, R., (2024). Understanding and measuring skill gaps in Industry 4.0 — A review. *Technological Forecasting and Social Change*, 201, 123206.

Shore, A., Dinning, T., (2023). Developing student's skills and work readiness: an experiential learning framework. *Journal of Work-Applied Management*, 15(2), 188-199.

Southworth, J., Migliaccio, K., Glover, J., Glover, J.N., Reed, D., McCarty, C., et al., (2023). Developing a model for AI Across the curriculum: Transforming the higher education landscape via innovation in AI literacy. *Computers and Education: Artificial Intelligence*, 4, 100127.

Wang, X.H., Wang, X., (2021). Problems and strategies on cultivating excellent vocational education teachers in local normal university. *Creative Education*, 12(9), 2167-2179.

Yan, J.F., (2024). Research on project teaching method reform and practice based on "dynamic website development" course. *Curriculum and Teaching Methodology*, 7, 119-125.

Zhang, S.Z., (2024). Educational cooperation in the perspective of tripartite evolutionary game among government, enterprises and universities. *Plos One*, 19(1), e0294742.

Zhao, B., Xudong, H., Gao, D.K., Xu, L.Z., (2020). Construction and evaluation of talent training mode of engineering specialty based on excellence engineer program. *Sage Open*, 10(2), 2158244020922889.

Zheng, B., Liu, Y.Q., Guo, D.C., Sun, P., (2016). Multilevel practical teaching system based on the excellent engineers education mode. *Proceedings of the 2016 International Conference on Education, E-learning and Management Technology*, 1, 61-66.