

Empowering Talent Cultivation in Water Supply and Drainage Science and Engineering through “Three-Color Embedding”: Exploration and Practice at Nanyang Normal University

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Keywords: Three-Color Embedding; Water Supply and Drainage Science and Engineering; Talent Cultivation

Abstract: In light of China's ecological civilisation initiative and the new engineering education strategy, talent cultivation in Water Supply and Drainage Science and Engineering urgently needs to be more intelligent, eco-friendly and innovative. A typical local university needs to find a way to use its own strengths to avoid being one of many. Located at the canal head and core water source area of the Middle Route of the South-to-North Water Diversion Project, Nanyang Normal University has innovatively incorporated the philosophy of "Three-Color Education" in its talent cultivation process for this program: red gene inheritance, green ecological stewardship, and blue innovation development. This paper explores the theoretical basis of the Three-Color Embedding method and puts forward a reform system that focuses on value leadership (red), knowledge organisation (green), and ability cultivation (blue). Through initiatives such as the "Water Lifeline of a Great Nation" ideological and political curriculum cluster, a special curriculum module on water source protection, and an industry-education integration platform for smart water management, the program has integrated professional education with education in national and local realities, ecological civilisation, and innovation. The results show that this model can enhance students' sense of social responsibility and national commitment, ecological literacy, engineering practice skills, and innovation ability, providing a good model for high-quality talent cultivation in Water Supply and Drainage Science and Engineering programs at local universities.

1. Introduction

With the progress of national strategies, such as the development of ecological civilisation,

sponge city construction and intelligent water management, as well as the increasing demand for high-quality engineering talents driven by new quality productive forces, the water supply and drainage sector is changing from traditional municipal engineering to intelligent, ecological and integrated services [1-3]. This change has created new requirements for the knowledge system, professional qualities and values of students in Water Supply and Drainage Science and Engineering. However, many application-oriented local universities still face problems, such as a mismatch between talent cultivation and the needs of new industries, a lack of distinct program features, insufficient integration of ideological and political education with professional education, and weak innovation and practical abilities among students [4-6].

In light of the above problems, Nanyang Normal University has taken advantage of its advantageous location in the core water source area and at the canal head of the Middle Route of the South-to-North Water Diversion Project. As an institution responsible for supporting this important national project in talent cultivation and intellectual contributions to water ecological protection and water resource utilisation, the university has developed and actively promoted a distinctive "Three-Color Education" model that integrates red gene inheritance, green ecological stewardship, and blue innovation development. To nurture high-quality, application-oriented talents with professional abilities and moral character, the Water Supply and Drainage Science and Engineering program has been in line with national strategies and regional demands by incorporating the Three-Color philosophy at all times in talent cultivation. Through a series of new and effective practices, the programme has found a special way to develop talent. This study systematically summarises the reform efforts and practices to provide a reference for programme development and educational reform at other similar institutions.

2. Theoretical Logic and Framework Construction of “Three-Color Embedding”-Empowered Talent Cultivation in Water Supply and Drainage Engineering

2.1 Connotation and Program Relevance of the Three-Color Education Philosophy

The size of the red gene (value guidance) shows political support and commitment to the country's development. The programme integrates patriotism, engineering ethics, social responsibility and craftsmanship into all aspects of education to foster a strong desire in students to serve the country through engineering and make contributions to society through water-related work.

The green ecology dimension (knowledge foundation) refers to the disciplinary essence and development ideas of the program. In line with the goals of ecological civilisation, it puts forward a knowledge system and ecological ethics based on sustainable water use, integrated water-environment management and water ecological security.

The blue innovation dimension (competency driver) refers to the features of the new era and future-oriented development. As technology advances and a new era dawns, intelligent water management, digital twins, artificial intelligence, etc., are becoming increasingly cutting-edge fields that can stimulate students' interest in exploration and help them solve real-life engineering problems.

As an application-oriented engineering discipline directly related to public welfare, water security and ecological protection, Water Supply and Drainage Science and Engineering covers the entire cycle of planning and design, construction and operation, as well as maintenance and management, making it highly compatible with the philosophy of Three-Color Education. The Red Dimension will promote the moral education and sense of social responsibility for students in their future careers in engineering services; the Green Dimension will strengthen the academic foundation and clarify the purpose of professional training; and the Blue Dimension will provide

impetus for innovation and continuous improvement of the program.

2.2 Framework Design of the Three-Color Embedding Approach for Talent Cultivation

Based on the above reasons, the program has built a Three-Color Embedding talent cultivation framework that progresses in the integration of values, knowledge and abilities, and deeply fuses the three dimensions (Figure 1).

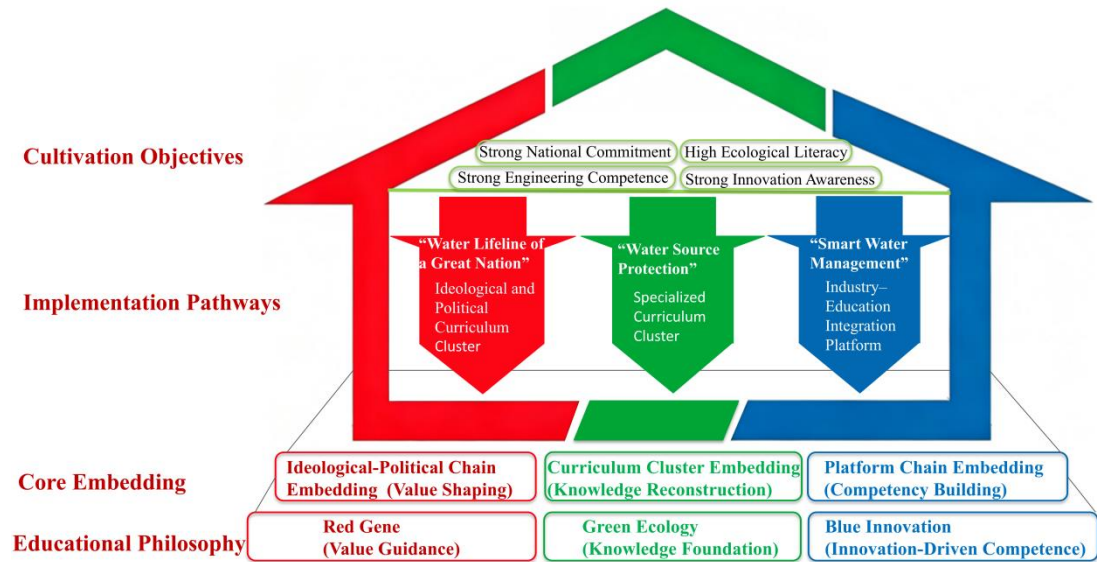


Figure 1. Overall Framework of the Three-Color Embedding Approach for Talent Cultivation in Water Supply and Drainage Science and Engineering

In the spirit of Three-Color Education, the three directions of this system are ideological and political integration, curriculum integration, and platform integration. Through the above strategies, the red value guidance, green knowledge system and blue innovation capabilities will be systematically integrated into the curriculum, teaching process and practical training. Finally, we hope to cultivate high-quality, application-oriented talents with a strong sense of social responsibility and national aspiration, good ecological literacy, strong engineering capabilities, and powerful innovative ability.

3. Practical Pathways of the Three-Color Embedding Approach for Talent Cultivation

3.1 Integration and Alignment of the “Three-Color” Philosophy with Program Educational Objectives and Graduation Requirements

The three colours are the aims of education for this programme. The program hopes to cultivate graduates with a strong sense of social responsibility and sound engineering ethics (red), effective communication and teamwork skills (red/blue), the ability to solve complex water supply and drainage engineering problems (blue), and a commitment to supporting the economic development of Henan Province (red/green). Graduates are also expected to consider social, health, safety, legal, cultural and environmental factors in their work (green). Among the five expected achievements five years after graduation, Objective 1 (personal development and social responsibility) focuses on the red dimension; Objective 2 (professional competence) emphasizes the blue dimension; Objective 3 (engineering capability) integrates all three dimensions; and Objective 4 (lifelong

learning) stresses the blue dimension, thus forming a balanced Three-Color objective system.

The graduation requirements offer specific support for these Three-Color Objectives. The programme constructs a matrix that links graduation requirements with the educational goals of the programme to ensure that all of them are in line with the Three-Color Goals. For example, Graduation Requirement 7 (professional ethics) directly supports the red dimension; Graduation Requirement 6 (sustainability) directly supports the green dimension; and Graduation Requirements 4 (research) and 5 (modern engineering tools) directly support the blue dimension. At the same time, Graduation Requirement 3 (design/development of solutions) also supports the blue dimension through new designs and the green dimension by considering environmental factors. Concrete indicators are the above relationships in measurable form (Table 1).

Table 1: Matrix of Support Strengths between Graduation Requirements and the Three-Color Talent Cultivation Objectives

Graduate Attributes	Three-Color Talent Cultivation Objectives			Integrated Support Description
	Red Value Objective (Objectives 1 & 3)	Green Sustainability Objective (Objectives 1 & 3)	Blue Competency Objective (Objectives 2, 3 & 4)	
1.Engineering Knowledge		L	H	Provides the Knowledge Base for Blue Competencies
2.Problem Analysis		M	H	Core Blue Competence with Green Considerations (M)
3.Design/Development of Solutions	M(Considering legal and cultural factors)	H(Considering Environmental, Safety, and Health Factors)	H(Innovative Design)	High Integration of the Three Colors
4.Investigation		M	H	Core of Blue Innovation Competence
5.Modern Tool Usage			H	Core of Blue Digital Competence
6.Engineering and Sustainability	M(Social Impact)	H	M(Supporting Sustainable Engineering Competence)	Green Core with Red–Blue Integration
7.Professional Ethics	H	M(Understanding Environmental Responsibility)		Red Core with Green Awareness
8.Individual and Team Work	H(Dedication)		M(Collaboration Skills)	Red Values and Blue Collaboration Skills
9.Communication	M(Public Communication)	M(Environmental Awareness Promotion)	H(Global Perspective and Professional Communication)	Blue Competence Supported by Red and Green Elements
10.Project	M(Understanding	M(Economic and	H(Management	Blue Management

Management	Responsibilities)	Environmental	and	Competence within a
		Decision-Making)	Decision-Making	Red–Green Context
			Skills)	
11.Lifelong Learning	M(Adaptability	M(Keeping	H(Self-Directed	Blue Development
	to Social	Abreast of Green	Learning and	Competence Guided by
	Development)	Technologies)	Innovation	Red and Green Values
			Adaptability)	

Note: H = High Support; M = Moderate Support; L = Low Support.

3.2 Embedding Red Gene Inheritance: Building the “Water Lifeline of a Great Nation” Ideological and Political Curriculum Cluster to Strengthen Value Guidance

To address the fragmented identification of ideological and political elements and their frequent superficial integration into professional courses [7], a four-year immersive ideological and political curriculum cluster has been developed around the South-to-North Water Diversion Project, a typical national infrastructure project (Table 2).

Table 2: Design of the “Water Lifeline of a Great Nation” Ideological and Political Curriculum Cluster

Academic Year	Course/Activity	Red Ideological and Political Themes	Key Integration Points and Educational Objectives
Freshman Year	Introduction to Water Supply and Drainage Science and Engineering, Water Lifeline of a Great Nation: The South-to-North Water Diversion Project	Engineering Awareness and Original Aspiration Mission	In light of the history of the discipline and the South-to-North Water Diversion Project, this course will also inspire students to develop a sense of professional identity and a mission in serving the country's development through water management.
Sophomore Year	Hydraulics, Water Engineering Regulations, Cognitive Internship (Canal Head and Water Treatment Plant)	Craftsmanship Spirit and Engineering Ethics	Exploring the beauty of engineering mechanics and precision through "the journey of a drop of water"; field trips show the demand for high-quality engineering in national defence and public security, and inspire a spirit of meticulous craftsmanship.
Junior Year	Water Quality Engineering, Water Resources Utilization and Protection, Production Internship (Water Source Protection Area)	Patriotism and Ecological Responsibility	The South-to-North Water Diversion Project serves as a case study to help students learn about water purification technology and source protection policies, fostering a sense of ecological security and patriotism among "water guardians".

Senior Year Graduation Project (Thesis), Graduation Education	Serving the Nation through Science and Technology and Professional Aspirations	Encouragement Topics for Water Source Protection and Rural Wastewater Treatment; The "Embarking on a New Journey" Education Guide helps graduates align their personal aspirations with national water development.
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In addition, the programme actively promotes the synergy of ideological and political education at the programme, course and faculty levels [8]. The programme regularly organises collective lesson planning sessions and teaching workshops on curriculum-oriented ideological and political education to boost the faculty's awareness and ability in value-oriented education, and ensure that the inheritance of red genes is naturally and effectively integrated into professional courses.

3.3 Embedding Green Ecology: Reconstructing the Distinctive “Water Source Protection” Curriculum Module to Strengthen the Knowledge Foundation

Based on the Henan Province characteristic backbone discipline cluster of ecological security and water resources protection, the program has reformed its traditional curriculum into a greener and more distinctive system, and formed a characteristic knowledge module focused on water source protection and ecological restoration (Figure 2).

Enhancing core courses with ecological content. The core courses of *Water Quality Engineering* and *Water Treatment Biology* have added considerable content on micro-pollutant removal, ecological purification technology (e.g., constructed wetlands and ecological floating islands), and eutrophication control. Case studies from the Danjiangkou Reservoir area and other local engineering projects will be selected first.

Develop specialised elective course clusters. In light of the above special direction, a number of elective courses have been added to the program, including *Urban Aquatic Ecology and Water Environment*, *Environmental Impact Assessment*, *Introduction to Environmental Materials*, and *Membrane Technologies for Water Treatment*, to help students build a knowledge system that better meets the requirements of water source protection.

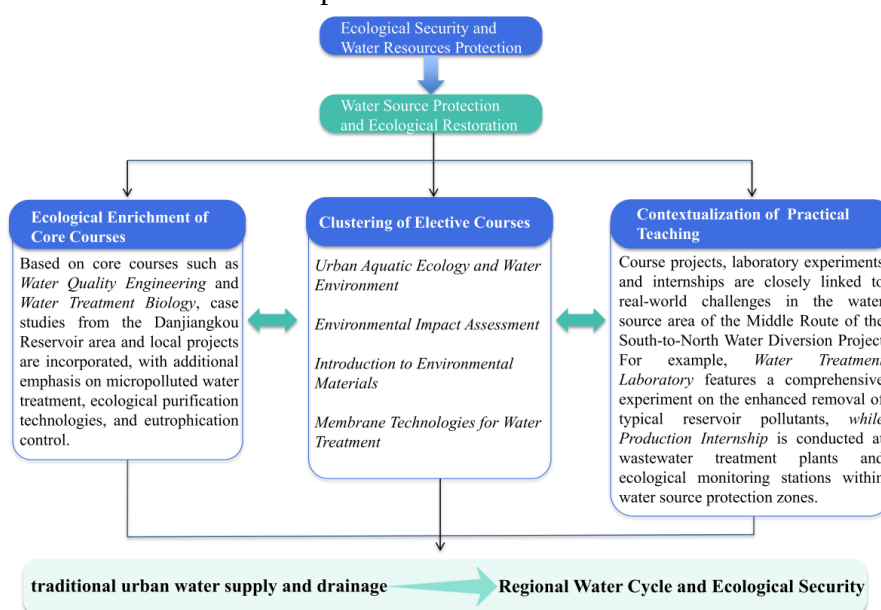


Figure 2. Structure of the Distinctive “Water Source Protection” Curriculum Module

Contextualizing Practical Education. Course projects, laboratory work and internships are all related to real-life problems in the South-to-North Water Diversion source area. *Water Treatment Experiments* include an all-encompassing experiment on the enhanced removal of typical reservoir pollutants, and Production internships are carried out at wastewater treatment plants and ecological monitoring stations in the water source protection area.

Through this modular restructuring, students' knowledge system has expanded from traditional urban water supply and drainage to regional water cycling and ecological security, making ecological literacy a defining characteristic of their professional competence.

3.4 Embedding Blue Innovation: Building a Smart Water Management Industry–Education Integration Platform to Strengthen Core Competencies

To meet the demands of the industry's digital transformation and address students' insufficient proficiency in modern engineering tools and innovation capabilities [9–10], the program has established a three-dimensional blue innovation competency development system integrating on-campus platforms, university–industry collaboration, and disciplinary competitions.

Developing smart teaching platforms. Relying on the university's Water Science and Engineering Training Center, the program has introduced virtual simulation software for water supply and drainage systems, a Building Information Modeling (BIM) platform, and a digital twin system for water treatment plant operation. Courses such as *Principles and Applications of BIM Technology* and *Introduction to Smart Water Plants* have been offered to deeply integrate modern information technologies into teaching [11].

Strengthening industry–education collaboration. The program has partnered with local water utility groups and environmental technology enterprises to establish a Smart Water Management Industry College and internship bases. Industry engineers are invited to serve as mentors and jointly develop practical training projects, such as *SCADA-Based Simulation for Water Plant Operation Optimization* and *Smart Monitoring Solutions for Water Distribution Network Leakage*. This dual-participant educational model enables students to engage directly with real-world industrial challenges [12].

Promoting innovation through competitions. A progressive innovation training system has been established, linking course projects, undergraduate innovation and entrepreneurship programs, and disciplinary competitions. Students are encouraged to transform ideas generated in course projects into provincial- and national-level innovation and entrepreneurship projects and further refine them for competitions such as the China International College Students' Innovation Competition ("Internet+"), the *Challenge Cup*, and the National Water Supply and Drainage Science and Technology Innovation Competition for College Students (*Deepwater Cup*). Over the past three years, students in the program have won more than 20 provincial- and national-level awards in these competitions.

4. Implementation Outcomes and Social Impact

After years of continuous reform and practice, the Three-Color Embedding talent cultivation model has achieved remarkable results.

4.1 Significant Improvement in Students' Comprehensive Competencies

Enhanced value identification. Students have developed a stronger sense of professional identity and a greater commitment to serving national water strategies. More than 95% of the graduates are willing to work in the field of water resources and environmental protection.

Improved Practical and Innovative Capabilities. The proportion of students in research projects and academic competitions has risen from 30% to 65%. The number of software copyrights and utility model patents obtained by students has been increasing steadily. In the past three graduating classes, more than 80% of the undergraduate thesis projects were based on real engineering applications or scientific research.

Gradually improving employment quality. The year-end employment rate of graduates has been consistently over 96%, and the major-related employment rate is 85%. Based on the employer satisfaction survey, over 90 per cent of employers rated the graduates highly in responsibility, practical skills and adaptability to new-age technologies.

4.2 Remarkable Achievements in Program Development and Educational Reform

Substantial progress in curriculum and teaching material development. The program has set up eight provincial- or higher-level courses, including model courses for curriculum-based ideological and political education, first-class undergraduate courses, demonstration courses integrating innovation and entrepreneurship education, and outstanding online undergraduate courses. In addition, two textbooks were approved under the Second Batch of the Henan Province 14th Five-Year Plan for Higher Education Textbooks, and six undergraduate theses were selected as Outstanding Bachelor's Theses of Henan Province. Based on the themes of the South-to-North Water Diversion Project and ecological civilisation, a series of special teaching materials, courseware resources and standardised case databases have also been developed by the programme.

Optimisation of the Faculty Structure. A high-quality teaching team with strong professional ethics, excellent academic ability and all-round talents has been established. All faculty members have a master's or doctoral degree, and 50% are associate professors or above.

Improved Platforms and Practice Bases. The program has built several high-level teaching and research platforms, such as the Henan Engineering Research Center for Green Construction and BIM Technology, the Nanyang Key Laboratory of Water Pollution Control and Resource Utilization, the Henan Characteristic Teaching and Research Center for Curriculum-Based Ideological and Political Education under the "South-to-North Water Diversion+" initiative, and the Henan Off-Campus Practice Education Base for Emerging Engineering Education. These platforms offer strong institutional and material support for the implementation of the Three-Color Embedding approach.

4.3 Growing Social Service Contributions and Broader Impact

Faculty members and students in the program have actively participated in social service activities, such as baseline ecological and environmental surveys in the South-to-North Water Diversion source area and performance evaluations of rural wastewater treatment facilities. Several recommendations from the above projects have been implemented by the local government. The reform experience of the program has also been presented at regional and national conferences on water supply and drainage engineering education, providing valuable ideas and references for other institutions.

5. Conclusion

Nanyang Normal University's Water Supply and Drainage Science and Engineering program has creatively incorporated the university's Three-Color Education philosophy into all aspects of talent cultivation by utilizing its special location in the water source area of the Middle Route of the South-to-North Water Diversion Project. A new type of talent cultivation model has been

established based on the red-value direction, green-knowledge reconstruction and blue-competency development. Concrete measures have been taken to address the typical problems faced by local application-oriented universities in the programme, such as homogeneous talent cultivation, a lack of connection between ideological and professional education, and insufficient student innovation and practical ability, by developing the *Water Lifeline of a Great Nation* ideological and political curriculum cluster, reconstructing the *Water Source Protection* curriculum module, and building a *Smart Water Management* industry-education integration platform. Thus, the general level of talent cultivation has been raised to some extent.

Looking ahead, the program will continue to deepen the Three-Color Embedding reform in the three key areas. First, it will further explore the reasons for the combination of the three aspects and build an all-encompassing assessment system. Second, it will promote the frontier orientation of the blue innovation dimension by integrating new technologies such as artificial intelligence and big data into water management education and practice. Third, it will expand the international dimension of red gene inheritance by sharing China's water governance experience with the world and cultivating water supply and drainage professionals with global literacy. With continuous optimisation and innovation, the Three-Color Embedding method will become more mature and influential in cultivating excellent engineering talents with strong political awareness, a deep sense of social responsibility, a solid professional foundation, and powerful innovative ability for the sustainable development of the water industry in the new era.

Acknowledgements

Support for this work came from three projects: the Major Project of Higher Education Teaching Reform Research in Henan Province "Water as the Soul: Exploration and Practice of Application-Oriented Talent Cultivation in Local Universities Geared to National Strategies" (Grant No. 2024SJGLX0027); the Teaching Research Project of Nanyang Normal University "Research and Practice on the Talent Training Model for Water Supply and Drainage Engineering Synergistically Driven by Emerging Engineering Education and Engineering Accreditation" (Grant No. 2026-JXYJYB-31); and Henan Province Undergraduate University "South to North Water Diversion Project+" Curriculum Ideological and Political Teaching Research Characteristic Demonstration Center Project (KCSZZX202216).

References

- [1] Yang, R., Tang, Y., & Jiang, C. T. (2025). Research on teaching reform of water supply and drainage science and engineering program based on industry needs. In *Proceedings of the Classroom Teaching Sub-forum of the 2025 Higher Education Development Forum* (Vol. 1).
- [2] Yu, L., Huang, J., Yang, H. Y., Wei, W., & Hu, H. (2024). Innovation and practice of integrating ecological civilization thought into talent cultivation for water supply and drainage science and engineering program. *Journal of Higher Education*, 10(S1), 165-169.
- [3] Chen, J., Sun, S. Q., & Chen, H. (2024). Research on talent cultivation strategies for water supply and drainage program under the background of smart water services. *The Guide of Science & Education*, 28, 65-67.
- [4] Cheng, Y., Wen, G., Yang, F. L., Yang, C. J., & Zhou, S. L. (2025). Innovative practical teaching empowering talent cultivation for water supply and drainage science and engineering program: Exploration and practice of Xi'an University of Architecture and Technology. *Municipal Engineering Technology*, 43(6), 206-214.
- [5] Dou, Y. Y., Zhou, Z. Z., Duan, X. J., Li, Y., Gong, W. J., Liu, Y., Lü, J. J., & Wang, S. Y. (2025). Construction of practical teaching system for water supply and drainage science and engineering program in application-oriented universities. *NeiJiang Science & Technology*, 46(5), 51-52+55.
- [6] Li, S. Y., Zhou, S., & Wang, G. H. (2024). Exploration on cultivation and improvement strategies of disciplinary literacy for water supply and drainage science and engineering program in local universities. *Learning Weekly*, (10), 41-44.
- [7] Liu, W. L., & Guo, J. B. (2025). Construction and implementation of collaborative education system of

"professional ideological-political education – curriculum ideological-political education – teacher ideological-political education": A case study of water supply and drainage science and engineering program. *Journal of Higher Education*, 11(7), 188-192.

[8] Huang, X. Y., Wang, Y. Q., & Xiao, T. L. (2024). Exploration and practice of ideological and political education for civil engineering-related majors in universities. *Anhui Architecture*, 31(8), 91-92+126.

[9] Zheng, M. Q., Xu, Q., Gong, M., Feng, J. W., & Wang, W. (2025). Practice and thinking on talent cultivation for water supply and drainage science and engineering program oriented to the demand of new quality productive forces. *University Education*, (17), 121-127.

[10] Li, Z. H., & Huang, J. Y. (2025). Thoughts on curriculum optimization of water supply and drainage science and engineering program in application-oriented undergraduate colleges under the "artificial intelligence +" background. *Heilongjiang Education (Theory & Practice)*, (4), 54-56.

[11] Cao, X. L. (2024). Exploration on BIM integration into water supply and drainage science and engineering program under outcome-based education and engineering accreditation. *Popular Science & Technology*, 26(2), 175-179+191.

[12] Luo, J. Y., Lin, T., Feng, Q., Zheng, X. Y., & Cheng, S. (2025). Thoughts on cultivating innovative top-notch talents for water supply and drainage program driven by industry-education integration and science-education integration. *China Journal of Multimedia & Network Teaching (First Ten Days)*, (2), 157-160.