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Research on the Training Model of Engineering Talents Based on Major Projects: A Case on the ”Ecological Civilization Initiative”

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Abstract

Background: Strengthening technological innovation in the field of ecological environment poses higher requirements for the cultivation of ecological environment talents. However, issues such as the disconnection between course content and the actual needs of ecological civilization construction, and the weak integration between practical projects and major ecological and environmental issues still severely constrain the quality of talent cultivation. Major projects serve as vital vehicles for tackling scientific and technological challenges in the field of ecological and environmental protection, embodying unique educational value. However, the academic community has yet to systematically identify the key elements for cultivating talents based on major projects. Against this backdrop, exploring and constructing an engineering talent cultivation model based on major projects, and deeply integrating the scientific research resources, practical scenarios, and problem-solving demands of major projects into the entire talent cultivation process, has become crucial for addressing the existing shortcomings in talent cultivation.

Purpose: Zhejiang University initiated a major on-campus project, the "Ecological Civilization Initiative," in 2019, aiming to advance reforms in the cultivation of high-level ecological environment talents through interdisciplinary convergence in fields such as Environmental Science, Agricultural Resources and Environment, Chemical Engineering, and Computer Science. This study took the project as the research subject and, based on the TOE framework, systematically identified the key elements for cultivating engineering talents based on major projects across three dimensions: technical factors, organizational factors, and environmental factors. Based on the findings, this study constructed a novel cultivation model.

Method: This study adopted a single-case study methodology by conducting semi-structured interviews with researchers and relevant administrators involved in the program, and collecting relevant information from internal channels, official websites, and mainstream media to ensure the authenticity, richness, and completeness of the qualitative data.

Results: First, this study identified key elements of the cultivation model, including educational platform, interdisciplinary course resources, institutionalized research team, organizational structure, research organization model, organizational support system, orientation of serving national strategies, international cooperation and

exchange network, and interdisciplinary research atmosphere. Second, Zhejiang University's "Ecological Civilization Initiative" has successfully constructed a distinctive engineering talent cultivation model through organized scientific research. Specifically, Zhejiang University translated "national strategic demands" into cultivation objectives, converted "scientific research resources" into cultivation conditions, and transformed "problem-solving processes" into cultivation stages, ultimately cultivating high-quality innovative talents that meets the needs of national ecological civilization development.

Conclusion: This study has opened the "black box" of the process for cultivating engineering talents based on major projects and can provide references for the cultivation of high-level strategic scientific and technological talents.

Keywords: Major Projects; Interdisciplinary Training; Engineering Talents

1 Introduction

Globally, there is a pressing need to cultivate multidisciplinary talents equipped to address ecological and environmental challenges[1], thereby generating the technological innovation required to achieve carbon peak and neutrality targets and advance new productive forces[2]. According to EU projections, 35% to 40% of jobs over the next decade will be linked to the green transition[3]. Statistics show that China's demand for professionals in carbon peak and neutrality during the 14th Five-Year Plan period is projected to reach 600,000 to 1,000,000, yet a substantial gap remains between the existing talent pool and actual needs[4]. The ongoing scientific and technological revolution and industrial transformation, along with the global urgency of energy transition, necessitate the establishment of an education-technology system that closely integrates innovation with talent cultivation[5]. However, cultivating innovative talents in the ecological and environmental field still faces multiple bottlenecks, among which curriculum design, faculty development, and educational platforms represent particularly prominent challenges[6]. In this context, reforming talent cultivation in the ecological and environmental field—shifting from traditional knowledge transmission to an innovation-driven, full-chain education model—has become a critical contemporary priority[7]. In 2022, China's Ministry of Education issued the "Work Plan for Strengthening Higher Education Talent Cultivation for Carbon Peaking and Carbon Neutrality," which explicitly advocates accelerating the integration of research outcomes into teaching content and cultivating high-level professionals through major projects, platforms, and engineering initiatives.

In cultivating innovative talents in the ecological and environmental field, integrating project-based learning (PBL) concepts into educational settings centered around major projects has emerged as a promising direction for pedagogical reform. Especially in university-level major projects—a crucial vehicle for education—the principles of PBL can be fully realized. University-level major projects constitute high-level research initiatives that are independently initiated by universities to address national strategic demands and tackle cutting-edge academic challenges. As one of the most prestigious and well-funded categories within university research systems, these projects are tasked with the critical mission of achieving breakthroughs in key scientific and technological areas. Consequently, they have become vital platforms for cultivating high-level innovative talents. These flagship projects engage students in authentic research contexts, requiring them to identify complex problems, synthesize diverse resources, devise viable solutions, and ultimately generate innovative scholarly outputs. This experiential learning process is fundamentally consistent with the core tenets of PBL, namely, fostering problem-oriented competencies and facilitating the construction of knowledge through situated practice.

In 2019, Zhejiang University launched the "Ecological Civilization Initiative," a flagship project designed to support national strategies for ecological civilization construction. This major project aims to generate significant original breakthroughs and cultivate top-tier interdisciplinary talents by leveraging converged strengths from multiple disciplines. Although the potential of university-level major projects to foster talent cultivation has attracted increasing scholarly attention, the existing literature has largely concentrated on their scientific research outputs, leaving a significant gap in the theoretical frameworks by which such projects systematically integrate technological, organizational, and environmental elements to establish effective talent cultivation models.

To address this research gap, this paper focuses on the following core research question: How can university-level major projects effectively empower innovative talents cultivation in the ecological and environmental field？ Specifically, this study adopts a single-case study approach, examining Zhejiang University's "Ecological Civilization Initiative" as an empirical case to explore innovative talents cultivation in the ecological and environmental field. Guided by the TOE framework, this research systematically identifies the elements for cultivating engineering talents based on major projects and constructs a cultivation model across three dimensions—technical factors, organizational factors, and environmental factors. The research findings aim to offer insights for universities to cultivate first-class talents capable of serving

national ecological civilization development based on major projects.

2 Literature Review

2.1 Talents Training Model Based on Major Projects

Project-based Learning (PBL) advocates placing students in authentic problem situations and guiding them to solve real-world problems through collaborative inquiry [8]. In contrast to traditional instructional models, projects transcend their former role as merely supplementary or ancillary activities, instead constituting a pedagogical approach designed to foster higher-order thinking skills. In this context, "projects" encompass a range of pedagogical formats, including case studies, presentations, and comprehensive training [9]. Researchers have further proposed six essential elements for designing PBL: problem-driven, sustained inquiry, student engagement, interdisciplinary integration, product-oriented, and assessment-driven [10]. Regarding the educational efficacy of project-based learning, the extant literature presents three distinct perspectives: some researchers contend that PBL has a significant positive impact on student learning outcomes; others argue that its benefits are aspect-specific, yielding significant improvements in certain aspects but limited effects in others; and a third group posits that PBL exerts no significant influence on student achievement [11].

In the field of engineering education, participation in major projects has become a key pathway for cultivating high-level scientific and technological talents. National major science and technology projects possess strategic, systematic, and driving characteristics, offering distinct advantages in training graduate students' research skills and comprehensive capabilities [12]. Lin Qingguo et al. posit that involvement in national major science and technology projects substantially facilitates both the personal growth and innovation capacity development of graduate students. Their survey findings indicate that over 93% of graduate students perceived notable improvements in three key aspects: professional knowledge, scholarly mindset, and research capabilities — after participating in such projects [13]. Researchers have systematically analyzed the distinctive experiences of Chinese universities in cultivating engineering talents based on major projects, drawing on representative projects from diverse fields. Using the Changying UAV national major science and technology project as a case study, Zhang Feng et al. identified key elements of a graduate training model based on such projects. These elements encompass multiple stakeholders, supporting conditions, organizational forms, operational methods, and quality assurance [12]. Through a qualitative analysis of science and engineering graduate students involved in national major science and technology projects, Zhang

Feilong et al. developed a "context-process-values" pathway model to illustrate how such participation enhances research capabilities [14]. Zhou Fuhui et al. distilled key experiences in cultivating high-level aerospace information talents by leveraging major project clusters, focusing on four dimensions: curriculum development, practice-driven teaching, textbook system reform, and collaborative education platform construction [15]. Wu Yirong et al. contend that successful cultivation of engineering doctoral candidates based on national major engineering projects hinges upon two critical factors: institutionalized research teams (or supervisor groups) and sustained technical and financial investment [16]. Collectively, these studies underscore the widely acknowledged importance of talent cultivation based on major projects. However, existing research lacks systematic refinement of critical elements, hindering the theoretical construction and practical optimization of major project-based education models.

2.2 Theoretical Foundation: TOE Framework

The TOE (Technology-Organization-Environment) framework proposed by Tornatizky et al. is a comprehensive analytical framework grounded in technology application. This framework categorizes the conditions influencing technology adoption into three types: technological factors, organizational factors, and environmental factors [17]. Technological factors emphasize the characteristics of the technology itself and other related technological elements, including existing or emerging technologies, supporting infrastructure, the technological application capabilities of economic entities or organizations, and the degree of technological coordination [18]. Organizational factors comprise the internal attributes of an organization, including its size, structure, as well as internal communication and monitoring processes. Environmental factors include the support and challenges arising from the macro-social environment (both domestic and international) in which the organization operates, as well as relevant policy guidelines and planning [19].

As a theoretical model grounded in emerging technology application contexts, the TOE framework demonstrates strong systematicity, applicability, and flexibility, and has been widely adopted in fields such as education and government data openness and sharing [20]. Therefore, this study employs the TOE framework as its core analytical lens. It guides the systematic identification of key elements involved in cultivating engineering talents based on major projects, structured along the three dimensions of technological factors, organizational factors, and environmental factors, as illustrated in Figure 1.

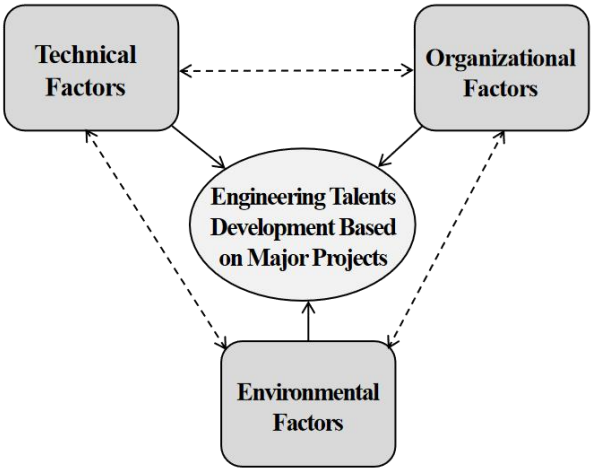

Figure 1 TOE Framework

3 Research Design

3.1 Research Methodology and Case Selection

This study employs an exploratory single-case research approach for the following reasons: First, it aims to address the question of "how to cultivate engineering talent through major projects," aligning well with the case study method's strength in exploring "how" questions in unexplored domains[21]. Second, the selected case—the "Ecological Civilization Initiative"—was chosen precisely because it demonstrates the key attributes of typicality, instructiveness, and accessibility. Specifically, on one hand, in recent years, Zhejiang University has cultivated a cohort of outstanding interdisciplinary talents with both academic and practical capabilities through the "Ecological Civilization Initiative." On the other hand, the author has maintained a sustained focus on university-level major projects, possessing stable and reliable access to internal documentation and having accumulated extensive materials over time.

3.2 Data Collection

Data were collected through two main channels. First, primary data were generated via semi-structured interviews. Seven semi-structured interviews were conducted with key stakeholders — including researchers, project managers, and departmental administrators — directly involved in the major project. These interviews were designed to elucidate the major project's implementation, the graduate students' training process, and the outcomes of this training. Second, secondary data was collected. The study relied on internal channels to collect project implementation

plans and annual self-assessment reports, while also extensively gathering normative documents published on official websites and relevant media coverage of the project from mainstream outlets. These complementary data sources enabled methodological triangulation, which served to enhance data accuracy and authenticity, thereby strengthening the overall credibility of the research findings. A detailed overview of the primary data sources, including interview profiles, is presented in Table 1.

Table 1 Primary Data Sources

Data Type	Data Source		Encoding
Primary Data	College of Environmental & Resource Sciences, Zhejiang University	Project Manager	A1
		Project Manager	A2
		Researcher	A3
		Researcher	A4
	Development Planning Department of Zhejiang University	Administrator	A5
		Administrator	A6
		Administrator	A7
Secondary Data	Internal Materials	Project Implementation Plan, Project Annual Self-Assessment Report, etc.	B1
	External Materials	Official Website and Related Public Account Posts, Mainstream Media Coverage, Academic Papers, etc.	B2

4 Elements for Cultivating Engineering Talents Based on Major Projects

4.1 Technical Factors

4.1.1 Educational Platform

Full-chain Innovation Platform. The "Ecological Civilization Initiative" has systematically constructed three distinct platform types: basic research platforms, interdisciplinary research platforms, and technology transfer platforms. These platforms provide an integrated practical base for innovative talents in the ecological and environmental field to engage in cutting-edge theoretical exploration, breakthroughs in key technologies, and technology transformation. At the core of this project are local research institutes, which serve as primary educational hubs. *Notable examples include the Zhejiang Ecological Civilization Academy, the Soil Pollution*

Control and Remediation Innovation Workshop at the ZJU-Hangzhou Global Scientific and Technological Innovation Center, the ZJU-Anqing Yangtze Delta Future Industry Institute, and the Smart Oasis Future Environment Laboratory (B1). By integrating these platforms' scientific instruments, high-level talent teams, and local industrial resources, it promotes deep integration among academia, government, industry, research, and application.

Integrated Industry-Academia-Research Practical Teaching Base. Building upon the "Government-University-Enterprise Collaborative Innovation Consortium," the project has established a trinity of ecological civilization practice education ecosystem encompassing "practical education—joint research—outcome transformation." *In 2025, the Zhejiang University—Zhejiang Ecological Civilization Academy Graduate Joint Training Base, in which the College of Environmental & Resource Sciences participated in the construction, was successfully approved (B2).* Operationalized under the dual guidance of major research demands and pressing industry challenges within ecological civilization, the base effectively amalgamates university-based disciplinary expertise, research resources of institutes, and local practical scenarios. Thereby, it establishes a comprehensive training platform for innovative talents in the ecological and environmental field, encompassing "theoretical instruction—research training—engineering practice—industrial application."

4.1.2 Interdisciplinary Course Resources

Interdisciplinary Courses. The "Ecological Civilization Initiative" leverages strengths in Environmental Science, Ecology, Energy Science, Computer Science, and Public Administration to actively develop interdisciplinary environmental and ecological courses. One prominent offering is the general education course Ecological Civilization, designed for all undergraduates. *This course employs a multidisciplinary lens to elucidate the core principles and imperatives of ecological civilization, thereby enabling students to critically analyze both the challenges and strategic advantages inherent in China's pursuit of ecological civilization development (B2).* Concurrently, drawing on interdisciplinary innovation teams from six distinct research streams, the project introduced the graduate elective "Environmental Planning and Management" in 2023, integrating it into the Environmental Science Major Training Program in 2024. *This course focuses on conducting seminars addressing current hot-button environmental issues, organizing the design of corporate environmental management systems, and undertaking environmental planning and design work (B2).*

Problem-Based Courses. Beginning in 2022, the College of Environmental & Resource Sciences has partnered with a consortium of leading international

institutions—such as Yale University, Leibniz University Hannover, the University of Nottingham, University College London, and France's Laboratory for Climate and Environmental Sciences—to deliver a flagship English-medium course titled "Carbon Neutrality." These 22 lessons are structured around three core thematic pillars: carbon emission reduction, ecological carbon sequestration, and industrial carbon capture, directly confronting pressing global ecological challenges. *The course has attracted significant global engagement, with 647 participants from numerous countries in its inaugural 2022 offering, followed by 202 students from 41 distinct countries and regions in 2023 (B1).* Consequently, it has become a vital platform for students globally to explore pathways toward achieving carbon peak and neutrality.

4.2 Organizational Factors

4.2.1 Institutionalized Research Team

Interdisciplinary Mentor Groups. The "Ecological Civilization Initiative" has strategically integrated expertise from diverse fields — including Environmental Science and Engineering, Ecology, Agricultural Resources and Environment, Energy Engineering, and Computer Science — to establish six dedicated interdisciplinary innovation teams. These teams focus on distinct thematic areas: ecological economics, digital ecology, ecological governance, ecological health, collaborative environmental pollution remediation, and carbon neutrality technology and institutional innovation. *The project has fostered a high-caliber talent pipeline, spearheaded by the academicians and comprising recipients of the National Science Fund for Distinguished Young Scholars, Outstanding Young Scientists Fund recipients, and Changjiang Scholars Program (A2).* These interdisciplinary innovation teams effectively transcend traditional disciplinary silos, thereby establishing a vital foundation for cross-disciplinary graduate education. One interviewee noted, *"Faculty from different disciplines engage in joint supervision of graduate students. For example, I collaborate with professors from the School of Public Administration to co-supervise doctoral candidates...This collaboration directly contributes to research publications(A4)."*

Industry-Academia-Research Integrated Faculty. The "Ecological Civilization Initiative" actively integrates academic and industrial talent resources globally to build an industry-academia-research integrated faculty supporting full-chain innovation. One strategy involves utilizing specific policy instruments, such as the International Academic Master Studios program and formal foreign faculty appointment schemes, to attract and integrate distinguished researchers from leading external institutions. *This is exemplified by the 2024 appointment of internationally*

renowned scholars such as Professor Pedro Alvarez from Rice University and Professor Budiman Minasny from the University of Sydney as visiting professors (B1). Furthermore, leveraging policies like the "Senior Citizen" initiative and dedicated researcher/associate researcher positions, it has assembled a high-caliber team for technological equipment R&D and achievement transformation (B1). As one respondent explained, "*Individuals from diverse fields approach the same problem from different perspectives—academics focus on the front end of the industrial chain, while industry professionals concentrate on the back end...This synergy creates an integrated team capable of addressing the entire innovation chain (A3).*"

4.2.2 Organizational Structure

Academic Committee. The Academic Committee serves as the highest decision-making and advisory body for academic affairs, responsible for setting overarching strategic direction, establishing standards, and overseeing quality to ensure the strategic alignment of major projects and talent development initiatives. *The "Ecological Civilization Initiative" is led by a Chief Scientist, with an Academic Committee established comprising leading scholars and strategic scientists from relevant disciplines. This committee is vested with the authority to deliberate on and make decisions regarding key academic matters, resource allocation, and project implementation plans (B1).* Regarding talent development, the Academic Committee reviews student training programs and clarifies the integration points between major projects and talent cultivation (e.g., course modules, assessment criteria).

4.2.3 Research Organization Model

Organized Research. Cultivating talents based on major projects is essentially an innovative educational model driven by organized research. Its core characteristics lie in the strategic anchoring of research directions and the systematic focus on research content. The former refers to determining research directions closely align with national strategic needs and key industry common issues, ensuring that graduate student topics are forward-looking and targeted. The latter involves leveraging the project's predetermined objectives and technical roadmap to help graduate students define clear research boundaries and establish detailed task lists, enabling them to accumulate knowledge in a targeted manner through research practice. Crucially, the effective implementation of this organized research model is contingent upon robust interdisciplinary collaboration mechanisms. As elucidated by interviewees, *"When facing different collaboration needs, the approach to working with faculty from various disciplines also varies... In other words, identify the specific need and seek support from faculty in the corresponding discipline (A3; A4)."*

4.2.4 Organizational Support System

Multi-resource support. Based on the actual needs of major project advancement, the university coordinates relevant functional departments to conduct feasibility studies. Upon approval by university-level decision-making bodies, comprehensive support is mobilized across key domains, including talent recruitment, physical infrastructure, and disciplinary platform development. Specifically, the resources allocated to the "Ecological Civilization Initiative" are as follows: First, in terms of talents, *quotas for recruiting personnel including researchers and engineering technicians (A5; A6);* Second, in terms of funding, *initially relying on the university's "Double First-Class" construction funds, and subsequently leveraging funding provided by local research institutes (A1; A2);* Third, in terms of material resources, *obtaining support for specialized equipment, laboratory and office space, and computational infrastructure (A5, A6).* The various resources provided on demand offer precise guarantees for talent cultivation.

Targeted Institutional Safeguards. *The "Ecological Civilization Initiative" evaluates the "entire project" rather than individual teams or personnel (A5).* In terms of assessment criteria, *the emphasis shifts from demanding "comprehensive" outputs to "landmark achievements." A prime example is the approval of a national key laboratory, which itself constitutes a fulfillment of assessment criteria. Such an achievement serves as a powerful proxy, demonstrating national-level recognition of the project's research capabilities (A5).* In short, this evaluation mechanism helps cultivate a value orientation of "serving national strategies" among graduate students. At the same time, deep involvement in the cultivation of landmark achievements generally enhances their strategic judgment and technical problem-solving capabilities.

4.3 Environmental Factors

4.3.1 Orientation of Serving National Strategies

Demand-driven and problem-oriented. Major projects are always anchored to serve the national strategy, promoting the education model based on major projects to place talent cultivation in the real problem field of ecological civilization construction. In 2019, with the dual objectives of supporting national ecological civilization development and pursuing breakthroughs in frontier domains of ecological governance and sustainable development, *Zhejiang University's leadership at the time launched the "Ecological Civilization Initiative" as a special project under the*

"Innovation 2030 Plan." This project embodies a distinct national perspective and long-term strategic vision (A1). Its "problem-oriented, strategy-driven" cultivation logic ensures targeted development of innovative talents in the ecological and environmental field.

4.3.2 International Cooperation and Exchange Network

International Academic Forum. In recent years, the College of Environmental & Resource Sciences has capitalized on its disciplinary strengths to convene leading scholars in ecological and environmental fields from around the world. It has hosted a series of academic events, including the Nexus of Environmental Science and Technology Forum, the International Symposium on Soil Health and Environment, and the Sino-US Foundation Project Promotion Meeting. *In July 2024, the "Carbon Neutrality Workshop" drew participation from more than 20 students from leading institutions worldwide, including the University of Hong Kong, University of the Punjab, Nanjing Agricultural University, and Zhejiang University (B2).* These international forums provide students with premium platforms to access cutting-edge global academic resources, broadening their scholarly horizons through international exchanges and deepening their understanding of frontier issues in ecological civilization.

International Joint Laboratories. Supported by major project, the College of Environmental & Resource Sciences has fostered sustained collaborations with several world-leading universities, such as the University of Oxford, Stanford University, and the University of Cambridge. These partnerships have culminated in the establishment of multiple high-level international joint laboratories. *In November 2021, Zhejiang University signed a memorandum of cooperation with the University of Sydney for a joint laboratory, with the core mission of addressing major global ecological challenges such as climate change and natural disasters (B1).* Such laboratories integrate global innovation resources and establish transnational scientific collaboration networks, providing innovative talents in the field of ecological and environmental with research scenario that align with international frontiers.

4.3.3 Interdisciplinary Research Atmosphere

Interdisciplinary Academic Forum. In recent years, Zhejiang University has dedicated significant efforts to fostering the interdisciplinary research atmosphere. To this end, Zhejiang university organizes regular academic exchanges via internal seminars and open forums. *A notable initiative is the "Qingshan Forum," a distinctive academic symposium brand that has convened 11 sessions to date (B1).* The forum is

designed to foster in-depth discussions concerning the current state, emerging trends, cutting-edge scientific questions, and critical engineering challenges within ecological and environmental studies. It thereby serves as a vital exchange platform connecting students with established academic leaders. As one interviewee indicated, "*the cross-disciplinary forums also play a significant role in cultivating an atmosphere conducive to interdisciplinary research (A7).*" Another key initiative is the Interdisciplinary Doctoral Forum, which constitutes a crucial component of the "Ecological Civilization Initiative" aimed at cultivating multidisciplinary talents. *During this forum, advisors offer personalized feedback to doctoral candidates on their interdisciplinary backgrounds, research content, and preliminary findings. The forum thus functions as a dedicated platform for students to present their research and engage in scholarly exchange (A4; B1).*

4.4 Summary

Zhejiang University has established a distinctive talent cultivation model based on the "Ecological Civilization Initiative," which is schematically illustrated in Figure 2. *Since 2021, Zhejiang University has recruited 31 full-time interdisciplinary doctoral students under the major project (B1). According to Chief Scientist Professor Zhu, the implementation of the "Ecological Civilization Initiative" has led to significant achievements in cultivating multidisciplinary talents (B2).*

First, the major project offer graduate students opportunities to engage in innovative interdisciplinary research, thereby substantially enhancing their scientific literacy and cross-disciplinary research competencies. The most striking indicator of this achievement is the breakthrough in high-level academic output achieved by the doctoral students participating in the project: Illustrating this, *a doctoral student jointly supervised by the School of Environment and Resources and the School of Public Administration published a first-author paper in Nature in February 2023. Subsequently, in June 2025, a doctoral student from the School of Environment and Resources also achieved first-authorship in Science (B2). These achievements not only demonstrate the project's scientific research capabilities but also serve as compelling evidence that students' individual academic innovation abilities have reached the world-class standards.*

Second, the major project facilitates graduate students' active involvement in national and local ecological civilization practices, which strengthens their engineering skills and problem-solving abilities. Driven by this project, *graduate students have not only participated deeply in frontline initiatives, such as soil pollution remediation, and contributed to the research and development of related technologies and equipment,*

but have also applied their expertise to formulate local standards and specifications, draft think tank reports, and provide decision-making support for regional ecological civilization development. These outcomes have been recognized by relevant national ministries, as well as provincial party committees and governments (B1). For example, seven think tank reports authored in 2024 — including "Recommendations on Effectively Controlling Agricultural Nonpoint Source Pollution Through Full-Chain Regulation of Nitrogen Cycling" and "Policy Recommendations on Accelerating the Categorized Management and Utilization of Severely Polluted Farmland" — were adopted by relevant ministries and commissions such as the General Office of the State Council of the People's Republic of China, the Office of the Central National Security Commission, and the Ministry of Education of the People's Republic of China. These outcomes directly demonstrate that students participating in the project possess exceptional capabilities to transfer academic knowledge into policy-making and social service domains, achieving the integration of academic value and social value (B1).

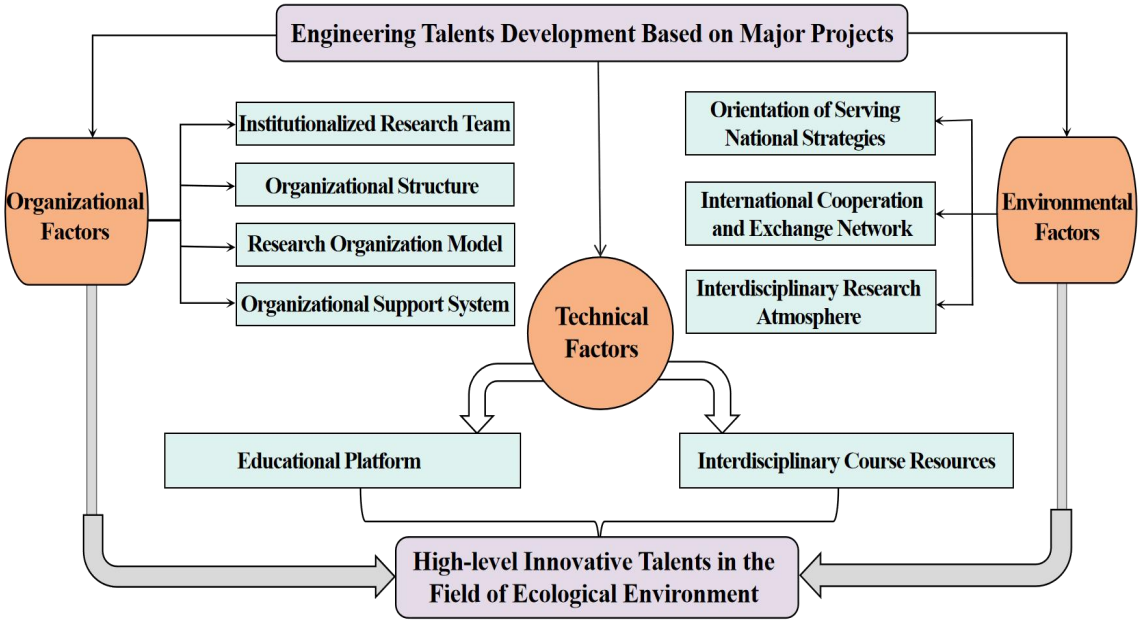

Figure 2 Training Model of Engineering Talents Based on Major Projects

5 Discussion

First, the nine key elements identified through the TOE framework constitute an educational model centered on "technology support, organizational assurance, and environmental empowerment". From the perspective of technical factors, the educational platform provides practical scenario carriers, while interdisciplinary course resources solidify the interdisciplinary knowledge foundation, achieving

precise alignment between practical scenarios and knowledge provision. In terms of organizational factors, institutionalized research teams, a scientific organizational structure, and efficient research organization model define clear implementation pathways for education, while a robust organizational support system provides institutional and material backing. From the perspective of environmental factors, the orientation toward serving national strategies anchors the direction of talent cultivation. International cooperation and exchange networks broaden academic horizons, while the interdisciplinary research environment sparks innovative vitality. Together, these three elements forge a high-quality ecosystem for nurturing talent.

Second, this study reveals that the logic behind major projects empowering talent cultivation lies in "deeply integrating the unique advantages of major projects with the principles of engineering talent cultivation." Firstly, the precision in educational objectives: Guided by "national strategic needs" rather than traditional "disciplinary knowledge transmission," this model ensures that talent cultivation closely aligns with critical demands in the ecological and environmental field. Secondly, the integration of educational resources — by consolidating multidisciplinary assets to establish cross-disciplinary training platforms — aligns with the inherent nature of ecological and environmental challenges, which involve multiple intertwined factors and require collaborative solutions across various disciplines. Thirdly, the practicality of the educational process: It transforms the process of tackling major tasks into training modules, enabling graduate students to hone their scientific research competencies and practical abilities through solving real-world problems, thereby addressing the weakness of "insufficient practical training" in traditional models. Fourthly, the openness of the educational system: By linking internal and external resources, as well as domestic and international high-quality resources, it broadens graduate students' academic horizons and practical perspectives.

Third, the talent cultivation model refined in this study exhibits strong universality and scalability, thereby offering practical guidance for universities to advance the reform of engineering talent development initiatives based on major projects. For one thing, universities should leverage their disciplinary strengths and research expertise, align with national major strategic demands to clarify the research directions of university-level major projects, and further focus on the goal of cultivating high-caliber talents. On this basis, they need to systematically sort out and deeply integrate three key talent cultivation elements — technical factors, organizational factors, and environmental factors — to lay a solid foundation for talent cultivation based on major projects. For another, universities should break down the traditional barriers between research and teaching, implement the educational logic of "deeply integrating the advantages of major projects with the inherent laws of talent

cultivation", and thus achieve the dual goals of "driving teaching through projects and nurturing talents through scientific research". Finally, the sustainable operation of the talents training model based on major projects requires collaborative efforts from multiple parties, including governments, universities, and industrial enterprises. Therefore, it is imperative to establish a collaborative linkage mechanism among multiple stakeholders.

6 Conclusion

Taking the cultivation of innovative talents in the field of ecological environment through the "Ecological Civilization Initiative" at Zhejiang University as a case study, this research identified nine core elements of engineering talents cultivation drivened by major projects from three dimensions—technical factors, organizational factors, and environmental factors—based on the TOE framework. The research revealed the talent cultivation logic characterized by "demand-driven, resource transformation, and process empowerment". The contributions of this study are as follows. On one hand, this study enriches the theoretical framework and elemental system for major project-based education, unveils the "black box" of cultivating engineering talent based on major projects, and fills the research gap in "insufficient exploration of the educational functions of major projects." On the other hand, this research provides a replicable practical scheme for the cultivation of high-level innovative talents in the ecological and environmental field, and offers a replicable and generalizable paradigm for talent cultivation based on major projects.

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