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APPLICATION OF NEW TEACHING MODEL IN ENVIRONMENTAL BIOLOGY TEACHING

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ABSTRACT

As an interdisciplinary subject, environmental biology encompasses extensive and complex teaching content. The traditional teaching models exhibit numerous shortcomings in content updates, method diversification, scientific evaluation systems, and practical component development. To address these issues, this study introduces the "Two Innovations and Three Transformations" mode: innovation in classroom teaching theories and experimental teaching mechanisms, alongside visualization of course content, normalization of course management, and application-oriented course outcomes. This approach aims to enhance teaching quality and students' comprehensive abilities. Through theoretical innovation of classroom teaching—such as case-based learning, flipped classrooms, and interactive teaching—students' self-directed learning ability and critical thinking skills have significantly improved; innovations in experimental teaching mechanisms—including open-ended experiments, interdisciplinary experiments, and university-industry collaborations—have comprehensively enhanced students' research and practical capabilities. Course-content visualization utilizes multimedia technology and virtual simulation to render abstract knowledge intuitive, markedly increasing students' comprehension depth and learning engagement. Course management normalization through regular evaluations, digital resource library and online learning platforms enables continuous improvement in teaching quality and efficient resource sharing. By establishing a trinity cultivation mode of "university-enterprise coordination, practice-oriented education, integration of innovation and entrepreneurship", students have seen a significant improvement in their practical innovation capabilities and complex problem-solving skills. Evaluation system reforms, featuring diversified assessments alongside student self-evaluation and peer-review mechanisms, comprehensively assess students' overall competencies while strengthening their self-reflection abilities and learning motivation. Research indicates that implementing the "Two Innovations and Three Transformations" model in environmental biology education not only effectively enhances teaching quality but also cultivates students' comprehensive qualities and practical abilities. This provides robust support for cultivating high-caliber applied talents who meet the demands of national ecological civilization construction. Moving forward, further deepening the application of this model is essential. By integrating cutting-edge disciplinary developments and societal needs, teaching content and methodologies should be continuously optimized to cultivate and deliver more outstanding talents for national ecological civilization development and sustainable development.

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INTRODUCTION

Currently, overseas research focuses on models such as CBC (Competency Based Curriculum), as well as instructional approaches including complex adaptive capabilities and loose-tight coupling. In contrast, domestic research mainly centers on topics related to educational reforms against the backdrop of the new engineering disciplines initiative (Frank et al., 2010).

The Environmental Science major closely aligns with the strategic needs of the country's ecological civilization construction and is committed to cultivating interdisciplinary talents who possess a strong sense of national belonging, a broad international perspective, and all-around development in moral, intellectual, physical, aesthetic, and labor education. Students will systematically master fundamental theories and professional skills in environmental science, acquiring the ability to comprehensively analyze and resolve practical ecological and environmental issues using scientific research methodologies.

Concurrently, the program emphasizes cultivating students' innovative spirit, entrepreneurial awareness, and capacity for continuous learning and development, aiming to deliver high-caliber applied professionals capable of meeting the demands of the new era (<http://environ.gzhu.edu.cn/info/1058/3388.htm>; Wang *et al.*, 2024). Domestically, extensive research has been conducted on the methodologies and perspectives of teaching reform against the backdrop of the new engineering disciplines initiative, such as in chemistry (Jin *et al.*, 2025), artificial intelligence (Ling *et al.*, 2025), innovation and entrepreneurship (Gong *et al.*, 2025), etc. Practical teaching has revealed several challenges in environmental biology instruction: The content update mechanism lags behind, with textbook revisions occur only every 3-5 years. This makes it difficult to reflect cutting-edge developments in the field in real time. Course content shows a significant disconnect from practical environmental protection needs, and there is insufficient integration of emerging interdisciplinary knowledge such as environmental genomics and bioinformatics. Teaching methods lack innovation, with traditional "lecture-based" instruction accounting for over 80% of the curriculum. Student engagement is low, classroom interaction is insufficient, and modern teaching approaches like inquiry-based or project-based learning are not effectively applied. Weak practical teaching components, with less than 30% update rate for experimental projects. Development of on-campus and off-campus practice bases lags behind, and industry-academia-research collaborative education mechanisms remain underdeveloped. Therefore, this study aims to explore and demonstrate how teachers can leverage course instruction and institutional advantages within these pedagogical models and national policy reforms. It seeks to identify new approaches aligned with student growth and development, national progress, and a human-centered educational philosophy.

The Essence of the "Two Innovations and Three Transformations" Model

"Two Innovations" Achieve Theoretical Innovation in Classroom Teaching and Mechanism Innovation in Experimental Teaching:

The "Two Innovations"—theoretical innovation in classroom teaching and mechanism innovation in experimental teaching—represent a key direction for educational reform in the new era. They aim to comprehensively enhance students' overall quality and practical abilities through the optimization and innovation of teaching models. Regarding innovation in classroom teaching theory, transforming teaching delivery methods is central. Traditional "lecture-based" instruction no longer meets modern educational demands. Teachers must evolve from knowledge transmitters to learning facilitators, employing diverse pedagogical approaches such as heuristic, inquiry-based, and case-based methods to stimulate students' interest and initiative. Simultaneously, students' knowledge acquisition methods must evolve from passive reception to active exploration. Through independent and collaborative learning, they develop critical thinking and problem-solving abilities. Furthermore, interactive discussions during instruction are vital components of classroom theory innovation. In-depth communication and intellectual exchanges between teachers and students, as well as among peers, not only deepen students' understanding of knowledge but also cultivate their communication skills and teamwork spirit. Innovation in experimental teaching mechanisms hinges on creativity in conception, design, implementation, and execution. As a vital bridge linking theory to practice, traditional experimental teaching often remains confined to verification experiments, neglecting the cultivation of students' innovative abilities. Mechanism innovation emphasizes problem-oriented approaches, encouraging students to identify issues through practice, devise solutions, design experimental protocols, and execute them. This "from practice to practice" teaching model effectively enhances students' hands-on skills, innovative thinking, and ability to solve complex problems. For instance, by introducing open-ended experiments, interdisciplinary experiments, and industry-academia collaboration projects, students can apply their knowledge in real-world settings, cultivating comprehensive practical abilities and entrepreneurial spirit.

"Three Transformations" Achieve the visualization of course content, the normalization of course management, and the application of course outcomes:

Visualization of course content refers to transforming abstract theoretical knowledge into intuitive, vivid representations through modern information technology, aiding students in better comprehension and mastery. Traditional teaching methods often rely on textual and verbal descriptions, struggling to clearly present complex concepts and processes to students. Through visualization techniques—such as virtual simulations, dynamic charts, and 3D models—complex phenomena in environmental science, like ecological processes and pollutant migration and transformation, can be vividly displayed. This enhances students' sensory perception and depth of understanding. Additionally, visualization stimulates students' interest in learning, encouraging them to actively explore knowledge in immersive learning environments and improve learning efficiency. Normalization of course management refers to ensuring high-quality course delivery through scientific and standardized management mechanisms. Traditional course management often suffers from arbitrariness and fragmentation and lacks systematicness and continuity. Routine management emphasizes establishing comprehensive teaching management systems encompassing course design, instructional implementation, quality monitoring, and feedback-driven improvements to form a closed-loop management mechanism. For instance, regular teaching evaluations, student feedback surveys, and faculty training enable timely identification and resolution of instructional issues, ensuring continuous enhancement of course quality. Simultaneously, routine management prioritizes the optimized allocation and sharing of teaching resources, promoting their digitization and platform integration to provide more convenient learning support for both faculty and students. Application-Oriented Course Outcomes refers to integrating course outcomes with practical demands to drive knowledge transformation and application. Traditional teaching often remains confined to theoretical knowledge transmission, neglecting the practical value of knowledge. Application-Oriented Outcomes emphasizes a problem-based approach, closely integrating course content with societal needs, industry development, and research practices. It encourages students to apply acquired knowledge to solving real-world challenges. For instance, through industry-academia-research collaborations, social practice programs, and innovation/entrepreneurship initiatives, students can transform classroom theories into practical skills for addressing environmental issues. Simultaneously, this approach prioritizes the dissemination and sharing of outcomes. Through academic publications, patents, and technology transfer, teaching outcomes are applied to serve societal development and national strategic needs.

Existing Challenges: As a quintessential interdisciplinary field, environmental biology encompasses three core domains: the biological mechanisms of environmental pollution effects, biological remediation technologies for polluted environments, and ecosystem conservation and regulation. This discipline integrates theories and methodologies from molecular biology, ecology, environmental science, and other fields to systematically investigate the response patterns and regulatory mechanisms of organisms, populations, communities, and ecosystems to environmental changes. It particularly focuses on the interactions between organisms and their environments and their ecological consequences. Traditional teaching methods, primarily teacher-centered lectures, have been employed to systematically impart knowledge to students. However, this approach often leaves students in a passive role, lacking opportunities for active thinking and exploration, particularly in developing learning, innovation, and practical skills (Ma *et al.*, 2011). To overcome these limitations, numerous scholars have extensively researched and discussed methods to enhance environmental biology instruction. First, regarding teaching content, scholars emphasize selecting core knowledge points. By integrating cutting-edge developments in the discipline with real-world environmental issues, they advocate constructing a systematic, modular curriculum to ensure students master key theories and skills within limited class hours. Regarding pedagogical innovation, implementing research-based teaching methods is recommended. This involves establishing a tripartite

teaching system integrating “classroom interaction, case analysis, and group discussion” to effectively stimulate student motivation and engagement, focusing on cultivating critical thinking and complex problem-solving abilities. Additionally, leveraging multimedia technology and virtual simulation tools presents abstract environmental biology concepts in intuitive, visual ways, aiding students in comprehending and mastering complex environmental biological processes. Regarding teaching methods, scholars emphasize the importance of feedback mechanisms. Through in-class quizzes, surveys, and teacher-student interactions, educators can promptly assess student progress and adjust instructional strategies. Simultaneously, reforming evaluation methods is crucial for enhancing teaching quality. Traditional assessments overly emphasize exam scores while neglecting students' comprehensive competencies and practical abilities. Therefore, a diversified evaluation system should be established, incorporating classroom participation, laboratory skills, project outcomes, and innovative capabilities into assessments. This holistic approach assesses students' learning effectiveness and skill development (Cai *et al.*, 2018).

encouraging students to define research directions based on personal interests and independently design experimental protocols to strengthen scientific literacy and innovative thinking training. Establish an interdisciplinary integrated experimental system combining methodologies like chemical analysis and ecological assessment to cultivate students' comprehensive practical skills for addressing complex environmental challenges. Implement an experimental teaching model grounded in real-world environmental problems, guiding students through the entire process from design to practical validation. Collaborate with enterprises to design experimental projects, exposing students to authentic environmental issues and technical demands. Experimental process documentation and reflection: Students are required to document experimental procedures and write reflective reports to cultivate scientific thinking and summarization skills. Organize experimental achievement exhibitions or academic posters sessions for students to share findings and receive peer evaluation.

Table 1. Specific Improvement under the New Model of "Two Innovations and Three Transformations"

Dimension	Specific Measures	Improvement Results
Innovation in Classroom Teaching Theory	<ol style="list-style-type: none"> 1. Adopt case teaching method, flipped classroom, and interactive teaching. 2. Encourage independent learning and cooperative learning. 3. Organize group discussions and classroom debates. 	<ol style="list-style-type: none"> 1. Students' participation has significantly increased, and classroom interaction has been enhanced. 2. Students' independent learning ability and critical thinking have been cultivated. 3. Students' expression ability and team cooperation ability have been improved.
Innovation in Experimental Teaching Mechanism	<ol style="list-style-type: none"> 1. Design open experiments and interdisciplinary experiments. 2. Design experiments with a problem - oriented approach. 3. School - enterprise cooperative experimental projects. 	<ol style="list-style-type: none"> 1. Students' scientific research ability and innovative thinking have been significantly improved. 2. Students' ability to solve complex environmental problems has been enhanced. 3. Students' practical ability is in line with industry demands.
Visualization of Course Content	<ol style="list-style-type: none"> 1. Utilize dynamic charts, animations, and virtual simulation technologies. 2. Introduce MOOCs and three - dimensional model resources. 	<ol style="list-style-type: none"> 1. Abstract knowledge is visualized, and students' depth of understanding is improved. 2. Students' interest in learning is enhanced, and teaching effects are significantly improved.
Normalization of Course Management	<ol style="list-style-type: none"> 1. Regularly carry out teaching evaluations and student feedback surveys. 2. Establish a digital teaching resource library and an online learning platform. 	<ol style="list-style-type: none"> 1. Teaching quality is continuously improved, and communication between teachers and students is smoother. 2. Teaching resources are shared efficiently, and course management is more standardized.
Application and Transformation of Course Achievements	<ol style="list-style-type: none"> 1. Carry out school - enterprise cooperation projects and social practices. 2. Promote the transformation of scientific research achievements and innovation and entrepreneurship education. 	<ol style="list-style-type: none"> 1. Students' ability to solve practical environmental problems has been significantly improved. 2. Students' innovation and entrepreneurship ability has been enhanced, and some achievements have been put into practice.
Reform of Evaluation System	<ol style="list-style-type: none"> 1. Establish a diversified evaluation system and focus on process evaluation. 2. Introduce student self-evaluation, peer evaluation, and teacher feedback mechanisms. 	<ol style="list-style-type: none"> 1. Students' comprehensive quality has been comprehensively evaluated. 2. Students' self - reflection ability has been enhanced, and learning motivation has been improved.

Specific Implementation Measures

Concrete Initiatives for Innovating Classroom Teaching Theory: Introduce real-world environmental problem cases (e.g., water pollution, biodiversity loss) to guide students in understanding core concepts and principles of environmental biology through case analysis. Pre-assign foundational knowledge lectures, allocating class time to discussion and practice—such as having students watch instructional videos beforehand and conducting group discussions or problem-solving activities during class. Enhance teacher-student interaction through questioning, discussions, and debates to stimulate students' critical thinking. Provide abundant learning resources (e.g., online courses, academic papers, databases) to encourage independent exploration of cutting-edge environmental biology knowledge. Organize group projects to cultivate teamwork and communication skills. Reserve time in each class for group discussions and presentations of learning outcomes, followed by teacher feedback and summarization. **Classroom Debates:** Organize debates on environmental hot topics (e.g., climate change, biological invasions) to cultivate critical thinking and communication skills.

Specific Measures for Innovating Practical Teaching Mechanisms: Develop self-directed inquiry-based experimental projects,

Specific Measures for Course Visualization

Multimedia technology application: Employ dynamic charts and animations to illustrate complex processes in environmental biology (e.g., pollutant migration and transformation, ecosystem energy flow). **Virtual Simulation Experiments:** Develop virtual simulation platforms enabling students to simulate experimental procedures in virtual environments, enhancing intuitive understanding. **Visual Teaching Resources:** Massive Open Online Courses (MOOCs): Integrate high-quality domestic and international environmental biology MOOCs to enrich instructional content. **3D Models and Virtual Reality (VR):** Employ 3D models and VR technology to visually demonstrate ecosystem structure and function.

Specific Measures for normalization of course management

Institutionalized Teaching Management: Conduct regular teaching evaluations and student feedback surveys to adjust instructional strategies promptly; organize faculty participation in teaching training and academic exchanges to enhance teaching quality. **Digital Teaching Resource Repository:** Establish an environmental biology teaching resource repository integrating courseware, lab manuals, academic

literature, and other resources for shared access by faculty and students. Utilizing Online Learning Platforms: Employ learning management systems (e.g., Moodle, Blackboard) to achieve digital and routine course management.

Specific Measures for Practical Application of Course Outcomes

Industry-Academia Collaboration Projects: Partner with enterprises on environmental research projects, enabling students to apply acquired knowledge to real-world problem-solving. **Research-to-Practice Conversion:** Encourage student participation in research projects and facilitate the transformation of research outcomes into practical applications (e.g., patents, technical solutions). **Social Practice:** Organize students to participate in environmental surveys, biodiversity conservation studies, natural resource planning and utilization, ecological conservation, and other social practice activities to enhance their comprehensive problem-solving abilities. **Innovation and Entrepreneurship Education:** Offer innovation and entrepreneurship courses to encourage students to apply environmental biology knowledge to entrepreneurial projects.

Specific Outcomes Under the New Model: Theoretical Innovation in Classroom Instruction: Through case-based teaching, flipped classrooms, and interactive methods, student engagement and self-directed learning initiative have significantly increased. This approach also cultivates critical thinking and team collaboration skills. Innovation in Experimental Teaching Mechanisms: Open-ended experiments, interdisciplinary projects, and industry-academia collaborations have comprehensively enhanced students' scientific innovation mindset, practical abilities, and research capabilities. Course Content Visualization: Multimedia technology and virtual simulation tools render abstract concepts intuitive, deepening student comprehension and learning engagement. Normalization of course management: Regular assessments, digital resource repositories, and online learning platforms enable continuous teaching quality improvement and efficient resource sharing. Application-Oriented Outcomes: Through industry-academia partnerships, social practice, and innovation/entrepreneurship education, students' practical problem-solving and innovation/entrepreneurship capabilities have significantly improved, with some achievements successfully applied in practical contexts. The above new educational model has yielded concrete improvements in environmental biology instruction, with detailed results presented in Table 1.

CONCLUSION

Guided by the “Two Innovations and Three Transformations” model, environmental biology teaching has achieved remarkable outcomes across multiple dimensions. Through theoretical innovation in classroom teaching—employing case-based learning, flipped classrooms, and interactive methods—student engagement, self-directed learning abilities, and critical thinking have markedly improved.

By innovating experimental teaching mechanisms—designing open-ended experiments, interdisciplinary experiments, and industry-academia collaboration projects—students' research capabilities, innovative thinking, and practical skills have been comprehensively strengthened. Course content visualization utilizes multimedia technology and virtual simulation to render abstract knowledge intuitive, significantly enhancing students' comprehension depth and learning interest. Routine course management achieved continuous teaching quality improvement and efficient resource sharing through periodic evaluations, digital resource repositories, and online learning platforms. Applied course outcomes significantly enhanced students' practical problem-solving and innovation-entrepreneurship capabilities through industry-academia collaborations, social practice, and innovation/entrepreneurship education, with some achievements successfully commercialized. Evaluation system reforms comprehensively assessed students' overall competencies via diversified assessments and peer/self-evaluation mechanisms, simultaneously strengthening their self-reflection abilities and learning motivation.

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