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Improving the Quality of Ecological Experiment Teaching with Diversified Teaching Method Innovations

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Abstract This paper addresses key issues in current ecological experiment teaching, such as an overreliance on confirmatory experiments, insufficient development of practical skills, limited teaching resources, and monotonous pedagogical models. It further analyzes how these problems constrain the cultivation of students' innovative thinking and practical abilities. To address these challenges, the study proposes several practical approaches from the perspectives of optimizing experimental content design and strengthening skills training. These include restructuring the experiment curriculum, introducing project-based learning, and implementing modular skills instruction. The aim is to establish a clearly structured, practice-oriented experimental teaching system. This system is designed not only to enhance the overall quality of ecological experiment teaching but also to equip students with the comprehensive capabilities needed to solve complex ecological problems.

Key words Ecological experiment teaching, Diversified teaching method innovations, Experimental skills training

0 Introduction

Ecology is the discipline that studies the interactions between organisms and their environment. Experimental teaching serves as a critical bridge linking theoretical knowledge with practical application, and its quality directly influences the depth of students' understanding of ecosystems as well as their practical ability to address complex environmental issues.

1 Problems in current ecological experiment teaching

1.1 Excessive proportion of confirmatory experiments At present, confirmatory experiments occupy an excessively high proportion in ecological experiment teaching. In such experiments, teachers typically design the complete procedures and expected outcomes in advance. Students simply follow the prescribed steps to arrive at conclusions consistent with established theory. Under this model, students' primary task is to replicate known processes rather than actively contemplate the experimental design logic, the rationale behind variable control, or the underlying mechanisms behind the results. They are seldom required to consider the connection between the experiment's purpose and ecological phenomena, nor to attempt solving unexpected problems that arise during the experiment, as all aspects are predetermined. Prolonged exposure to this experimental environment can easily rigidify students' thinking, making it difficult for them to develop the ability to independently identify, analyze, and solve problems.

1.2 Neglect of mastery in experimental skills Training in experimental skills is often reduced to isolated, atomized operations rather than fostering a coherent skill set. For instance, students may learn to measure soil pH in one experiment and practice insect specimen mounting in another, yet they frequently lack an understanding of the logical chain connecting these skills. This includes knowing how to select appropriate measurement tools based on a research question, mastering techniques to calibrate instruments and minimize errors, or integrating disparate skills to conduct a comprehensive ecological survey. Such fragmented training leaves students ill-prepared for authentic research or practical scenarios. They often struggle to flexibly combine skills to solve problems and may even find themselves unable to perform when faced with a slightly different experimental setup.

1.3 Inadequate allocation of teaching resources Effective ecological experiment teaching requires substantial resource support, which is often lacking in many institutions. Laboratory hardware is frequently insufficient to meet teaching needs, with key instruments being both limited in number and, in some cases, outdated or dysfunctional. This restricts students' hands-on experience and impedes their acquisition of practical skills. Moreover, the absence of advanced data analysis software and simulation platforms limits students' ability to engage deeply with experimental data using contemporary methods and to expand their learning through virtual experimentation.

1.4 Monotonous experimental teaching model The current model for ecological experiment teaching lacks diversity, predominantly following a traditional pattern of instructor explanation followed by student implementation. In this model, the teacher first elaborates in detail on the experiment's objectives, principles, procedures, and precautions in the classroom. As a result, students perform the operations in the laboratory according to the given instructions. Throughout this teaching process, students remain in a passive, receptive role with limited opportunities for active participation or critical thinking. The teacher often remains the central focus of instruction, while students merely complete tasks by following prescribed procedures rather than exploring and experimenting based on their own interests and ideas.

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2 Practical paths of innovating diversified teaching methods

2.1 Optimizing the design of experimental content

2.1.1 Adjusting the experiment structure. Traditional, fragmented basic operations are consolidated into cohesive skill modules. Each module focuses on one or two core techniques and is delivered through a streamlined format such as a "mini-experiment". For example, the analysis of soil physicochemical properties is broken down into three modules: (i) Soil sample collection and pretreatment; (ii) Operation of pH and electrical conductivity meters; and (iii) Determination of organic matter content. Each module establishes clear skill objectives and incorporates a "skill assessment → problem feedback" mechanism to ensure student mastery. This approach prevents fragmented learning of foundational skills and equips students with a solid operational foundation before they engage in comprehensive experiments.

2.1.2 Implementation of project-based learning. Within the framework of project-based learning, students transition from passive recipients of knowledge to active participants in the full project cycle. Instructors define suitable project themes according to educational objectives and student contexts, ensuring these themes are sufficiently challenging and relevant to motivate student exploration[1]. Organized into groups, each assigned a distinct project, students undertake independent literature reviews, raise research questions, devise experimental methodologies, execute procedures, and interpret results, ultimately producing a detailed research report. Throughout, instructors assume the roles of facilitators and supporters, providing essential guidance while refraining from direct intervention in student decision-making.

2.2 Strengthening experimental skills training

2.2.1 Modular teaching of skills. The experimental skills are systematically organized and categorized to clarify the teaching objectives and content of each module. For example, the skills can be divided into modules such as basic operations, instrument use, data acquisition and processing, and experimental design. Each module is equipped with a detailed syllabus and operational guidelines, enabling students to engage in targeted learning based on their individual needs. The teaching process adopts a model combining theoretical explanation, demonstration, hands on practice, and assessment feedback to ensure students can master the skills in each module proficiently.

Theoretical explanation introduces the fundamental principles and key operational points of the skills in detail. Demonstration is conducted by the instructor through standardized and normative performance, allowing students to observe the operational process directly. Hands-on practice provides students with repeated opportunities to perform the operations, reinforcing the skills they have learned. Assessment and feedback evaluates students' learning outcomes through rigorous and comprehensive testing, offering timely feedback and guidance.

2.2.2 Innovative assessment methods. The entire process of students conducting experiments is incorporated into the assessment framework. The scope of evaluation covers whether the experimental design is reasonable, whether operations are standardized, and whether data recording is authentic and complete, among other aspects. Teachers can conduct comprehensive and objective assessments of students' experimental processes through methods such as classroom observation and reviewing experiment records[2]. Emphasis should be placed on evaluating students' innovative and practical abilities, encouraging them to propose new ideas and methods during experiments. Special recognition should be given to innovative experimental proposals and outcomes. Additionally, teamwork skills should be included in the assessment system. During group experiments, not only individual performance but also the overall collaboration and achievements of the group should be evaluated.

2.3 Increasing investment in teaching resources

2.3.1 Upgrading hardware facilities. A comprehensive inventory and assessment of laboratory instruments and equipment should be conducted. Aging or damaged equipment must be phased out, and necessary instruments should be replenished and updated in a timely manner. When selecting new equipment, priority should be given to its advanced nature, practicality, and safety to ensure it meets the needs of experimental teaching. Additionally, the management and maintenance of instruments and equipment must be strengthened by establishing a complete equipment management system and maintenance procedures. Regular inspections, upkeep, and repairs should be carried out to ensure all equipment operates properly.

2.3.2 Expanding off-campus resources. Universities should collaborate with environmental protection enterprises and ecological monitoring institutions to transform actual industry projects into teaching content. For example, by partnering with local environmental protection departments to carry out watershed water quality monitoring and ecological restoration projects, students can be divided into groups responsible for sampling tasks in different river sections. Using professional instruments such as multi-parameter water quality analyzers and plankton counting frames, they measure indicators like pH and dissolved oxygen levels in water bodies. By analyzing the data and writing reports that provide foundational data for corporate restoration plans, students directly participate in industry practices, gain an understanding of workflows in positions such as ecological monitoring and environmental assessment, and simultaneously develop professional competence. Some universities also introduce advanced enterprise equipment through university-industry joint laboratories, allowing students to access cutting-edge industry technologies and enhance their employability.

2.4 Innovative teaching mode

2.4.1 Introducing blended learning. High-quality online teaching resources such as instructional videos and virtual experiments are developed to enable students to engage in self directed learning before class, understanding the basic principles and operational procedures of experiments, thereby preparing adequately for in person sessions. In the classroom, instructors can provide focused explanations and guidance on issues encountered during online learning, while organizing students to conduct hands on experi-

ments and participate in discussions[3]. In addition, online platforms can be utilized for after class tutoring, assignment distribution, and evaluation feedback, thereby extending the time and space of classroom teaching. Blended learning emphasizes student autonomy and personalized learning, allowing students to independently choose learning content and methods according to their own progress and needs.

2.4.2 Implementing interdisciplinary collaboration. Teachers can organize interdisciplinary experimental projects, grouping students from different academic backgrounds to complete comprehensive experiments together. During project implementation, students must apply multidisciplinary knowledge and methods, communicate effectively, and collaborate to solve problems collectively[4]. Instructors from various disciplines can be invited to participate in experimental teaching, jointly designing experiment content and teaching plans to provide students with interdisciplinary guidance. Additionally, academic lectures, seminars, and other cross disciplinary exchange activities can be held, helping students understand different research approaches and stay updated on cutting edge developments, thereby broadening their academic perspectives.

2.4.3 Enhancing field practice. The duration and frequency of field practice should be increased to encourage students to step out of the laboratory and immerse themselves in natural environments, where they can personally experience and observe ecological phenomena. During field practice, emphasis should be placed on cultivating students' abilities to observe, analyze, and solve problems. Instructors should guide students in applying acquired knowledge and methods to investigate, monitor, and analyze natural ecosystems, thereby enriching the content and forms of field practice. In addition to traditional field surveys and sampling, activities such as ecological restoration, environmental monitoring, and science popularization can be organized. These experiences enable students to understand the importance of ecological and environmental protection and enhance their sense of social responsibility.

3 Conclusions

Ecological experiment teaching reform is a systematic project that requires coordinated advancement across multiple dimensions, including content design, skill training, resource support, and model innovation. Optimizing the experiment structure and introducing project-based learning can stimulate students' inquiry motivation. Implementing modular skill training and diversified assessment can solidify students' practical foundation. Upgrading hardware and expanding off-campus resources can broaden students' learning boundaries. Conducting blended teaching, interdisciplinary collaboration, and field practice can enhance students' ability to solve complex problems.

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social humanities, and economic operations into every aspect of teaching. Only by elevating the conceptual dimension of objectives, systematically reorganizing content, and achieving cross-disciplinary synergy of methods can we guide students to enhance their design capabilities within the intricate real urban system. In this way, we can cultivate versatile and innovative urban design talents who possess profound humanistic sentiments and a grand ecological vision, while being down-to-earth and capable of effectively solving the human settlements pain points faced by ordinary people.

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