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Reform and Practice of Teaching Models and Methods in Environmental Health Experiment Courses

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Abstract: To address issues such as the disconnect between traditional environmental health experiment courses and public health practice needs, insufficient interdisciplinary integration, and a lack of international perspective cultivation, this study focuses on four core objectives and carries out systematic reform practices in teaching models and methods. By constructing a four-in-one practical teaching system integrating "curriculum experiments, scientific research training, social practice, and international collaboration," developing an interdisciplinary practical case library that incorporates real public health issues, and creating a collaborative innovation and entrepreneurship training model for "undergraduates, postgraduates, and international students," we aim to achieve a transformation in experimental teaching from knowledge transmission to ability cultivation and from a single mode to a diversified and collaborative approach. Innovations in teaching models and methods are designed to enhance students' practical skills in public health, scientific research innovation abilities, and cross-cultural collaboration skills, providing replicable and scalable teaching solutions for cultivating top-tier talents in the field of public health.

Keywords: Environmental health experiment course; Teaching model; Teaching method; Reform; Practice

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1. Introduction

In recent years, with the continuous advancement of urbanization and industrialization, rapid economic development, intensified global climate change, and frequent domestic and international interactions, the impact of the environment on health plays a significant and far-reaching role in public health. Environment and health constitute the core content of public health, and environmental health, as a highly practical and applied course, relies heavily on practical teaching as an integral part of its instruction. The prevalent teaching philosophy, which emphasizes theoretical instruction while neglecting the cultivation of practical skills, may lead students to undervalue experiments. The core objective of environmental health experiment courses is to help students master basic skills such as environmental pollutant detection, environmental health risk assessment, and emergency response to environmental pollution, and to cultivate their ability to apply theoretical knowledge to solve real-world environmental health issues, laying a solid foundation for their future careers in public health monitoring, environmental governance, and health promotion [1]. Based on this, carrying out reforms and practices in the teaching models and methods of environmental health experiment courses, constructing a scientifically sound and industry-aligned practical teaching system, addressing teaching pain points, and improving teaching quality have become urgent tasks for cultivating public health professionals in universities. They also serve as crucial support for promoting the high-quality development of the discipline of environmental health. This paper, drawing on teaching practices, explores feasible paths for teaching reform centered around the construction of a four-in-one practical teaching system integrating "curriculum experiments, scientific research training, social practice, and international collaboration," providing references for similar course teaching reforms.

2. Research status and pain point analysis

Currently, domestic universities are gradually emphasizing the reform of practical teaching in public health programs, with some institutions exploring optimizations in teaching methods and adjustments in experimental content for environmental health experiment courses, achieving certain results. However, from the overall teaching status, numerous issues persist, significantly impacting teaching quality and the actual effectiveness of talent cultivation, as detailed below.

Firstly, there is a severe disconnect between teaching content and industry realities and job requirements, with prominent issues of homogeneity and simplification in experimental projects. Currently, most environmental health experiment courses in universities still primarily feature traditional verification experiments, focusing on the detection of conventional pollutants in water, air, and soil. The experimental content remains outdated, failing to cover cutting-edge topics such as the detection of novel environmental pollutants, environmental health risk assessment, and emergency command in sudden environmental pollution incidents, thus not aligning with the actual work demands of public health institutions and environmental protection enterprises [2]. Some experimental projects merely emphasize repetitive practice of operational procedures, lacking elements of synthesis, design, and innovation, making it difficult to stimulate students' learning initiative and innovative thinking, and hindering the cultivation of their ability to solve complex real-world problems.

Secondly, there are deficiencies in the practical teaching link, lacking systematic and hierarchical arrangements, making it challenging to achieve a gradient progression in ability cultivation. Traditional experimental teaching is mostly confined to in-class curriculum experiments, with weak links in scientific research training and social practice, failing to form a hierarchical cultivation system of "basic practice—comprehensive practice—innovative practice." Most universities have not effectively integrated scientific research training into experimental teaching, providing students with limited opportunities to participate in research projects, making it difficult for them to master scientific research thinking methods, and resulting in subpar cultivation of scientific research innovation abilities. The social practice segment is often formalistic, mostly consisting of short-term visits and simple surveys, without in-depth collaboration with public health institutions, communities, and environmental protection enterprises. Students are unable to gain an in-depth understanding of actual industry workflows, making it difficult to translate experimental skills into job-related practical abilities.

Thirdly, teaching methods are monotonous and rigid, with poor interactivity and practical effects, making it difficult to mobilize students' learning initiative. Currently, environmental health experiment courses still adopt the traditional didactic teaching method, where teachers explain and demonstrate operations, and students imitate. Teaching is teacher-dominated, with students passively receiving knowledge, lacking space for active thinking and independent exploration. The central role of students is overlooked in teaching, with no targeted personalized guidance provided, failing to meet the actual learning needs of students at different levels.

3. Core design and implementation path of teaching reform

3.1. Construction of a four-in-one practical teaching system

The four-in-one practical teaching system focuses on cultivating students' practical operational abilities, scientific research innovation abilities, job competency abilities, and international collaboration abilities. It organically integrates four links: curriculum experiments, scientific research training, social practice, and international collaboration, forming an interconnected, mutually supportive, and gradient-progressing practical teaching pattern, achieving comprehensive ability cultivation from basic practice to innovative practice, from on-campus practice to off-campus practice, and from domestic practice to international collaboration.

Curriculum experiments, as the foundational base of the system, focus on the cultivation of basic skills, optimizing and adjusting experimental content and teaching links. In actual construction, the dominant mode of traditional verification experiments is changed, establishing a three-tier experimental curriculum system of "basic verification—comprehensive design—innovative exploration." Basic verification experiments focus on cultivating students' basic operational skills, retaining core experimental projects such as the detection of conventional pollutants in water, air, and soil, standardizing experimental operational procedures, and laying a solid foundation for students' practice [3]. Comprehensive design experiments are arranged according to actual industry demands, planning comprehensive topics such as environmental health risk assessment, emergency response to environmental pollution, and detection of novel pollutants, guiding students to independently formulate experimental plans, complete experimental actions, and organize experimental results, enhancing their comprehensive application abilities and improving the safety and effectiveness of experimental teaching. Innovative exploration experiments encourage students to combine disciplinary frontiers and personal interests to autonomously select research topics and conduct innovative experimental research under teacher guidance, cultivating their scientific research innovation thinking and abilities.

The system construction emphasizes scientific research training as the core, focusing on cultivating students' scientific research abilities and constructing a multi-level scientific research training platform. Scientific research training is integrated throughout all stages of talent cultivation, guided by curriculum experiment teaching, encouraging students to join teachers' research projects, advocating for students to apply for projects such as the Undergraduate Innovation and Entrepreneurship Training Program and university-level scientific research innovation projects, and promoting students' mastery of scientific research thinking and methods. Specialized courses on scientific research methods, experimental design, and paper writing are offered, inviting experts from research institutes and industry backbone members to give special lectures, enhancing students' scientific research literacy.

Social practice, as a further extension of the system, focuses on cultivating job competency abilities, deepening collaboration between schools and enterprises and localities. Specifically, it enhances cooperation levels with local public health institutions, environmental protection enterprises, community health service centers, and other units, constructing stable off-campus practical teaching bases, creating real work environments and practical opportunities for students, aligning with the disciplinary characteristics of environmental health. Students are guided to conduct practical activities such as community environmental health surveys, environmental health publicity and education, and identification of potential environmental pollution hazards. Students are encouraged to go to the grassroots, get close to the people, understand the actual work demands in the field of public health, and translate experimental skills into job-related practical abilities.

International collaboration serves as an expanding role in the system, aiming to cultivate an international perspective and build an international exchange and cooperation platform. Universities emphasize strengthening cooperation with foreign universities, research institutes, and public health institutions, formulating international collaborative teaching mechanisms, conducting joint teaching, student exchanges, scientific research cooperation, and other related activities, introducing international first-class practical teaching concepts and resources, inviting foreign experts to give online and offline special lectures and provide teaching guidance, and enhancing the international level of teaching.

3.2. Development of an interdisciplinary practical case library

To promote the implementation of the four-in-one teaching system, we systematically carry out the development of an interdisciplinary practical case library. The construction of the case library adheres to four principles: authenticity, cutting-edge nature, comprehensiveness, and ideological and political education, extensively collecting typical environmental health events, policy practice cases, and scientific research achievements from home and abroad, and reshaping them for teaching purposes [4]. The content of the case library covers environmental health-related fields such as atmosphere, water, soil, indoor environment, public places, and urban and rural planning, with each case including sections such as background information, core dilemmas, data materials, analytical frameworks, and expanded resources. For example, the "Drinking Water Safety" topic not only includes knowledge on the prevention and control of traditional water-borne infectious diseases but also incorporates cutting-edge knowledge such as the screening of emerging pollutants, new water treatment technologies, and the impact of climate warming on water resources, transforming cutting-edge research achievements in areas such as air pollution and drinking water standards into teaching cases, making the course content timely and scientific. The case library adopts an open architecture, encouraging teachers and students to jointly add new cases, and establishes a dynamic updating mechanism, labeling all cases with applicable teaching links, ability cultivation objectives, and interdisciplinary dimensions, facilitating teachers to flexibly select and combine cases according to different teaching objectives.

3.3. Development and implementation of a blended teaching model and assessment mechanism

In terms of teaching models, a blended teaching model primarily consisting of "online virtual simulation + offline physical operation + PBL/TBL group exploration + on-site practice" is constructed. Students grasp basic experimental principles and operational procedures through virtual simulation platforms, completing simulated training projects for high-risk, high-cost, or macro processes; conducting core skill training and deepening in laboratories; engaging in group research on real cases in PBL/TBL discussion sessions, enhancing problem-solving and team collaboration abilities; and conducting environmental monitoring, health surveys, and intervention practices in communities, enterprises, or the wild during on-site practice stages.

Taking the "Environmental Heavy Metal Pollution Investigation and Risk Assessment" experiment as an example, the teaching process involves students using virtual platforms to simulate sampling site layout, sample pretreatment, and ICPMS detection processes; actually operating atomic absorption spectrometers in laboratories to measure heavy metal concentrations; using PBL group discussions to analyze pollution sources and health hazards; and finally conducting on-site investigations in typical areas to provide risk control recommendations [5]. This blended model achieves a deep integration of knowledge learning, skill training, and ability cultivation.

3.4. Construction of a three-in-one systematic reform model

To ensure the coordination and sustainability of reform measures, a three-in-one systematic reform framework of "curriculum system reconstruction—teaching resource construction—faculty team development" can be constructed. In curriculum system reconstruction, the traditional chapter layout divided by environmental media is broken, and teaching content modules are replanned according to the logical main thread of identifying, assessing, intervening in, and evaluating environmental health issues. Each module includes sections such as theoretical instruction, virtual experiments, physical operations, case discussions, and on-site investigations, forming a coherent learning loop, creating elective course module systems in cutting-edge areas such as environmental health interdisciplinarity and global environmental governance, aligning with students' personalized development needs. In the field of teaching resource construction, continuous investment is made to develop diversified resources such as virtual simulation projects, practical case libraries, online open courses, and wild practical bases. In faculty team development, a strategy of internal training and external recruitment and cross-domain collaboration is adopted to form a reasonably structured and highly capable teaching faculty team, establishing a regular teaching discussion mechanism internally, encouraging teachers to explore teaching improvements; inviting disease control experts, environmental protection engineers, and international scholars as part-time teachers externally, constructing a collaborative education mechanism involving on-campus mentors, industry mentors, and international mentors.

3.5. Construction of a collaborative innovation and entrepreneurship training model involving multiple entities

To cultivate students' innovative thinking and entrepreneurial abilities, we draw on the experience of Suzhou Health College and construct a collaborative innovation and entrepreneurship training model involving multiple entities such as schools, enterprises, communities, and government. Regular environmental health innovation and entrepreneurship workshops are held, inviting entrepreneurs, leaders of public interest organizations, and policymakers to discuss real-world topics with teachers and students, inspiring innovative ideas [6]. Meanwhile, an environmental health innovation project incubation plan is initiated, providing small amounts of funding, mentor guidance, laboratory space, and industry connection support for potential student projects, collaborating with environmental protection enterprises and public interest organizations to create social innovation practice bases, providing students with real project experience opportunities. Under mentor guidance, students can participate in activities such as solving enterprise technical problems, promoting community environmental education, and advocating for environmental protection policies, enhancing their innovation and entrepreneurship skills through practice.

3.6. Cultivation of an internationalized industry-academia-research teaching team

The cultivation of an internationalized industry-academia-research teaching team should emphasize optimizing the teaching team structure, strengthening the training of on-campus teachers, formulating teacher training plans, regularly organizing teachers to participate in industry training, scientific research exchanges, and teaching discussions, encouraging teachers to take positions in public health institutions and environmental protection enterprises for practical experience, and enhancing teachers' practical teaching abilities and industry insights. Teachers should be supported to study abroad, participate in international academic conferences, and international cooperation projects, improving their internationalization levels and cross-cultural collaboration abilities. Meanwhile, actively recruit outstanding talents with international exchange backgrounds, industry practical experience, and scientific research innovation abilities to enrich the teaching team, optimizing the team's age, educational background, and professional title structures [7].

4. Teaching reform and effectiveness analysis

4.1. Implementation of teaching reform plan

To test the feasibility and effectiveness of the teaching reform implementation plan, this paper selects students from the 2021 and 2022 cohorts of the Public Health and Preventive Medicine major at a certain university as the research subjects, implementing teaching reform practices in the Environmental Health experiment course. Students from the 2021 cohort are taught using the traditional teaching model and serve as the control group, while students from the 2022 cohort adopt the teaching reform model proposed in this paper and serve as the experimental group. A comparative analysis is employed to examine the learning outcomes, ability enhancements, and teaching evaluation results of the two groups, comprehensively assessing the effects of the teaching reform and summarizing the achievements and existing shortcomings of the reform.

The teaching reform practice spans two academic years and covers the entire scope of the Environmental Health experiment course. All tasks are carried out strictly in accordance with the teaching reform implementation plan introduced in this paper. Students in the experimental group adopt a four-in-one practical teaching system integrating "course experiments–scientific research training–social practice–international collaboration," supported by an interdisciplinary practical case library. They implement a "blended online and offline" teaching model, adopt multi-dimensional assessment and evaluation methods, participate in innovation and entrepreneurship training jointly conducted by multiple entities, as well as international cooperation and exchange activities. The teaching tasks are undertaken by an international industry-academia-research teaching team. In contrast, students in the control group are taught using the traditional teaching model, focusing mainly on verification experiments. The teaching approach involves teacher explanations and demonstrations, with students imitating the procedures. A single assessment method, consisting of experimental reports and final exams, is used. These students do not participate in scientific research training, social practice, or international collaboration activities, and the teaching work is carried out by a traditional teaching team.

4.2. Multi-dimensional evaluation system and result analysis

This study establishes a multi-dimensional evaluation system to comprehensively assess the effectiveness of the teaching reform from three dimensions: learning outcomes, ability enhancement, and teaching evaluation. A combination of quantitative and qualitative analysis methods is used to ensure the comprehensiveness, objectivity, and scientific rigor of the evaluation results.

The results show that the average score of students in the experimental group in the experimental course is 88.6 points, while that of the control group is 76.3 points. The experimental group significantly outperforms the control group, with a statistically significant difference ($P < 0.05$). Compared to the control group, students in the experimental group produce significantly better case analysis reports and experimental design plans, demonstrating a markedly enhanced ability to apply theoretical knowledge to solve practical environmental health problems. An assessment of scientific research and innovation capabilities reveals that 85% of students in the experimental group participate in scientific research or innovation and entrepreneurship projects, with 30% winning school-level or higher innovation and entrepreneurship competition awards and an increase in the number of academic papers published and patents applied for. In contrast, only 20% of students in the control group participate in scientific research projects, with no relevant scientific research or innovation achievements. The scientific research and innovation capabilities of students in the experimental group are significantly stronger than those in the control group. A student questionnaire survey indicates that 92% of students in the experimental group are satisfied with the teaching reform model, believing that it stimulates learning interest, enhances practical and innovative abilities, aligns teaching content with practical needs, and employs diverse and flexible teaching methods, significantly outperforming the traditional teaching model.

4.3. Reform achievements, promotional value, and shortcomings

Through two academic years of teaching reform practice, this study has achieved significant reform outcomes, effectively addressing prominent pain points in the traditional teaching model and improving teaching quality and talent cultivation effects. The four-in-one practical teaching system, blended teaching model, and multi-dimensional assessment and evaluation mechanism constructed in this study can effectively overcome the shortcomings of the traditional teaching model, enhance teaching quality, and improve talent cultivation effects. They provide practical references for the teaching reform of Environmental Health experiment courses and similar practical courses in the public health major at other domestic universities. However, the depth and breadth of international collaboration still need to be expanded, and the content of the interdisciplinary practical case library needs to be enriched. These aspects require gradual optimization and improvement in subsequent teaching reforms.

5. Conclusion

In summary, based on the actual situation of public health major teaching in universities and in response to the prominent issues in the current Environmental Health experiment course teaching, this paper constructs a four-in-one practical teaching system model integrating “course experiments–scientific research training–social practice–international collaboration.” It simultaneously carries out key measures such as the development of an interdisciplinary practical case library, the application of a blended teaching model, the construction of a three-in-one systematic reform model, the establishment of a multi-entity collaborative innovation and entrepreneurship training model, and the cultivation of an international industry-academia-research teaching team. A comprehensive and systematic teaching reform implementation plan is formulated, and the reform effectiveness is tested through teaching practice. This provides references for the teaching reform of similar practical courses in the public health major at other domestic universities, promoting the overall advancement of public health practical teaching reform and the high-quality development of the discipline.

Disclosure statement

The authors declare no conflict of interest.

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