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Exploration of Innovation Ability Cultivation Pattern for Environmental Students based on Open Experiments

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Abstract: The cultivation of innovation ability is especially important for students majoring in environmental science and engineering. In order to solve the problems existing in the process of traditional innovation ability cultivation, a novel pattern of innovation ability cultivation for environmental science and engineering majors based on open experiments is proposed. Through the exploration of platform construction, project declaration, process supervision and effect evaluation, an innovation-oriented open experiment system is constructed and put into practice, which provides students with richer practice opportunities and innovation space, further improves students' practical ability and innovation ability, and is a scientific and effective mode of cultivation of innovation ability.

Keywords: Innovation Ability; Cultivation Pattern; Open Experiment; Environmental Majors.

1. Introduction

As an emerging interdisciplinary specialty involving the fields of environmental protection, green chemistry and resource utilization, environmental majors are particularly demanding of students' innovative ability [1]. Cultivating students' innovation ability not only helps students to better solve practical environmental and chemical problems, but also stimulates their creative potential and career competitiveness, and is also an effective way to improve students' comprehensive quality [2]. Therefore, it is important to explore new mode for cultivating the innovation abilities of students majoring in environmental studies.

With the development of higher education and the continuous promotion of teaching reform, more and more educational practices are adopting open experiments as a new teaching mode to enhance students' innovative and practical abilities [3]. Open experiments emphasize students' independent inquiry practice, which can meet students' individual needs and play an increasingly important role in the cultivation of students' innovative ability [4].

This paper will address the deficiencies in the process of cultivating innovation ability of traditional environmental majors, explore the realization path of open experiments based on the theory and practical experience of open experiments, and verify its feasibility and effectiveness through practice, with a view to providing useful reference for the cultivation of innovation ability of environmental majors.

2. Problems in Traditional Cultivating System

At present, there are the following deficiencies in the process of cultivating the innovation ability of environmental majors: firstly, the traditional teaching process more focuses on theoretical explanations and ignores practical operation links, resulting in the lack of students' ability to deal with practical problems and innovation ability; secondly, there are big limitations in the current curriculum and experimental teaching, which makes it difficult to stimulate the students' innovative thinking and practical ability, and students only passively accept the knowledge and lack of practice opportunities and simulation of real scenes, which leads to students' innovative ability not being sufficiently practiced; thirdly, the current teaching mode lacks openness and interactivity, and it is difficult to create an open, innovative and independent learning environment for students, which leads to the lack of students' motivation for innovation.

3. Current Status of Open Experiments Teaching Application

Open experiments adopt an open experimental environment and independent inquiry learning mode, aiming to stimulate students' innovative thinking and practical ability [5]. In China, the open experiments teaching mode has gradually been noticed and recognized by the higher education community, and a large number of colleges and universities have carried out the pilot work of open experiments [6] [7] [8]. For example, Tsinghua University, Peking University, Nanjing University and other colleges and universities are actively exploring and promoting the open experiments teaching mode, and have achieved remarkable results in teaching reform. In addition, the Ministry of Education has also put forward relevant policies to strengthen practical teaching, which provides policy guarantee for the promotion of open experiments. In foreign countries, the open experiments teaching mode has also been widely applied and promoted. For example, the Massachusetts Institute of Technology (MIT) and Stanford University in the United States and other world-famous colleges and universities are in the leading position in open experiments teaching. In addition, some countries in Europe have also tried and promoted open experiments teaching, such as the United Kingdom, Germany and other countries. Overall, the open experiments teaching mode is a cutting-edge teaching mode and its application prospect is getting broader and broader [9].

4. Realization Path Exploration of Open Experiment

4.1. Construction of Open Experimental Platforms

A perfect open experiments platform is the basis for conducting open experiments. Firstly, equipment and space are necessary conditions for conducting open experiments [10]. In the environmental field, a variety of advanced experimental equipment must be used to conduct experiments. Therefore, the construction of the open experiments platform must be equipped with advanced experimental equipment and provide enough experimental space. This can ensure that students have enough space to conduct experiments and can fully develop their innovative ability. Secondly, teachers are an important guarantee for the implementation of open experiments. Teachers need to have rich practical experience and the teaching concept of open experimentation, and they also need to have some management ability to guide and supervise students. In addition, the management system is an important part of the open experiments platform. The establishment of a perfect management system can guarantee the safety of students in open experiments and ensure the reliability of experimental data.

4.2. Declaration of Open Experiment Projects

The standardisation of declarations for open experimental projects is a prerequisite for their smooth implementation. Schools should regularly release such declarations, encourage students to actively declare their projects, and provide guidance accordingly. For the selection of experimental projects, it is important to consider the environmental conditions of the students and choose specific projects that enable them to acquire practical skills and knowledge. When declaring an open experimental project, it is important to establish a clear and complete declaration process. This should include project initiation, project review, experimental programme design, and experimental process supervision. These steps are necessary to ensure the quality and feasibility of the project. In the project funding for open experiments on security, the school must provide financial support while ensuring that the source and use of funds comply with relevant regulations. This will ensure transparency and fairness in the use of funds.

4.3. Regulation of Open Experimentation Process

The implementation of open experiments requires rigorous supervision to ensure both teaching effectiveness and experimental safety. To ensure laboratory safety and the smooth implementation of experiments, it is necessary to establish a standardized laboratory management system. This includes maintaining and updating laboratory equipment, ensuring cleanliness and hygiene in the laboratory environment, and managing laboratory supplies in a unified manner. In terms of faculty strength, open experiments require professionals with practical experience and a rigorous scientific research attitude. They should possess a sense of responsibility and be able to guide students in conducting experiments and solving problems in a timely manner. Instructors should develop a detailed experimental guidance programme based on the experiment's difficulty and the students' level. This programme will help students overcome any difficulties or problems that may arise during the experiment, ensuring that it proceeds according to plan. From a safety and security perspective, safety is the primary concern in open experiments. It is essential to strictly adhere to safety norms to prevent accidents. Therefore, laboratory safety education should be strengthened to improve students' safety awareness. Additionally, the safety performance of experimental equipment should be regularly checked to ensure experimental safety.

4.4. Effectiveness Evaluation of Open Experiments

The teaching effectiveness of open experiments needs to be scientifically evaluated. First of all, open experiments emphasize students' practical ability, so it is necessary to evaluate students' experimental results and assess their experimental ability and innovation ability from various aspects. Secondly, students' evaluation is an important part of the evaluation of the effect of the open experiments, and it is necessary to collect students' feedback through questionnaires and interviews to understand their knowledge, experience and suggestions about the open experiments in order to assess the acceptance and effect of the teaching mode. Thirdly, the evaluation of teachers is also an important part of the evaluation of the effect of open experiments, teachers can evaluate the experimental ability and innovation ability of students by observing their experimental performance, the quality of the experimental report, the accuracy of the experimental results, etc., and provide targeted guidance and advice. Finally, the evaluation of the teaching effect of open experiments also needs to be considered as a whole, and the whole process of experimental teaching needs to be evaluated in order to facilitate better improvement by instructors.

5. Analysis of Practical Effects

Chengdu Technological University, as an applied undergraduate college, pays particular attention to the cultivation of students' innovation ability, and in recent years, it has carried out a lot of explorations and practices on the mode of cultivating students' innovation ability in environmental majors. The university actively builds open experimental platforms and in addition to laboratories for teaching purposes, it has also set up specialized innovation studios for university students, entrepreneurship nurseries, and the distinctive Creative Space, which provide diversified open experimental venues for students. In the setting of open experiments projects, in addition to national and provincial innovation and entrepreneurship training programme for college students, the university has also specially set up the university-level experiment open fund, the Youth Seedling Program, and the innovation and entrepreneurship training programme, etc., which provide students with abundant financial support for experiments. In terms of teacher team building, the university carries out regular dual innovation training for teachers, and has cultivated a group of dual-teacher and dual-competence teachers, who can provide effective supervision and guidance throughout the whole process for students to carry out open experiments. Not only that, the university has also set up a special innovation and entrepreneurship scholarship for college students to reward students who have made outstanding achievements in practice and innovation, so as to motivate students to actively carry out open experiments. The implementation of the above

initiatives has also brought significant practical results.

5.1. Significant Improvement in Course Grades

Under the open experiment mode, students propose research programs and launch experimental demonstration according to what they have learned in class and their own interests, which can effectively stimulate students' interest and enthusiasm in learning environmental and chemical professional knowledge, and then improve their learning effect and course assessment results. After adopting the open experiment mode in the environmental majors of Chengdu Technological University, the students' learning performance has been significantly improved. Take "Water Pollution Control Engineering" course as an example, based on the content of the course declared more open experimental projects, students through the combination of theoretical knowledge learning and open experiments, a more profound mastery of the principles and techniques of water pollution control, more creative in its application to the actual treatment of wastewater, the course average score than before the implementation of open experiments increased by about 10 points, the enhancement of the effect is significant.

5.2. Significant Improvement in the Quality of Graduation Programs

Graduation design is the most important course for environmental majors before graduation, and it is also an important opportunity for students to synthesize and apply the knowledge and skills they have learned. Under the open experiment mode, students can freely choose the theme and direction of graduation design according to their own interests and practical needs, which makes the graduation design more in line with the actual needs of students and more innovative. Figure 1 shows the changes in the content of students' graduation design topics before and after the implementation of the open experiment mode, taking the environmental science and engineering major as an example. It can be seen that after the adoption of the open experiment mode, the topics of the graduation design are more abundant and diversified, not only covering the traditional fields of environmental protection and chemical industry, but also involving the emerging fields such as green environmental protection science and technology, dual-carbon technology, environmental functional materials and other directions. Among them, "Experimental Research on the Treatment of Bathing Wastewater by Artificial Rapid Percolation System" and "Adsorption of Methylene Blue in Water by Rape Straw Biochar" and other graduation projects based on open experimental projects have also been selected as excellent theses at school or college level, and the quality of graduation design has been greatly improved.

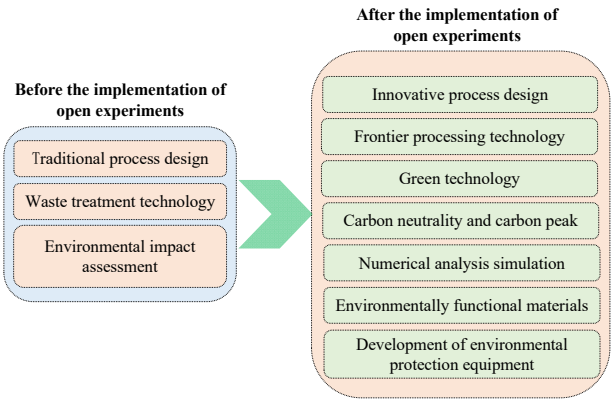

Figure 1. Changes in the content of the graduation design selection

5.3. Significant Increase in Competition Awards

Table 1. Open experiment-based derivative dual innovation competition projects

Textbook knowledge points	Open experiment projects	Innovation competition projects
Adsorption	Preparation, modification and application of green adsorbent materials	Black Guardian: Expert in preparation of rural livestock and poultry manure biochar material for environmental protection
Coagulation	Development and application of new flocculants	Preparation of walnut shell-based cationic flocculants and rapid water purification mechanisms
Advanced oxidation	Application of advanced oxidation technology in wastewater treatment	Water Purification: UV activated peroxodisulfate degradation device for organic wastewater
Filtration	Key technology of industrial wastewater purification based on filtration method	Clear Colour: Removal expert for dyeing and printing wastewater
Activated sludge process	Domestication and regulation of sequencing batch activated sludge method	Purification mechanism of high salt pharmaceutical wastewater by SBR method based on domestication of salt-tolerant sludge
Biofilm method	Experimental study on the treatment of bathing wastewater by biofilter method	Clean Bathing: High-efficiency and low-consumption recycling system for rural bathing wastewater
Nitrogen and phosphorus removal	Experimental research on low carbon green biological nitrogen and phosphorus removal technology	Nitrogen cleaning expert: A kind of sewage deep denitrogenation and decarbonisation system
Process design	Design and development of high efficiency and low consumption wastewater purification combined process	Mechanism and application study of combined CRI process for deep treatment of industrial wastewater

The innovation and entrepreneurship competition are an important platform for environmental students to show their innovative ability. Under the open experiment mode, students can maximize the development of their research interests and tap their creative potential, and on the basis of learning textbook knowledge points, they declare open experimental projects, which in turn derive a series of dual innovation competition projects (as shown in Table 1), and finally form a team to take part in various types of innovation and entrepreneurship competitions. This model can not only stimulate students' sense of innovation, but also enhance their teamwork spirit, so that students can learn to move from

individual innovation to group innovation and make the process of innovation more efficient. With the support of open experiments, students of Chengdu Technological University majoring in environment have actively participated in various innovation and entrepreneurship competitions and gained excellent results. In the past two years, students have won more than 30 awards in national and provincial Internet Plus, Challenge Cup, Environmental Protection Science and Technology Creativity Competition, College Students' Life Science Competition and other dual innovation or disciplinary competitions, and a number of projects have been incubated in the Science and Technology Nursery.

5.4. Increasingly Fruitful Scientific Research

Under the open experiment mode, students can independently choose their research direction, actively participate in scientific research activities, cultivate scientific research consciousness and innovation ability, and at the same time provide more opportunities for students to publish papers and obtain patents. Students of Chengdu Technological University majoring in environment have actively participated in scientific research activities and achieved fruitful academic results under the promotion of the open experiment model. Taking "Wastewater Treatment Technology Innovation Studio for Students" as an example, this open experimental platform selects students who are interested in research and then station them there to carry out innovative research in their spare time, during which two to three young teachers with doctoral degrees will provide them with technical guidance in the whole process. Based on the strict scientific research training, members of the studio have now participated in the publication of more than 30 academic papers in well-known academic journals at home and abroad, and applied for or authorized more than 20 patents based on the results of the open experiments, which has qualitatively improved the innovation ability of the students, and laid a solid foundation for them to follow up their further studies or engage in related scientific research or practical work.

6. Conclusion

Open experiments can provide a proven new mode for environmental majors to carry out innovative work independently and flexibly, which not only helps to improve students' course learning performance and enhance the quality of graduation design, but also provides material or research basis for students to participate in dual-creation competitions, as well as allows students to obtain more academic achievements and development opportunities. Extending the open experiment mode to the cultivation of innovation ability of environmental majors will help to cultivate more high-quality applied talents with innovation motivation and ability for the environmental protection and chemical industry fields.

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