

Integrating Safety Education into the Teaching of “Solid Waste Treatment Engineering Experiment” under the Background of Double First-Class Discipline

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Abstract

With the deepening of the construction of first-class disciplines, in order to cultivate more comprehensive and outstanding talents, continuous innovation in education and teaching is needed. Taking the current situation and problems of the “Solid Waste Treatment Engineering Experiment” experimental course as a starting point, integrating safety education into teaching, and discussing how to promote the comprehensive quality improvement of students in practice. In this context, suggestions for reforming the “Solid Waste Treatment Engineering Experiment” course are proposed from four aspects: increasing course resources, combining virtual and real teaching, adding interactive sessions, and integrating safety education, aiming to improve the quality of course teaching, enhance course development, and deepen teaching reform, providing reference and guidance.

Keywords

Double First-Class, Solid Waste Treatment Engineering, Experimental Teaching, Safety Education

1. Introduction

The “double first-class” construction is an important reform measure in the field of higher education, aimed at improving the academic level and international competitiveness of disciplines and majors. With a focus on solving problems in construction engineering, through planning and reform, accelerating the governance system and governance capacity of higher education, and promoting the

connotation development of higher education institutions (Liu et al., 2018). Adhering to the principles of overall planning, strengthening performance, and diverse inputs, and implementing hierarchical, dynamic, and concerted support measures to promote fair competition among higher education institutions, supporting excellence and strength in competition (Zhao & Zhao, 2019). However, solely pursuing the improvement of academic research level may no longer meet the demand for the cultivation of comprehensive quality talents.

Laboratory safety is the foundation for the teaching and research work undertaken by university laboratories. According to analysis, over 80% of laboratory safety accidents are caused by human factors, attributed to the lack of safety awareness and knowledge among operators. Experimental safety education is an important means to enhance the safety awareness and knowledge of experimental personnel. The goal is to improve the laboratory safety atmosphere, enhance the safety awareness of experimental personnel, raise the safety skills level of experimental personnel, and ensure the safe operation of laboratories (Xiao et al., 2024). The 2021 “Notice on Carrying Out Special Actions to Strengthen Laboratory Safety in Colleges and Universities” issued by the Ministry of Education explicitly requires universities to incorporate experimental safety education into the training process of students, specifying the training requirements for students at all levels and types in different disciplines and majors. The “Solid Waste Treatment Engineering” experimental teaching is an important practical component in the field of chemistry, and by integrating safety education, student growth and development can be promoted.

2. Research Background

Guilin University of Technology’s discipline of Environmental Science and Engineering was established in 1993. In 2000, it was granted the authority to confer master’s degrees. In 2012, it was included in the Ministry of Education’s “Excellent Engineer Education and Training Program.” In 2013, it obtained the doctoral degree authorization point in the first-class discipline of Environmental Science and Engineering (Fowode et al., 2023). In 2014, a postdoctoral research mobile station was approved for establishment. In 2018, the Environmental Science and Engineering discipline was selected for Guangxi’s list of first-class disciplines. In the 2023 national fourth-round discipline evaluation, it was the only “B” grade discipline in the technology and engineering disciplines of Guangxi province’s state-owned universities.

Guilin University of Technology’s new Environmental Engineering talent cultivation program has elevated its student training requirements and positioning to the level of the “national ecological environment protection strategy and the development needs of the Li River Economic Belt.” Building upon this foundation, the curriculum has been comprehensively updated, with higher teaching goals also set for the “Solid Waste Treatment Engineering Experiment” course (Xie et al., 2022). Currently, research on the teaching reform of the “Solid Waste Treatment Engineering Experiment” course mainly focuses on this specific topic. There

are also studies on curriculum reform in various situational modes, but few studies have addressed the reform of the “Solid Waste Treatment Engineering Experiment” course against the background of “Double First-Class” disciplines (Minick et al., 2022). Education aims to cultivate students’ correct outlook on life, values, and worldview, enabling them to possess the right moral concepts and a sense of social responsibility (Misnan et al., 2017). Safety education is crucial for ensuring students’ personal and equipment safety during experiments, enhancing their safety awareness, and their ability to deal with emergencies.

3. Current Situation and Issues of the Course

3.1. Experimental Resource Constraints

Local universities are constrained by financial and geographical factors, resulting in limited experimental facilities and teaching resources. However, the construction of first-class disciplines requires resource investment to enhance students’ engineering capabilities. Under the background of “Double First-Class,” the “Solid Waste Treatment Engineering Experiment” course necessitates that experimental teaching be combined with engineering practice. This approach encourages students to actively engage in experiments in laboratories, workshops, and even external factories to strengthen their engineering awareness and thinking. The goal is to cultivate students’ ability to integrate theory with practical engineering aspects.

3.2. Insufficient Course Projects

The course “Solid Waste Treatment and Disposal” is a core course in environmental science or environmental engineering majors, with a total of 16 class hours. For this course, which is in high demand for environmental engineering students, the number of class hours is relatively limited. Due to resource constraints in local universities, the “Solid Waste Treatment Engineering Experiment” includes four experimental projects: Soxhlet extraction experiment for extracting substances from solid waste, vacuum distillation of organic solvent-immersed tea withered liquid, thin-layer chromatography analysis of chlorinated pesticides, and gas chromatography determination of benzene series compounds. The experimental content tends to focus on the treatment and analysis of chemical toxins, lacking core experimental projects such as organic waste composting experiments and solid waste resource utilization experiments.

3.3. Traditional Teaching Mode

The traditional classroom teaching model often involves the teacher “lecturing” while students “listening,” where the teacher mainly imparts knowledge and the students passively receive it, ultimately placing the teacher at the center. In the course “Solid Waste Treatment Engineering Experiment,” the processing and disposal equipment involves a significant amount of mechanical structure content. If the traditional teaching model is still employed, students can only rely on the

teacher's explanation and visual aids to imagine the learning process. This approach does not allow for a true hands-on experience and makes it difficult to cultivate students' engineering design and practical skills.

In traditional classroom teaching, teachers impart knowledge to students and hold a dominant position in the teaching process, leading to passive learning where students do not develop independent thinking habits. This lack of fostering independent thinking habits hinders students' active engagement and fails to enhance their learning interests. Teaching interaction involves engaging students in classroom teaching to capture their attention and stimulate their learning interest. It allows teachers to adjust the teaching pace, modify teaching plans, and focus on addressing students' difficulties based on teaching feedback. However, in our university, the course "Solid Waste Treatment Engineering Experiment" continues to utilize traditional lecture-based teaching methods with limited interaction, failing to spark students' interest in learning and resulting in poor student engagement.

3.4. Lack of Security Awareness

Some students lack sufficient safety awareness and operational skills during experiments, resulting in increased safety hazards in the laboratory. For example, some students overlook self-protection measures and fail to strictly follow safety operating procedures during the experimental process.

Some laboratories have evident deficiencies in safety facilities such as fire prevention measures, ventilation systems, with issues like insufficient and substandard fire extinguishers, lack of smoke and fire alarms. The management system is imperfect, including the absence of access control and monitoring systems, leading to ineffective control of safety risks in sensitive and dangerous areas of the laboratory. Violations in experimental operations, such as unauthorized or improper actions in daily research activities, are the primary "trigger" for laboratory safety accidents, like unfamiliarity with laboratory safety management systems and lack of knowledge in safe use of chemical reagents and equipment.

4. Measures for Curriculum Reform

4.1. Increase in Curriculum Resources

The laboratory course has been separated from the theoretical course, and a new course titled "Solid Waste Treatment Engineering Experiment" (2 credits, 16 hours) has been introduced, taught by a full-time laboratory instructor. The experimental course resources have been enhanced with one set of aerobic composting training equipment, one set of compost granulation training equipment, and one set of organic composting and garbage incineration virtual simulation software.

Through the experimental course, students can address shortcomings such as limited time for external internships, restricted learning opportunities, and insufficient depth of understanding. Additionally, the training equipment plays a crucial role, especially during special circumstances like pandemics when external

internships are not feasible.

By adding a visit to the waste incineration plant as part of the practical course, students can gain a deeper understanding of the principles and processes involved in waste incineration treatment. This initiative aims to strengthen students' awareness of waste reduction, harmlessness, and resource utilization.

With these improvements in the experimental teaching, students have shown further understanding of the basic principles of aerobic composting of organic waste, various influencing factors in the composting process, and control measures. They have also developed a deeper appreciation for waste incineration for power generation and resource utilization.

From the student evaluation results, the comprehensive average score for the "Solid Waste Treatment Engineering Experiment" course is 93.77 out of 100, with the highest score being 100 and the lowest score 74.99, resulting in an excellent overall evaluation. In specific evaluations, teaching literacy, teaching content, teaching strategies, and teaching effectiveness all received excellent ratings.

Looking at the overall grades of students in the "Solid Waste Treatment Engineering Experiment" course in the fall semester of 2023, all enrolled students achieved passing grades, with an excellent and good rate reaching 70%, meeting the expected teaching objectives.

4.2. Combining Theory with Practice in Teaching

The approach of combining virtual experimental teaching with physical experimental teaching, experimental teaching with theoretical teaching, experimental teaching with research training, experimental teaching with practical engineering, and experimental teaching with market demands is crucial. The experimental training teaching method supports university students in technological project proposals and integrates practical engineering aspects, aiming to cultivate students' abilities to independently complete the entire process of experimental design, research exploration, and results summarization, fostering their scientific thinking and research interest.

By integrating practical training with actual production internships, students are immersed in frontline production scenarios through virtual simulations. This approach provides simulated training conditions for process debugging, equipment maintenance, and production management. It allows students to go through a teaching process of "making mistakes-correcting-optimizing" in production training, thereby enhancing students' vocational skills and professional attributes.

The experiment, based on simulation software and integrating the principles of solid waste treatment processes with manual design and calculation processes, is divided into 6 parts:

- 1) Theoretical knowledge assessment and expansion
- 2) Virtual simulation experiment scenario design
- 3) Simulation design-based experiment design
- 4) Processing and analysis of virtual simulation experiment results

5) Troubleshooting and adjustment

6) Evaluation of virtual simulation experiment results

Initially, students need to have a certain understanding of waste incineration technology and calorific value calculation, aerobic composting, anaerobic fermentation theory, and processes. They should grasp the experimental principles, understand the experimental purpose, and clarify the experimental steps.

Next, students need to set clear experimental parameters and understand the methods for analysis and processing. Combining their knowledge, students design their own experimental plans based on the design scenarios provided by the teacher. They start with manual calculations for preliminary design and then use simulation experiments for optimization calculations and verification through single-factor or multi-factor impact simulation experiments, comparing and analyzing the results obtained from both methods.

Finally, students write an analysis report and a simulation experiment design report based on the experimental results and process debugging. The experiment concludes with a defense presentation for final assessment and evaluation. This structured approach encourages students to apply theoretical knowledge, practical skills, and critical thinking in a simulated experimental setting, enhancing their learning outcomes and research capabilities.

4.3. Increase in Interactive Sessions

Experimental classroom teaching utilizes the interaction between teachers and students to shift students' attention to the classroom, away from using mobile phones. This transition from passive learning to active engagement leads to significantly different learning outcomes. As many students in our school come from minority areas in the southwest, there exist significant differences in comprehension, perspectives, and knowledge levels. Encouraging students to ask questions and express their opinions without fear of making mistakes or being ridiculed for asking superficial questions is crucial. The aim is to foster an environment where questions are answered promptly and doubts are resolved.

Teachers tailor their teaching strategies based on students' grasp of knowledge and individual differences. They promptly address learning difficulties, correct any negative learning habits, and optimize teaching effectiveness. By providing targeted guidance and addressing individual needs, teachers help students overcome obstacles, which enhances learning outcomes. This approach promotes interaction and communication between teachers and students, nurtures students' interest in learning, and develops their self-directed learning abilities, ultimately improving teaching quality and learning effectiveness.

However, there are currently some challenges in the implementation process. For example, students may not prioritize education enough, educational materials and teaching methods may lag behind disciplinary developments, the teacher team may need to strengthen their professional knowledge, and there may be limited teaching hours despite the abundance of course content. In curriculum design

and experimental teaching, it is essential to integrate more ecological elements, such as discussing the social significance of environmental protection, professional ethics, etc., to enhance students' sense of social responsibility and environmental awareness.

4.4. Integration of Safety Education

Integrating elements of safety education into the solid waste disposal curriculum can help students better understand the potential risks and safety issues associated with the solid waste disposal process, enabling them to take appropriate preventive measures. For example, students can be taught how to properly handle hazardous waste, how to protect themselves from harmful substances during the handling process, and how to take appropriate measures in emergency situations. Through this approach, students can acquire not only professional knowledge in solid waste disposal but also enhance their safety awareness and coping skills.

In the context of experimental teaching in solid waste disposal, there are indeed some issues related to safety awareness. These issues include incomplete experimental setups, low student engagement, and difficulties in conducting some experiments. In response to these challenges, the curriculum has implemented measures to enhance the quality and safety of experimental teaching. One solution is to utilize virtual simulation teaching resources.

For instance, the School of Environmental Science and Engineering has introduced a teaching model for the "Solid Waste Treatment and Disposal Experiment" course based on shared virtual simulation teaching resources. This model combines traditional offline experimental teaching with online virtual simulation experimental teaching, aiming to enhance students' practical skills and comprehensive application abilities. Through this approach, students can conduct experiments in a safe virtual environment, learning about solid waste treatment and disposal techniques while reducing potential safety risks associated with practical operations.

Furthermore, the "Solid Waste Treatment and Disposal Experiment" course emphasizes that through experimental learning, students acquire the knowledge of analyzing and testing the basic properties and indicators of solid waste, as well as gaining proficiency in operating experimental equipment. This course design not only enhances students' practical laboratory skills but also enhances their awareness of experimental safety. In summary, by integrating virtual simulation technology with traditional experimental teaching, safety awareness in solid waste disposal experimental teaching can be effectively enhanced. Additionally, this approach provides students with a more comprehensive and secure practical learning environment.

5. Conclusion

Against the backdrop of constructing first-class disciplines, integrating safety education is one of the important pathways to achieving high-quality education.

Taking the current situation and issues of the “Solid Waste Treatment Engineering Experiment” course as the starting point, using safety education as an example in teaching, explores how to enhance students’ comprehensive qualities through practical application. In this context, suggestions for reforming the “Solid Waste Treatment Engineering Experiment” course are proposed from four aspects: increasing course resources, integrating virtual and real teaching, adding interactive sessions, and incorporating safety education. Through practical exploration in experimental teaching, new ideas and practical experience can be provided for higher education teaching reform, fostering students’ growth and development, and supporting the continuous development of environmental engineering discipline construction and talent cultivation.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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