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Exploration of Teaching Reform in "Biosafety" Based on Network Platforms

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SUMMARY: *With the rapid development of information technology and the increasing complexity of global public health issues, the application of network platforms in higher education teaching has been expanding at an unprecedented speed and has gradually become indispensable. This paper will study in depth how to carry out teaching reform of the "Biosafety" course based on modern network platforms, address the current problems of traditional teaching models, such as old textbook content, inflexible instructional methods, and weak links between theory and practice. Guided by the outcome-based education (OBE) concept in the system of engineering education professional certification, all-round reform strategies are proposed in this paper. By systematically integrating rich digital network resources, innovating heuristic and case-based teaching methods, and building a multi-dimensional, continuous-improvement teaching evaluation system, a more efficient, highly interactive, and practical blended teaching system for "Biosafety" has been constructed. The construction of this reform will help students cultivate stronger self-study abilities and independent learning habits, improve their critical thinking and sense of social responsibility, thereby producing excellent all-round biosafety talents for the nation.*

KEYWORDS: *Biosafety; Network Platform; Teaching Reform*

1 Introduction

The course "Biosafety" will be a required elective for undergraduate students in Bioengineering. With the rapid development of synthetic biology, genetic engineering and metabolic engineering in recent years that have changed industrial applications, this course will help cultivate a general knowledge system and all-round professional qualities for future bioengineering students. All subjects are covered by biosafety, and it is not limited to a particular domain; molecular biology, clinical medicine, ecology, bioinformatics, and environmental science are all such examples. Through the above study of this course, students will learn to master the basic theoretical knowledge, precise risk assessment techniques, and new ideas in the field of biosafety prevention; at the same time, they will be able to apply all these contents in their own work. In the end, they need to have good analytical and research skills to address unforeseen circumstances and new biosafety problems in daily life, and be able to actively protect biological security rather than passively receiving knowledge [1].

Recently, the scope of biosafety has extended beyond the standards for scientific research and laboratories to encompass national defence as well. The world's public health system is now in a "One Health" phase and understands that the health of people, animals and the

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environment are closely related. The devastating global spread of the COVID-19 pandemic has revealed, in recent times, the severe risks posed by inadequately constructed biosafety governance systems worldwide to the international supply chain and public health facilities from biological threats. With the exponential and rapid development of modern biotechnology, coupled with profound structural changes in the international geopolitical environment and an accelerated pace of the great rejuvenation of the Chinese nation, the situation of biosafety in China has become extremely complex, multi-faceted, and severe. Over the past decade, many infectious disease outbreaks have occurred in China, such as SARS, Influenza A (H1N1) and H7N9 avian influenza. The emergence, rapid spread and cross-border transmission risk of these new and re-emerging infectious diseases are often unpredictable in time and thus difficult to control; they pose serious threats to public health as well as to the long-term economy and social order.

In addition, the continuous decentralization of science, a decrease in the R&D expenses of life sciences, the ease of accessing open-source genetic data and advanced laboratory instruments, and a rapid increase in the number of amateur "biohackers" have created a regulatory lag. With the arrival of revolutionary but easily obtainable gene-editing technology, such as CRISPR-Cas9, supervising and regulating accidental or malicious use of advanced biology has been becoming more and more difficult. As a result, Dual-Use Research of Concern (DURC) - research with good intentions that could be used to cause harm - has attracted the attention of global academic ethics and scientific supervision more and more frequently.

Secondly, in terms of ecology, China is now facing a serious and urgent situation of alien species invasion and the irreversible loss of precious genes. With the rapid increase in international trade and travel under globalisation, China has been severely affected by invasive alien species to this day. As a result of these invasions, both the economy and natural resources in agricultural production and forestry across China have suffered some damage and are thus at risk of endangering the stability of the national economy and ecological balance. At the same time, there are serious risks of "biopiracy" and illegal collection of indigenous biological resources to the strategic gene banks of the country. In light of the increase in these many types of risks, the "Biosafety Law of the People's Republic of China" (known as the "Biosafety Law") has recently been officially adopted and implemented to provide strong legal support. This leading law has set much higher statutory standards for the new governance of biosafety risks and includes all aspects of laboratory safety, outbreak response and defence against bioterrorism [2].

Given the above reasons, in light of this broad background, introducing a well-structured and contemporary "Biosafety" course for students majoring in Bioengineering should no longer be seen as a simple academic obligation but as an urgent response to the strategic needs of national defence. The old teaching model is mostly one-way knowledge transfer and memorization, and it is now failing to prepare students for the changes in the world of biosafety. The transformation of this curriculum will help to foster a healthy industrial environment, nurture high-quality scientific talent with strong ethics, improve the practical engineering capabilities and deep social awareness of students, and so on. Based on the above foundation, this paper will explore how to reform the current teaching model by utilising digital network platforms, new teaching methods and goal-oriented evaluation systems, etc., to meet the demands of the times and build a future-oriented biosafety education system.

Figure 1: The Multi-dimensional Framework of National Biosafety and its Interdisciplinary Links.

2 Current Deficiencies in the Teaching of "Biosafety" Course

2.1 Lack of Unified and Authoritative Textbooks and the Rapid Obsolescence of Knowledge

Currently, there are few textbooks on biosafety, and the five types used by universities across the country are as follows [3]. Among them, "Biosafety" by Liu Qian and Zhu Xinquan is the most widely used; however, this book was published a long time ago (2001) and some of the chapters are now outdated. Textbooks such as "Genetically Modified Organism Safety and Management" (edited by Xue Dayuan), "Agricultural Genetically Modified Organism Safety" (edited by Zhang Shuzhen), and "Genetically Modified Organism Safety" (edited by Zeng Beiwei) are restricted to the safety of agricultural genetically modified organisms and thus have certain disciplinary limitations.

In the past two decades, leading-edge technologies such as CRISPR-Cas9 gene editing, synthetic biology and deep-learning-based protein design have developed rapidly, and new types of biosafety risks (e.g., off-target mutations, bio-terrorism and ethical issues) have appeared. Therefore, the current textbooks are unable to present these new scientific frontiers. Based on the change in information, the correctness of textbook knowledge in fast-changing areas is subject to a cycle of knowledge decay. The effective knowledge capacity of a textbook at a certain time can be represented as:

$$K_v(t) = K_0 \cdot e^{-\lambda t} + \Delta K_{\text{supp}}$$

(Where $K_v(t)$ represents the valid and applicable knowledge volume at time t; K_0 is the initial knowledge volume at the time of publication; λ is the knowledge decay constant specific to the biotechnology field, which is currently at a historically high level; and ΔK_{supp} represents the supplementary dynamic knowledge updated by educators.)

Because λ is extremely large in the biosafety domain, the exponential decay of K_0 leads to a severe disconnect between textbook content and modern requirements. Therefore, the publication of biosafety textbooks needs to be urgently strengthened. It is suggested to take “Biosafety” edited by Liu Qian and Zhu Xinquan as the basic framework, systematically revise outdated content, incorporate the latest domestic and foreign research progress alongside current legal frameworks, and publish a new unified, authoritative, and dynamically updatable textbook system as soon as possible.

2.2 Relatively Single Teaching Model and High Cognitive Load

A large system of laws and regulations for biosafety covers ethics and technology. The traditional interpretation of these legal terms and rigid provisions is inherently abstract and dull; therefore, students lack motivation for learning and perform poorly. Only in the old way of teaching, without any interaction, heuristics or exploration will be used; students will be mentally exhausted.

Biosafety is generally an applied science that needs to introduce core theoretical mechanisms through real-life scenarios. Every point of knowledge in the discipline is connected to an in-depth representative case from history or today (e.g., laboratory leaks or biological invasions). Most of the teaching models in universities are still based on one-way multimedia presentations and blackboard writing, and full use of vivid and interactive case studies to arouse students' interest in learning has not been achieved. According to cognitive psychology and the model of educational retention, passive learning will fade in memory. The proportion of retained knowledge after traditional and interactive teaching can be expressed as the modified Ebbinghaus-Engagement formula:

$$R(t) = R_0 \cdot \exp\left(-\frac{t}{\alpha \cdot I + \beta}\right)$$

(Where $R(t)$ is the knowledge retention rate at time t after the lecture; R_0 is the initial comprehension rate; I represents the Interactivity Index of the teaching model (e.g., case discussions, multimedia engagement); and α and β are cognitive constants.)

In the old single-mode teaching, the Interaction Index (I) is close to 0 and therefore R(t) decreases rapidly. Students in modern times are digital natives, and their habits for obtaining information are heavily based on fragmented, highly visual, and interactive multimedia platforms (such as short videos and interactive mobile applications). They are more willing to learn independently by studying online rather than having the teacher teach it in class. Therefore, to reverse the problem of low course teaching quality, a single-teacher mode needs to be altered to raise the Interactivity Index (I).

2.3 Insufficient Integration of Theory and Practice in Teaching

The main purpose of biosafety is to protect human life and the environment, and it is thus a national life project. In order to train the new generation of biosafety experts well, students should have a good foundation in biosafety theory and be able to respond promptly to all kinds of risks in practice. At present, the few existing "Biosafety" courses are still mainly limited to classroom lectures. They are in a state of poor communication, joint cultivation and practical cooperation with biotechnology enterprises, custom laboratories and front-line interdisciplinary fields.

As a result, the theoretical support for emergency practice is still vague and lacking. After the official implementation of the "Biosafety Law", the education system has been required to foster talents capable of practical governance. Based on the above reasons, in the effort to fully assess the actual capabilities of bioengineering students, it is proposed to construct a multi-dimensional model of competence rather than being confined to academic scores. The comprehensive professional competency (C) of a student can be expressed as the combined effect of theory and practice:

$$C = \omega_1 T + \omega_2 P + \gamma(T \times P)$$

(C is the comprehensive biosafety problem-solving competency; T is the level of mastery of theoretical knowledge; P is the level of practical operation and crisis management skills; ω_1 and ω_2 are fundamental weight coefficients; and the crucial term $\gamma(T \times P)$ is the synergistic multiplier effect obtained by effectively integrating theory and practice.)

Currently, due to structural deficiencies in the curriculum at the practical component (P), the synergistic value $\gamma(T \times P)$ is almost negligible, and thus the overall competency (C) is relatively low. This fragmented educational output is completely out of line with the national goals of capacity-oriented and outcome-based education (OBE) for new engineering talents [4]. Build a high-quality theory-practice teaching ecosystem as soon as possible.

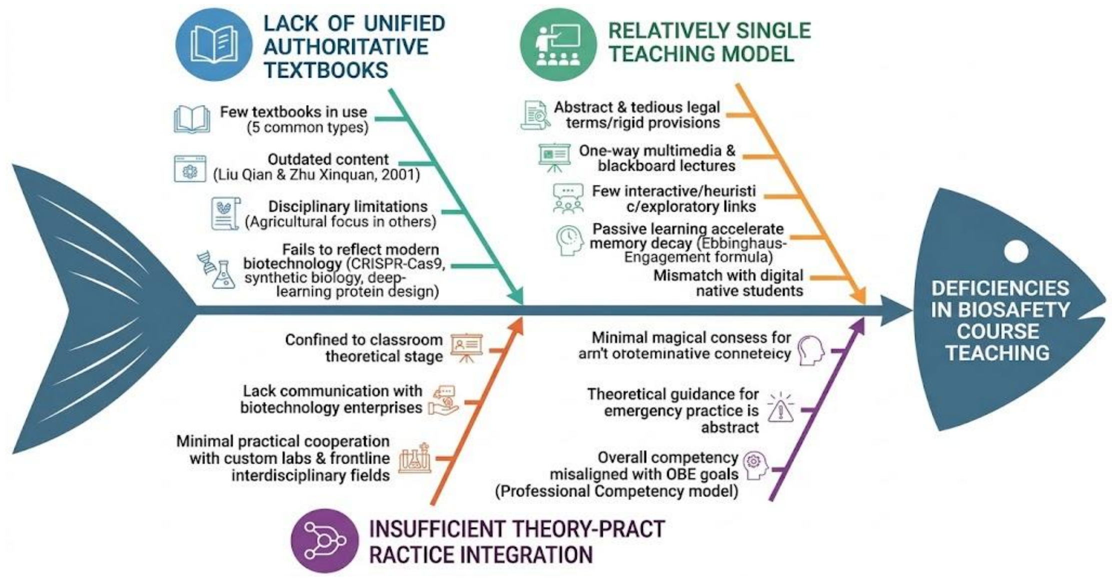

Figure 2: Fishbone Diagram Analysis of Current Deficiencies in "Biosafety" Course Teaching.

3 Exploration of Teaching Reform in "Biosafety" Based on Network Platforms

3.1 Innovation in Teaching Design

This large work has passed the national engineering education professional qualification. The first concept of engineering education professional certification is Outcome-Based Education (OBE); it is student-centred, aims to achieve specific learning outcomes for students, and conducts qualification evaluation and continuous quality improvement [5]. The design of the course in this study is based on the OBE concept of engineering education certification, and its purpose is to foster students' self-directed learning and enhance the effectiveness of learning. It studies teaching reforms for the "Biosafety" course to enhance the teaching quality of this course further and foster high-level, compound professionals for society. The whole process of teaching forms a closed loop of teaching, evaluation of teaching, analysis of achievement of teaching objectives, and continuous improvement.

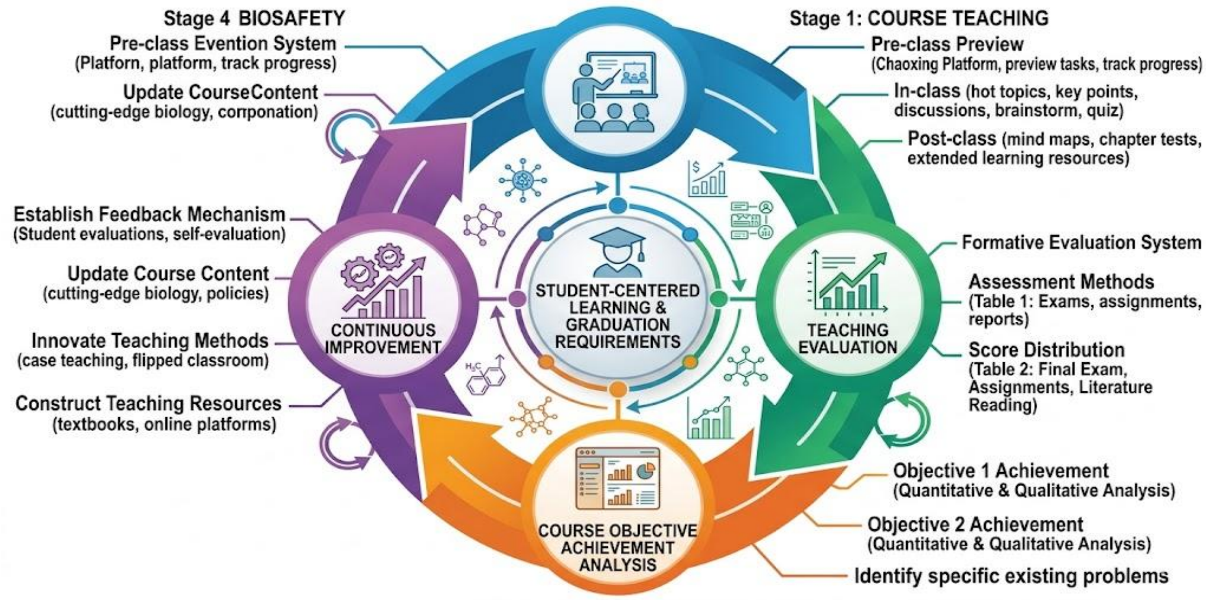

Figure 3: OBE-based teaching closed-loop for the "Biosafety" course.

1. Course Teaching

The three stages of course teaching are pre-class, in-class and post-class.

(1) Pre-class: Basic course knowledge is sent as preview tasks on the Chaoxing Fanya network platform. Students need to complete the learning of low-level knowledge through the intelligent tool Xuexitong. Teachers can see the students' study conditions on the platform and guide their learning.

(2) In-class: The five components of the course design are: pre-class review, hot-topic introduction, key and difficult point explanation, thematic discussion, and conclusion. From the bottom up and the top down, from theory to cases and then back to theory, students can follow their interests in class to learn about the knowledge point step by step and continue to study it. Among them, the "hot topic introduction" link introduces current cases, scientific frontiers and other content according to the course content to spark students' interest; the "pre-class review" and "key and difficult points explanation" links use functions such as voting, quick answers, selection and discussion in Xuexitong to assess students' mastery of low and intermediate knowledge; and the "thematic discussion" link designs classroom activities based on case teaching, problem-oriented methods, etc., to promote learning, guide students to discover problems, conduct in-depth analysis of problems, and dare to question. Through group discussion, brainstorming, defence and Q&A, students' usual cognitive models are broken. Students voluntarily participate in class activities to expand the scientific frontier, gain a broader view of the world, internalize professional knowledge into their emotional identities, achieve the internalization of high-level knowledge points, and cultivate teamwork and innovation abilities; in the "conclusion", "Xi Jinping's Quotes" and celebrity quotes are used to motivate students' enthusiasm for scientific exploration, pose high-level thinking questions, and have students search for information outside of class after class, enabling them to understand that the end of classroom teaching is not the end of learning, but rather the beginning of further learning and improvement.

(3) After class: Students are to summarize the chapter mind maps independently. Through this training, students can connect their dispersed and extensive knowledge points into a system,

form a framework, and deepen their understanding; chapter tests are posted on Xuexitong, and exercises of various difficulties are set to assess students' learning and grasp their proficiency; at the same time, the course network platform collects a large number of teaching resources such as cutting-edge progress in biology, social hot topics, and postgraduate entrance examination materials for universities, which are pushed to students for further study.

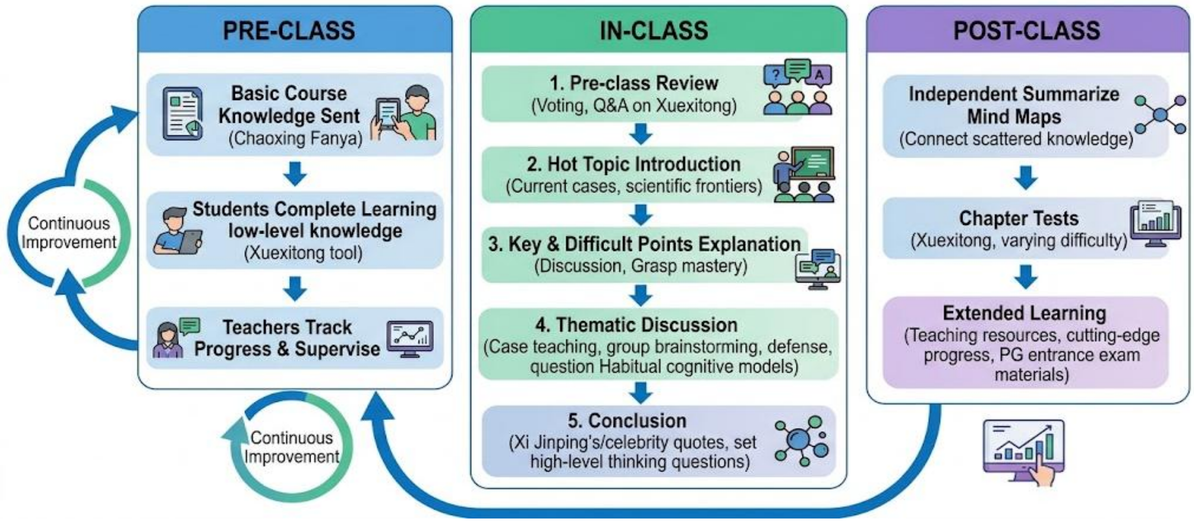

Figure 4: Blended Teaching Workflow Based on the Chaoxing Fanya Network Platform.

2. Teaching Evaluation and Analysis of Course Goals

To motivate students to learn more actively, we will introduce process assessment and establish a system for formative evaluation. Teacher evaluation is also used to judge how well the teaching has gone, and it can help us improve our teaching from time to time. Due to the long-term effects of exam-oriented education and the internal professional assessment system in schools, there have been some deficiencies in the evaluation methods for professional courses. Some students have strengthened their exam-oriented psychology to obtain scholarships and demonstrate their learning ability, thus leading to the utilitarianisation of evaluation. Currently, only classroom attendance and the results of the final exam are usually included in the evaluation. The above single form of assessment has some deficiencies and fails to reflect the students' actual learning results and knowledge absorption. In response to the above problems, in light of the engineering education certification, we have reformed the teaching and assessment mode to integrate course objectives, assessment content and score evaluation. The objectives of the course, assessment content and methods for "Biosafety" are shown in Table 1, and the distribution of assessment scores is shown in Table 2.

Table 1: Course Objectives, Assessment Content and Methods of "Biosafety"

Course Objectives (Corresponding to Graduation Requirement Indicators)	Assessment Content	Assessment Methods
Objective 1 (Graduation Requirement 7.1)	1. Protection of biodiversity 2. Hazards and prevention of invasive species 3. Safety assessment of various genetically modified organisms and products	Exams, assignments, literature reading + PPT reports/small theses
Objective 2 (Graduation Requirement 8.3)	1. Importance of biosafety 2. Domestic and foreign laws and regulations in the field of biosafety 3. Assessment, supervision, and prevention of biosafety	Exams, assignments

Table 2: Distribution of Assessment Scores for "Biosafety"

Assessment Content	Objective 1 (Graduation Requirement 7.1)	Objective 2 (Graduation Requirement 8.3)
Final Exam	30	20
Assignments	20	20
Literature Reading + PPT Reports/Small Theses	10	0
Total	60	40

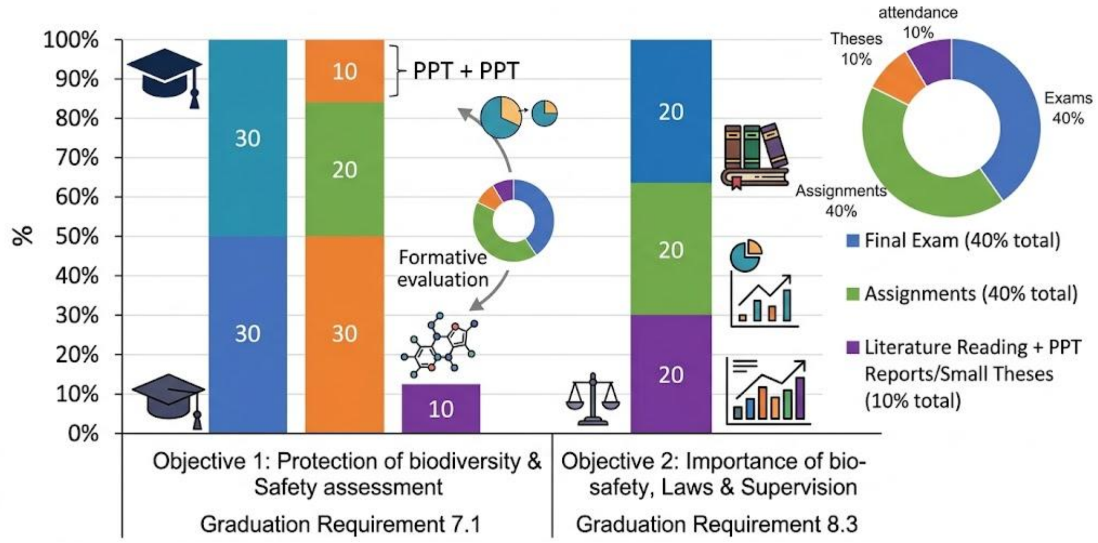

Figure 5: Weighting distribution of assessment methods for Course Objectives.

The accuracy of the classroom answers on the Chaoxing Fanya network platform will be used to assign quantitative scores for assignments, and in the past, general scores were too subjective and based on teachers' preferences. Second, the student's course thesis needs to collect a large number of related materials and academic papers from online platforms and databases, summarize relevant arguments and evidence, etc. It will enable the students to gain some initiative and a desire to learn. In short, we need to ensure the fairness and impartiality of the evaluation system, guide students' efforts in a specific direction, pay attention to the creativity of their thinking, and make the evaluation fully serve the multiple purposes of fostering students' all-around development, improving the level of teaching by teachers, and promoting the overall quality of education.

Based on the teaching syllabus, after the course, a quantitative and qualitative assessment method will be used to compile an analysis report of how well the goals of the "Biosafety" course have been achieved. Based on the evaluation of the whole and each component of the course goals, identify specific problems in the present situation and put forward countermeasures for continuous improvement.

The ways in which the achievement of course objectives will be assessed for all students and individual students are as follows:

1. The evaluation of the general achievement level of all students in objective i is calculated according to formula (1):

Achievement of course objective i = Actual score of course objective i / Theoretical score of course objective i... (1)

2. The assessment of the level of attainment for individual student m in learning objective i is given by formula (2):

Achievement of course objective i by student m = Actual score of course objective i by student m / Theoretical score of course objective i ... (2)

3. Continuous Improvement

The long-term development of course teaching will continue, and at the same time, teachers and administrators need to continuously assess changes. The following are the improvements we have made:

(1) Build a feedback mechanism: Collect teaching feedback through student evaluations of course goals and achievements, etc., to learn about the strengths and deficiencies in teaching.

(2) Update course content: With the rapid development of biosafety, this knowledge is also changing at a high speed. The course teacher team knows about the popular topics and the development of cutting-edge fields at present, keeps up with changes in discipline-related research, and regularly updates the course content based on new research results, technological progress and policy changes.

(3) New teaching ideas: Continuously learn about new types of teaching, such as case teaching, flipped classrooms, project-based learning, etc., to make learning more interesting and effective for students.

(4) Build teaching materials: Add more teaching resources, such as textbooks and network resources, to offer students different ways of learning.

(II) Application of Intelligent Teaching Platforms

Network teaching platforms are service support platforms for teachers to conduct online auxiliary teaching and for students to learn independently, and they also offer support for teaching models such as blended teaching and flipped classroom. Based on the OBE concept, this course will develop online and offline teaching materials through the Chaoxing Fanya platform. Online network resources for the teaching materials of the basic course include teaching syllabuses, courseware and lesson plans; personalised teaching resource construction covers video materials and question bank resources. A network teaching platform can be employed to conduct various teaching activities online, such as students submitting homework, online tests, releasing course notices by teachers, and evaluating teaching results online.

3.2 Application of Heuristic Teaching Methods

The main purpose of heuristic teaching is to inspire students to learn independently through their own thoughts, exploration and discoveries. Heuristic teaching does not follow the traditional mode of education and instead seeks to have students actively participate and take the initiative in learning through questioning, problem-solving and other ways. Therefore, cultivate the students' ability to think critically, solve problems and create independently, and deal with difficult real-life situations more flexibly. Heuristic teaching is less about transmitting knowledge; instead, teachers now guide and assist students in their learning. The teacher should provide heuristic questions, situations or cases to create a learning environment that can encourage students to think, and give feedback and support to help students learn better. Thus, heuristic teaching can spark students' interest in learning, boost their motivation for studying, help them learn independently, and promote deeper understanding rather than rote memorisation and learning by heart. Therefore, heuristic teaching is widely regarded as a good way to educate young children to help them develop a sense of curiosity and initiative. The actual teaching activities of this class are as follows:

1. Teachers set out some leading questions at the beginning of the lesson; for example, in teaching the "Biological Invasion" chapter, they have asked students what invasive species they have come across in their daily lives. Ecological damage caused by invasive species. Students independently think by studying relevant materials and participating in teacher-student and group discussions in class.

2. Help students learn by doing, encourage them to discuss, and foster an environment of learning and growth. The chapter "Safety of Genetically Modified Foods" is a typical case, and teachers can ask students in class, "Are genetically modified foods safe?". What do you think about genetically modified food? Would you purchase genetically modified food? Students can be organised into groups to learn about the above problems together and share their thoughts and ideas in a group discussion. Such discussions help the students consider the safety assessment of Genetically Modified Foods. Teachers can help students learn about moral and social problems in their daily lives at home or in school. The above subjects will attract students' interest and help them learn to think critically about the ethical and social problems in biotechnology and biosafety. Students can use their own learning and work in groups to review the professional knowledge they have been taught, understand the deep ideas and reasons behind this knowledge, and apply it in all kinds of practical situations. This can help develop their ability to think critically and solve problems in the future of their studies and life.

3.3 Application of Case Teaching Methods

Case teaching is a way of teaching that takes real-life cases as its foundation to help students gain a deeper understanding of knowledge and develop problem-solving skills through analysis, discussion and reflection. Application of case teaching can be shown in the following ways in the biosafety course:

1. Case selection: Select real-life cases related to biosafety, such as infectious disease outbreaks, biological invasions, laboratory biosafety accidents and genetically modified organism controversies, as the starting point for teaching. For example, the biological invasion of European rabbits in Australia is a typical case studied in this course. In the teaching process, first have the students watch video materials of this case, and then ask the teacher to pose questions for the students to answer: Why did the European rabbits successfully invade Australia? What harm have European rabbits done in Australia after their arrival? What measures has the Australian government taken to control and eliminate invasive species, reduce the number of rabbits? Based on the above questions, students will learn the general contents of biological invasion and be able to solve some problems in real life based on what they have learned.

2. Situation simulation: Simulate actual biosafety incidents and have students take on the role of decision-makers to face all sorts of problems and choices in the cases to improve their

situational analysis skills. As one of the witnesses to the bioterrorism, what safety measures will be taken to ensure our own safety? Through thinking, students will learn how to take the correct response measures in case of different biological weapon attacks during a bioterrorism incident. This will help to motivate students more and improve their sense of problem-solving.

3. Role-playing: Allow students to take on various roles in the cases, such as policymakers, researchers, and members of the public, to learn about the positions and demands of all sides through role-playing. For example, in the case of the safety of genetically modified food, students are divided into groups to take on different roles such as policymakers and managers of genetically modified food safety, researchers of genetically modified foods, operators of genetically modified foods, and ordinary consumers. Have students think about the positions and needs of all kinds of roles from their own perspectives, then reasonably assess the safety of genetically modified food. Through such thinking, students can learn to think rationally about the strengths and weaknesses of a particular case from various aspects and develop good rational and critical thinking skills.

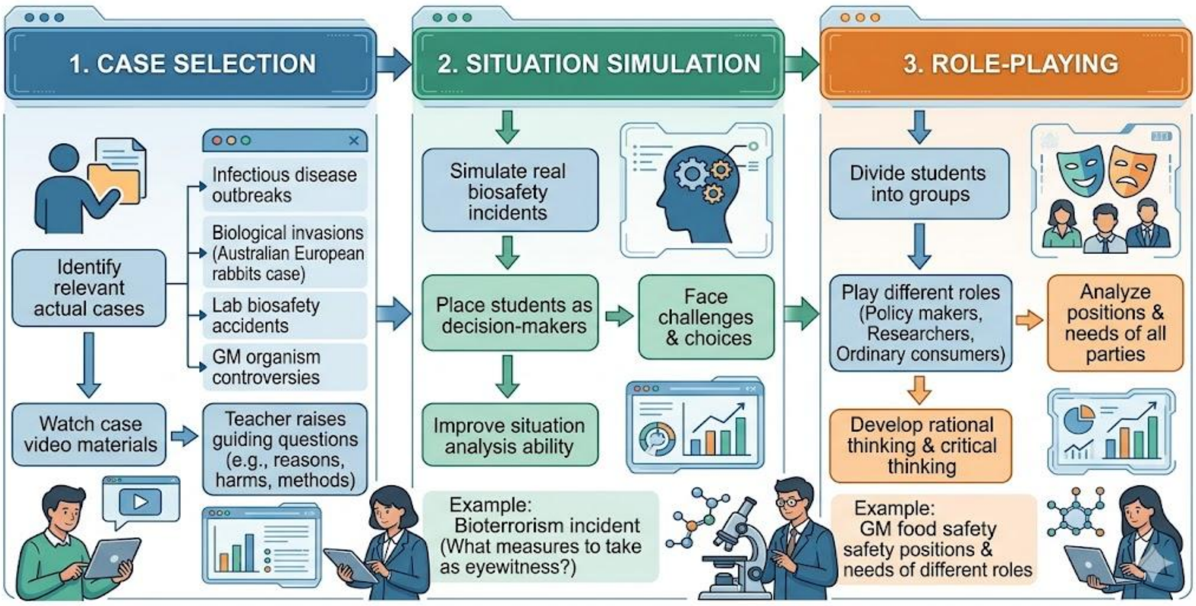

Figure 6: Implementation Path of the Case Teaching Method in Biosafety.

4 Conclusion

Biosafety is now one of the key fields in modern higher education, and as such, an integrated course that needs to combine theoretical foundations with actual experience is rapidly developing. In terms of the general idea of national security, good biosafety education should be carried out in a full-coverage manner to cultivate a new generation of high-quality, ethically responsible and technologically advanced workers. Given the strategic background of "New Engineering Education", it is necessary to cultivate versatile, high-quality engineering talents who can adapt flexibly to the changes in socio-economic development and technological innovation and meet the urgent demands of the nation in terms of defence and other areas.

In light of the country's top-level national security strategy and the legal provisions of the new "Biosafety Law", this paper has identified problems in the current system for training biosafety talents across China, including outdated teaching materials, rigid traditional teaching models, and a significant gap between theoretical knowledge and practical risk control skills. In light of this, the teaching team has proactively drawn lessons from empirical data collected over the past few years in the field of frontline biosafety education and proposed a clear plan for educational reform.

Through the above exploration, we have successfully built an all-around closed-loop teaching reform model based on the philosophy of Outcome-Based Education (OBE) and powered by modern digital network platforms. By combining various online resources strategically, deeply integrating heuristic and case-based teaching methods (such as role-playing and situation simulation), and comprehensively reforming the indicators of formative assessment, we have successfully built a high-interaction, student-centered ecosystem in the classroom. This new mode will help students learn better and think more critically, and it will also help them achieve the high standards set by the graduation requirements for engineering professionals.

In the future, the development of biosafety teaching reform will continue to be progressive rather than reached for. As global biotechnology, including synthetic biology, gene editing and artificial intelligence in life sciences, continues to develop at an ever-increasing speed, it presents both significant benefits for society and new existential risks; thus, the continuous improvement mechanism introduced in this course will be necessary. We hope that the theoretical reflection and practical exploration in this paper will serve as a starting point for peer institutions, providing them with some reference for the construction of training systems, the promotion of teaching practices, and in-depth research on curriculum reform. In the end, continuous pedagogical innovation in this field will provide a stable supply of top-tier professionals who can proactively protect the ecological balance and public health of the country in the face of changing conditions around the world.

About the Author

Yang Lu was born in Chibi City, Hubei Province in 1981. He graduated from Wuhan University with a doctor's degree. His main research directions include biological engineering.

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