Reform and Practice of Digital Platform-assisted Teaching in Molecular Biology under the Background of Engineering Education Accreditation

Li HAO, Aidong QIU, Xiaohong HU, Yan WAN, Min LI, Yanxia SUN*

College of Food and Biological Engineering, Chengdu University, Chengdu 610106, China

Abstract Under the background of the continuous deepening of engineering education accreditation and the construction of emerging engineering disciplines, a digital platform-assisted teaching model was explored for the teaching reform of the molecular biology course to effectively support the achievement of graduation requirements for bioengineering major and enhance the teaching outcomes of the molecular biology course. The teaching reform of this course took the 2022 cohort students majoring in bioengineering in Chengdu University as the practice object. The course evaluation method was improved by integrating digital platforms for process assessment, and real-world research and practical cases were incorporated into digital platforms to enrich teaching resources. Additionally, digital platforms were integrated throughout the entire teaching process (before, during, and after class), reshaping the instructional workflow into "pre-class online self-learning, in-class teacher-student interaction for deepening knowledge internalization, and practical case studies during and after class for strengthening application". The teaching reform results demonstrated that this teaching model significantly improved the attainment of course objectives, providing valuable experience for similar institutions to advance digital course reforms under the framework of engineering education accreditation.

Key words Engineering education accreditation; Digital platform; Molecular biology; Bioengineering; Teaching reform

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Engineering education accreditation adheres to three fundamental principles: "student-centered, outcome-oriented, and continuous improvement", and its core lies in ensuring that graduates have engineering practice and innovation ability recognized by the industry[1]. This outcome-based education (OBE) approach is a student-centered educational model with students' learning achievement as the core, emphasizing student-centered and demand-oriented design. It guarantees alignment between educational objectives and actual outcomes through backward curriculum planning, teaching activities, and evaluation mechanisms[2-3].

Molecular biology is a core course for junior students majoring in bioengineering in Chengdu University, with prerequisites including general biology, biochemistry, microbiology, and genetics. Its teaching system follows the "Central Dogma" as its framework, systematically covering the functions of biological macromolecules, the transfer mechanisms of genetic information, and application of molecular biology techniques. Its content is highly abstract, rapidly evolving, and involves complex regulatory mechanisms with abstract conceptions and conclusions requiring strong logical reasoning. Students often exhibit significant apprehension toward this course, resulting in suboptimal learning outcomes.

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Li HAO (1991 –), female, P. R. China, lecturer, PhD, devoted to research about molecular breeding and germplasm innovation of medicinal plants.

* Corresponding author.

Problems in the Teaching Process of Molecular Biology Course

In recent years, Chengdu University's bioengineering major has initiated accreditation under China Engineering Education Accreditation. When analyzing the outcome-based course objective attainment over the past three years, it was found that the achievement level of the course objectives was relatively low. While the teaching goals and corresponding graduation requirements were basically met, this only reflected students' fundamental grasp of the theoretical foundations and research methods of molecular biology. There remains a lack of integration and internalization of theoretical knowledge points, insufficient connection between theory and practice, and room for improvement in students' engineering practical ability and comprehensive competency. In summary, the current teaching model has exposed the following issues inherent in traditional instructional approaches:

① Abstract and difficult content: Cellular molecular mechanisms (*e.g.*, gene expression regulation, signal transduction) are challenging to visualize, making comprehension difficult for students.

② Insufficient problem-solving skills: Students lack tracking and thinking about current real-world issues and fail to connect these issues with course content, making them unable to turn knowledge into practical problem-solving ability.

③ Untimely formative assessment system: Feedback from routine process evaluation is delayed, preventing instructors from promptly assessing students' progress and learning outcomes.

Teaching Reform Measures for Molecular Biology Course

To address the existing problems in traditional molecular biology teaching, we explored the reform of digital platform-assisted molecular biology teaching for the 2022 cohort students majoring in bioengineering in Chengdu University according to the curriculum objectives under the background of engineering education accreditation. This exploration aimed to enhance teaching effectiveness and better support the achievement of graduation requirements.

Improving course evaluation methods and applying digital platforms to process assessment

In accordance with the course objectives set under the framework of engineering education accreditation, the evaluation methods were revised. The process assessment components (assignments and topic-based question and answer) in the 2021 syllabus were replaced with diversified approaches including group projects, discussions, assignments, regular quizzes, and classroom performance. The proportion of process assessment in the overall grade was increased to 60%, while the final exam as a summative assessment now accounted for only 40% of the total grade. The process assessment scores were primarily implemented through digital platforms, which digitally displayed students' participation in group projects, discussion performance, assignments, regular quizzes, and classroom performance in a timely manner. This allowed students to promptly understand their learning progress, compare their performance with peers, and foster a competitive yet collaborative learning atmosphere. Consequently, it enhanced students' participation, boosted their learning motivation, and improved their problem-solving and critical-thinking ability during group projects or discussions. This approach promotes the development of students' comprehensive skills and proactive learning attitudes, avoiding the sole reliance on final exams to evaluate learning outcomes, which is inadequate for comprehensively assessing students' analysis of complex engineering problems and their mastery, understanding, and application of professional knowledge.

Enriching course teaching resources by incorporating real research and practical cases through digital platforms

In classroom teaching, instructors not only explained the fundamental principles and key concepts of molecular biology but also introduced multiple real-world research and practical cases through digital platforms during lectures or assignments. This approach not only enriches teaching resources but also broadens students' knowledge scope, allowing them to directly appreciate the application value of molecular biology theories in biotechnology industry demands. It enhanced students' sense of achievement in learning and helped them experience the close connection between acquired knowledge and cutting-edge developments in their field. Additionally, guided by the OBE concept, digital platforms were employed after class to assign homework or project discussions. This encouraged students to integrate course content with industry demands and design appropriate practical solutions, thereby cultivating their independent innovation ability and problem-solving skills. For example, focusing on hot topics like gene editing and omics technologies, we connected them with real research scenarios such as precision medicine applications. After studying textbook techniques like PCR, gene chips, and DNA sequencing, digital platforms were employed to assign post-class assignments or project discussions that guided students to explore their applications in disease diagnosis.

Integrating digital platforms throughout the entire teaching process covering pre-class, in-class and post-class activities

Traditional molecular biology teaching primarily relies on offline lectures, on-the-spot questioning, and assigning of post-class homework to conduct process assessment of students. This approach limits teacher-student interaction, delays feedback on students' learning outcomes, and results in untimely responses from instructors. Consequently, it is not conducive for teachers to understand and monitor each student's learning progress and adjust teaching strategies promptly. Digital platforms such as Chaoxing Learning was seamlessly integrated throughout the entire teaching process covering pre-class, in-class, and post-class activities. Course materials and multimedia resources such as learning videos were published on the platform. Before class, students were assigned previewing tasks to gain a preliminary understanding of the course content. Engaging short videos or micro-lectures not only help students comprehend the dull and abstract concepts of molecular biology but also stimulate their interest in learning. Additionally, pre-class discussion sessions could be set up to further enhance students' engagement and facilitate better mastery of the course material. Meanwhile, they promoted interaction between teachers and students as well as among students, thereby enhancing teaching effectiveness. During class, digital platforms could be used for activities such as attendance checks, preemptive answer, and regular quizzes. This allowed instructors to quickly monitor whether students attend class on time and assess their grasp of key concepts, enabling timely resolution of learning difficulties. After class, teachers could assign and collect homework through the digital platform, allowing timely statistics on students' regular performance. This enabled instructors to quickly identify the highest and lowest scores, pinpoint frequently missed questions, and gain a clear understanding of students' current learning progress.

Implementation Results and Data Analysis

Based on the OBE (Outcome-Based Education) concept, the bioengineering major in Chengdu University aims to cultivate high-quality applied bioengineering talents who meet engineering certification standards. Therefore, the teaching objectives of this course align with societal expectations for bioengineering graduates. The correspondence between course objectives and graduation requirements is as follows:

Table 1 Correspondence between curriculum objectives and graduation requirement indicator points

No.	Graduation requirements	Graduation requirement indicator points	Curriculum objectives	Weight
1	2. Problem analysis	2.3 Be able to conduct literature searching and organize, analyze and synthesize information using literature and internet resources, explore multiple solutions to complex engineering problems in bioengineering, make informed selections, and justify the rationality of the chosen solutions using fundamental principles.	1	0.60
2	5. Use of modern tools	5.2 For complex engineering problems in biotechnology and bioengineering, be able to correctly select appropriate instruments, information resources, engineering tools, and specialized software to analyze, calculate, and design solutions.	2	0.40

To evaluate the effectiveness of this teaching reform, we conducted a comparative analysis of the course objective achievement evaluation reports for molecular biology between the pre-reform cohort (78 students matriculated in 2021) and the post-reform cohort (98 students matriculated in 2022) in the bioengineering major in Chengdu University. The achievement value of course objectives was calculated based on the average assessment scores of various assessment items for all evaluated students. The calculation method is as follows: the sum of the product of the average score of each assessment item under a course objective and its corresponding weight coefficient, divided by the sum of the product of the full score of each assessment item and its corresponding weight coefficient. The attainment levels of the course objectives are as follows:

Table 2 Comparison of achievement degree of curriculum objectives

Curriculum objective	Achievement degree of the 2021 cohort students	Achievement degree of the 2022 cohort students	Increasing rate//%
Curriculum objective 1	0.63	0.73	+15.9
Curriculum objective 2	0.63	0.69	+9.5
Overall objective	0.63	0.71	+11.3

Analysis of the course objective attainment revealed that the overall achievement rate for the students matriculated in 2022 was 0.71, indicating that the teaching objectives and corresponding graduation requirements were met. Compared with the students matriculated in 2021, the overall attainment rate increased by 11.3% after the teaching reform. Course objective 1 for the students matriculated in 2022: The attainment level was 0.73 (target achieved), showing a 15.9% improvement compared with the students matriculated in 2021. This objective corresponded to Graduation Requirement 2.3, demonstrating studentsD ability to conduct literature searching and organize, analyze and synthesize information using literature and internet resources, explore multiple solutions to complex engineering problems in bioengineering, make informed selections, and justify the rationality of the chosen solutions using fundamental principles. Course objective 2 for the students matriculated in 2022: The attainment level was 0.69 (target achieved), representing a 9.5% improvement compared with the students matriculated in 2021. This objective aligned with Graduation Requirement 5.2, indicating that students could correctly select appropriate instruments, information resources, engineering tools, and specialized software to analyze, calculate, and design solutions for complex engineering problems in biotechnology and bioengineering. The results demonstrated that the teaching reform, supported by digital platforms, has effectively enhanced students' problem analysis skills and ability to utilize modern tools. Significant improvements were observed in addressing complex engineering challenges in bioengineering, as well as in analyzing, calculating, and designing solutions for such problems. The overall curriculum objective attainment showed marked improvement, strongly supporting the fulfillment of professional accreditation requirements.

Conclusions

Guided by engineering education accreditation, this curriculum reform successfully implemented digital platform-assisted teaching in molecular biology for the 2022 cohort students majoring in bioengineering in Chengdu University. Through the establishment of a comprehensive digital support system integrating resources, interaction, practice, evaluation and feedback, we implemented a digital platform-assisted assessment approach throughout the entire teaching process (before, during, and after class). It achieved pre-class independent online learning, in-class teacher-student interaction for promoting knowledge internalization, and practical case studies during and after class for strengthening application. The evaluation of this teaching reform's impact on curriculum objective attainment, based on the OBE concept, revealed its effectiveness in overcoming the limitations of traditional teaching methods. The reform significantly enhanced students' knowledge application ability, engineering problem analysis and solving skills, as well as self-directed learning ability. These improvements ensure that graduates possess industry-recognized engineering practice and innovation ability.

In the future, we will continue leveraging functions of digital platforms (such as introducing AI teaching assistants to help answer questions and exploring personalized path recommendation

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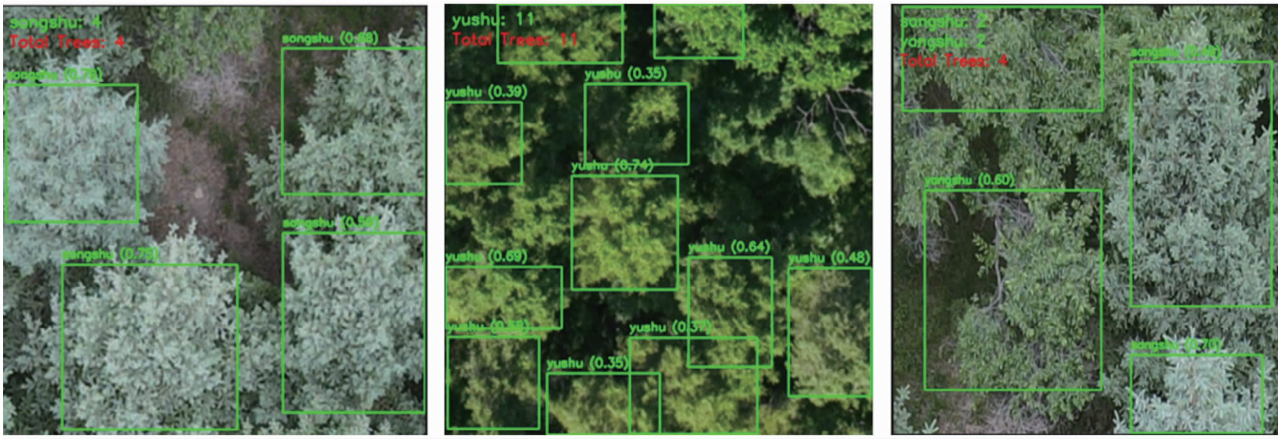

Fig. 6 Recognition performance of the YOLOv8n-CMEA-DPSA model

Conclusions and Discussion

In this study, the issue of low accuracy in tree species identification and counting in UAV optical images under complex backgrounds was addressed by proposing an improved model based on YOLOv8, incorporating two attention modules, CMEA and DPSA. The experimental results demonstrated that the improved YOLOv8n-CMEA-DPSA model significantly outperformed the original model in terms of accuracy, average precision, and recall, and the average precision increased to 92.1%, fully validating the practical application potential of the proposed method in forest resource monitoring. This study provides technical support for digital forest management and explores new approaches for applying deep learning to high-resolution remote sensing images.

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based on learning big data)[4-5]. We will deepen industry-academia collaboration to develop more cutting-edge virtual simulation and case resources[6], so as to establish a new digital teaching ecosystem. These efforts will sustainably enhance the cultivation of high-quality applied bioengineering talents meeting engineering certification standards to provide solid talent support for the development of Southwest China's bioindustry.

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