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Exploration and Practical Research on Microbiology Blended Teaching Mode based on THEOL Platform

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Abstract:

Microbiology stands as a pivotal foundational course within the vast domain of life sciences. Characterized by its deep theoretical underpinnings, microscopic abstractions, and inherent learning complexities, the subject often poses challenges to students. The exponential growth of information network technology and cloud computing, however, has ushered in new avenues for revolutionizing university course curricula. This advancement serves as a robust backbone for exploring and reforming blended teaching modalities that integrate online and offline learning experiences in microbiology. Our teaching plan design is anchored in the overarching educational principles of fostering morality, nurturing talents, and prioritizing student-centered development. Using Chapter 1, "Gram staining of bacteria," as a case study, this paper delves into the teaching design, practical implementation, and assessment rubrics associated with employing the THEOL platform to facilitate a blended teaching approach in microbiology. By underscoring the imperative need for such reforms, we aim to bolster students' capacity for continuous learning and foster a heightened sense of innovative development. Ultimately, this paves the way for cultivating a new generation of versatile, innovative talents.

Keywords:

THEOL platform
Microbiology
Blended learning mode

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1. Basic characteristics of blended teaching mode and basic overview of microbiology

The blended teaching mode is a new teaching approach that organically combines traditional classrooms (such as lecture-based classrooms and PowerPoint-based classrooms) with online and offline blended learning and flipped classrooms. In this mode, the role of teachers shifts from being traditional and dominant to being guiding, while students transition from passive learning to active learning [1]. Teaching under this new model can cultivate students' abilities for independent learning and

team collaboration. Through interactive classrooms or virtual classrooms, functions such as online teaching, teacher-student interaction, online Q&A, and teaching management are carried out. This enables students to increase their independent learning time, improve learning efficiency, enrich and flexibly engage in learning activities, and enhance teaching effectiveness [2]. In 2018, Gansu Agricultural University introduced the THEOL (Tsinghua Education Online) network teaching platform, which is an intelligent and comprehensive network teaching platform that provides comprehensive functional support and services for online teaching. With teaching management, course construction, and learning analysis as its core, the platform has built three main modules. Adopting advanced design concepts, it can integrate essential aspects such as course construction management, teaching, display, interaction, and teaching evaluation into one optimized system. This makes it easy to operate and fully interactive while further embodying the flexibility, autonomy, and adaptability of online teaching. Simultaneously, the platform is assisted by the mobile "UMOOC App," which enables synchronous updates of teaching content, making the learning process more convenient. This breaks through the temporal and spatial limitations of the learning environment, facilitating independent learning, online Q&A, and real-time interaction. In summary, the THEOL platform, with its prominent personalization, interactivity, and convenience, provides a reliable and efficient online teaching method for teachers and students, making it more suitable for exploring and reforming the blended online and offline teaching mode in microbiology courses [3].

Microbiology is a major basic course for students majoring in agronomy, grassland science, biotechnology, biological science, bioengineering, and other related fields in higher agricultural and forestry universities. It serves as the foundation for students to understand the basic laws of life activities at the microscopic level and acts as a link between basic courses and specialized core courses. The course is theoretically intense, with many difficult-to-understand concepts and abstract micro-level content. The theoretical teaching time is relatively limited, and the classroom teaching information is vast, making it challenging for students to grasp key learning points and affecting classroom teaching effectiveness. Additionally, microbiology has a strong practical aspect, requiring close integration of theoretical teaching, experimental skills, and scientific research training. Therefore, there is an urgent need to explore and reform the microbiology curriculum to address how to shift from passive learning to active learning, enhance students' interest in learning, expand their thinking and strengthen their hands-on abilities while acquiring basic knowledge, and cultivate their innovative consciousness and skills based on scientific literacy. With the current vigorous promotion of "golden course" construction, utilizing rich online teaching resources and the efficient THEOL platform, combined with the advantages of traditional offline teaching, presents a good opportunity for microbiology curriculum reform and an innovative approach to teaching mode exploration.

2. The necessity of implementing blended teaching mode in microbiology

2.1. Course content covers a wide range and requires careful selection

Currently, microbiology courses in higher education institutions typically encompass a broad range of content. In the microbiology course for biotechnology students at Gansu Agricultural University, the primary textbook used is *Microbiology Course (3rd Edition)* edited by Deqing Zhou. This textbook includes 13 chapters (including an introduction and conclusion) and 44 sections, covering topics such as the morphological structure and function of microorganisms, nutrition and metabolism, growth and reproduction, genetic breeding, microbial ecology, infection and immunity, and classification and identification. The vast span of time and space covered, as well as the inclusion of relevant knowledge from different disciplines, not only increases the difficulty for students but also poses higher demands and challenges for teachers' classroom instruction. The contradiction between limited class hours and the wide range of course content is prominent. Therefore, the selection, design, and arrangement of classroom teaching content have become urgent issues to be addressed in the teaching process of microbiology courses, and they are also the direction for improving the teaching level of microbiology courses. The online and offline blended teaching based on the

THEOL platform can reasonably solve this problem. The main content can be focused on through online self-study and offline Q&A sessions, while other background knowledge can be introduced through online resources (short videos, micro-lessons, animations, etc.), which can increase students' interest in learning and compensate for the reduction in teaching quality caused by the lack of background knowledge [4].

2.2. Teaching content and class hours need to be urgently addressed

In the current context of gradually increasing practical hours and compressing theoretical hours, there is a widespread issue of an imbalance between theoretical class hours and teaching content in microbiology. In the traditional lecture-based learning process, students often struggle with taking notes, have limited time for understanding, and possess relatively poor comprehensive analysis and problem-solving skills. How to efficiently transmit knowledge within a limited time and improve the level of mastery and understanding is an urgent issue to be addressed in current teaching. By adopting a blended teaching mode, students can independently learn and master basic knowledge online, while focusing on answering difficult questions offline. Simultaneously, classroom discussions and real-time interactions can be utilized to promote the achievement of course knowledge and ability objectives.

2.3. The balance between group and individual attention cannot be achieved, and real-time learning progress needs to be monitored

For modern college students who value both individuality and collective identity, traditional classroom teaching may face new challenges. For instance, when the classroom is geared towards all students, the individual attention given to each student may decrease, resulting in an incomplete understanding of their learning situation, unreasonable teaching process regulation, and greater difficulties in personalized training and teaching according to their aptness [5]. The THEOL online teaching platform allows real-time monitoring of each student's learning progress and course participation. It also enables timely reminders for students to enhance their learning through online topic discussions and interactive Q&A sessions. Additionally, it can be complemented by personal guidance via QQ, WeChat, and other means, facilitating personalized training and teaching tailored to students' needs.

2.4. Course assessment is not targeted and cannot fully and accurately reflect the actual situation

In traditional teaching, course assessment mainly consists of four parts: usual performance, midterm grades, experimental grades, and final grades. Usual performance is typically measured by indicators such as classroom questioning, note-taking, and homework. However, the evaluation criteria are relatively singular, lacking procedural indicators or specific targeting. The assessment of students' actual learning abilities and comprehensive application abilities is generally not involved, and the representativeness of the assessment results is poor.

To address the above issues, the microbiology teaching team in the Biotechnology Department at Gansu Agricultural University has adopted an online and offline blended teaching mode based on the THEOL online teaching platform. This reform and practical innovation in microbiology course teaching provide ideas for related course teaching reforms and the cultivation of innovative compound talents under the new situation.

3. Design of blended teaching plan for microbiology

The online and offline hybrid teaching plan for microbiology is rooted in the overall educational requirement of "cultivating morality and fostering talents" and adheres to the educational philosophy of "student development as the center." In the teaching of basic subject courses, moral education is integrated to help students establish a correct worldview, values, and outlook on life, enhance their ideological and moral cultivation, strengthen their determination and ability to solve practical problems, improve their continuous learning ability and awareness of innovative development, and cultivate innovative and compound talents [6].

The microbiology course content is divided into modules (**Table 1**), and blended teaching practices are carried out based on the THEOL platform. In the process of conducting online teaching represented by

MOOCs, resource-sharing courses, micro-lessons, and live teaching, as well as offline classroom teaching with problem-solving and highlighting key points as the core, students are always considered the main subject of teaching. Through multiple teaching links such as learning achievement display, case analysis, group discussion, knowledge expansion, and independent project design, a progressive approach is adopted, focusing on shaping students' values and scientific literacy, and cultivating their innovative awareness and abilities during the teaching process.

4. Implementation of teaching in a blended learning model

Taking Gansu Agricultural University as an example, the first round of blended learning reform in microbiology was implemented with second-year biotechnology students as the main participants. After repeated discussions among the teaching team, "Gram staining of bacteria" was selected as an illustrative case to detail the implementation process of blended learning. The blended teaching based on the THEOL platform is divided into three major teaching modules, including the design of independent learning task sheets by teachers, online independent learning and Q&A sessions for students, flipped classrooms, group discussions, and other offline teaching activities. Teacher guidance is closely connected with student exploration, achievement showcase, and multi-level evaluation, forming a seamless process.

4.1. Design of independent learning task sheets

Independent learning task sheets are designed by teachers to guide and help students clarify the content, objectives, and methods of independent learning. Through multiple discussions, teachers in the teaching and research section finally selected the "Gram staining of bacteria" chapter as the teaching content. Firstly, the Gram staining section includes basic knowledge such as the structure, main components, three-dimensional structure, and staining

Table 1. Distribution of class hours and knowledge modules for microbiology-related chapters

Knowledge modules	Chapters and contents	Class hour arrangements
Initial Understanding of Microorganisms: They Are Everywhere, Always Cognition of Microorganisms: Three Major Groups and Eleven Branches, Tracing Back to Their Roots and Ancestors	Introduction: Microorganisms and Humans	2
	Chapter 1: Morphology, Structure, and Function of Prokaryotic Microorganisms	4
	Chapter 2: Morphology, Structure, and Function of Eukaryotic Microorganisms	3
Growth of Microorganisms: Absorbing Nutrition, Metabolism, Controlling Growth, Genetic Variation, Serving Our Purposes	Chapter 3: Viruses and Subviral Factors	3
	Chapter 10: Classification and Identification of Microorganisms	2
	Chapter 4: Nutrition and Culture Media of Microorganisms	4
	Chapter 5: Microbial Metabolism	5
	Chapter 6: Growth and Control of Microorganisms	5
	Chapter 7: Genetic Variation and Breeding of Microorganisms	6
	Chapter 8: Microbial Ecology	2
Hazards of Microorganisms: Distinguishing Friend from Foe, Maintaining Health	Chapter 9: Infection and Immunity	3
Prospects for Microbiology, a Promising Future	Conclusion: Prospects for Microbiology	1
Total class hours		40

mechanism of bacterial cell walls, as well as the invention process and experimental operation steps of Gram staining. This can introduce the course content through the exploratory spirit of the inventor of Gram staining, sparking students' interest in learning. Secondly, as a typical representative of differential staining in bacterial staining methods, Gram staining plays an important role and significance in bacterial research. At the same time, as a basic experiment, it has strong practicality and can fully mobilize students' interest and initiative. Thirdly, this section is located in the first chapter of the microbiology course and is an essential representative that integrates basic theoretical knowledge and experimental operation skills. By introducing stories of scientific research figures, such as Dr. Feifan Tang, who is known as the "father of chlamydia," and his patriotic spirit in solving the mystery of trachoma and contributing to medical education, students' interest in learning can be stimulated. This allows students to learn basic theories driven by interest, which helps improve teaching effectiveness. Finally, combining experimental operations enables students to deepen their understanding and enhance their memory of theoretical knowledge. Arranging course content in the above order can help identify key points and difficulties more clearly, and sort out targeted content based on the teaching syllabus.

4.2. Online teaching

Teachers assign learning tasks one week ahead of time, requiring students to complete the following tasks in groups within a week: (1) Logging in to the THEOL online learning platform of Gansu Agricultural University according to the learning objectives in the independent learning task sheet, and complete the learning of character stories, courseware, videos, and other materials related to Gram staining. (2) Analyzing the cell wall component structure and participating in group discussions on the topic of "Gram staining mechanism" assigned by the teacher. (3) Summarizing the differences in cell wall components between Gram-positive and Gram-negative bacteria, and familiarizing themselves with the mechanism of Gram staining. (4) Consolidating theoretical knowledge, developing practical skills, and cultivating teamwork spirit through the Gram staining experimental operations assigned by the teacher. This module adopts process evaluation: students' online basic theory test scores and interaction counts (number of posts + replies) on Gram staining are included in their online grades, which are then converted and counted into the final grade for this course. Through online independent learning, students can master the basic knowledge and theories of Gram staining, and their abilities to learn independently, analyze and solve problems, and work in teams can be enhanced.

4.3. Offline teaching

Offline teaching for this course utilizes interactive classrooms designed for blended course instruction on campus, enabling network interaction during offline teaching. Students participate in five learning sessions in groups: presenting group learning achievements through PowerPoint presentations, taking basic theoretical knowledge tests, analyzing and discussing questions and answers, expanding knowledge, and completing homework (project design).

4.3.1. Group learning achievement presentation

Students present their independent learning outcomes on the topic of "Gram staining of bacteria" in PowerPoint format in groups. After the presentation, group leaders and teachers score simultaneously using the evaluation criteria and point values shown in **Table 2**. Scores are tallied, and finally, group ratings are determined and counted as part of their regular grades. Through the achievement presentation, students can master the basic theoretical knowledge of Gram staining of bacteria. At the same time, their abilities to analyze and solve problems, as well as their communication and expression skills, are improved.

4.3.2. Basic theoretical knowledge test

This section includes 10 basic theoretical knowledge questions. Students compete in groups to answer the questions. One point is awarded for each correct answer, and no points are deducted for incorrect answers. The scores are tallied for each group. Through this test, students deepen their understanding of the learned knowledge and develop their quick response abilities.

Table 2. Microbiology group learning achievement scores for biotechnology majors

Evaluation index proportion (%)	Evaluation criteria				
	Excellent	**Good**	**Medium**	**Qualified**	**Unqualified**
Structural design (10) Learning content (10) PPT production (20) Presentation (20) Questioning (10) Comprehensive ability (20) Knowledge expansion (10)	Structural integrity, Logical reasonableness, Clear distinction between primary and secondary elements, Highlighting key points, Emphasizing difficulties, Simplicity and clarity, Aesthetic and elegant appearance, Familiarity with content, Clear expression, Smooth reporting, Conciseness and precision, Clear thinking, Neat and tidy appearance, Adequate adaptability, Smooth communication, Reasonable expansion based on learning content.	The structure is relatively complete, the logic is reasonably sound, the primary and secondary points are relatively distinct, the key points are appropriately highlighted, the difficulties are emphasized, the presentation is concise and clear, and aesthetically pleasing. The content is familiar to a certain extent, the expression is relatively clear, the reporting is smooth, the thinking is relatively coherent, and the answers are fluent. The appearance is neatly presented, the adaptability is good, the communication is relatively smooth, and the expansion is basically reasonable.	The structure is basically complete and the logic is reasonable. The primary and secondary points are relatively distinct, with emphasis on key and difficult points. The presentation is generally concise, clear, and aesthetically pleasing. The content is mostly familiar, the expression is generally clear, and the reporting is relatively smooth with a clear line of thought. The answers are generally fluent, and the appearance is mostly neat. The adaptability and communication are basically smooth, with some expansion.	Basically meets the requirements, The primary and secondary points are generally distinct, Able to reflect the requirements of key and difficult points, Basically able to state clearly and meet the requirements, Basically able to answer questions, appearance is generally neat, Poor adaptability and communication, with limited expansion.	Incomplete structure, unreasonable logic, no distinction between primary and secondary points, key and difficult points are not prominent, poor PPT effectiveness, chaotic organization, poor expression, unclear thinking, poor dress and appearance, inadequate adaptability, smooth communication, and no expansion.

4.3.3. Question answering and analysis discussion

Each study group organizes and presents their questions and confusions encountered during the learning process. Through collective analysis and discussion, teachers do not provide detailed answers to questions where a consensus is reached. Instead, they focus on explaining common issues and summarize the content at the end. This section has a process evaluation worth up to 10 points. Teachers score based on the questions raised by students and the quality of their discussion and analysis, adding the points to the group's total score. This activity not only deepens students' understanding of the knowledge but also enhances their communication skills, problem-solving abilities, and analytical thinking.

4.3.4. Knowledge expansion

The teacher sets a discussion topic on "Bacterial Staining Methods." By providing an outline and guiding students to review relevant literature on bacterial staining methods, the teacher leads students to explore and understand the significance of staining methods in microbiology research and their crucial role in traditional microbial classification and identification. Additionally, through heuristic guidance, students recognize the continued importance of staining methods in the future development of microbiology. The teacher directs students to explore cutting-edge content and unresolved research areas, further stimulating forward-thinking, cultivating scientific literacy and innovation awareness, and inspiring students to track frontier knowledge and research progress for deeper exploration and innovation. This section is evaluated through process-based assessment, focusing on students' independent literature review, thematic discussion, and heuristic guidance, with teacher guidance as a supplement. This approach aims to further enhance students' forward-thinking mindset, scientific literacy, innovative abilities, and critical thinking.

4.3.5. After-class assignment (project design)

Following the practical hands-on learning of "Gram staining of bacteria," students are guided to independently design experiments related to the identification of unknown bacteria using staining methods. They submit their experimental design proposals and feasibility reports. Teachers evaluate and score the practicality of each group's experimental design and feasibility report, incorporating these scores into their regular grades. By reviewing the literature, students further expand their knowledge base, stay updated with disciplinary frontiers, and enhance their autonomous learning, exploration, and innovation abilities. Experimental design helps students gradually develop scientific thinking, fosters a scientific spirit, and lays a foundation for future research work in related fields.

5. Evaluation of teaching in a blended learning model

5.1. Innovating assessment and evaluation models, highlighting process evaluation

Before the reform of the blended learning model in microbiology, the course assessment consisted of regular grades (10%), midterm grades (10%), and final grades (80%). However, after the reform, the course assessment now includes process evaluation (50%), midterm grades (10%), experimental grades (10%), and final grades (30%). The process evaluation grade comprises various components and their proportions: attendance and online pre-class preparation (5%); classroom questioning (5%); course notes (5%); classroom discussion (group discussion) (5%); homework (5%); course papers (short papers, reviews, etc.) (5%); online interaction (online questions, answers, discussion forums, etc.) (5%); online tests (5%); online duration (5%); and surveys (5%). Through comparison, it has been found that the reformed comprehensive evaluation system more accurately and reasonably reflects students' learning effectiveness, with a higher proportion of process evaluation.

5.2. Introducing student satisfaction evaluation to improve the evaluation system

After completing the course teaching, a survey questionnaire for evaluating the effectiveness of online and offline blended teaching is designed through the survey module provided by the THEOL platform. The survey aims to conduct a comprehensive evaluation of teaching design, teaching methods, and teaching effectiveness. The results of the survey are promptly summarized and organized to facilitate teachers'

identification of gaps and improvements, further enhancing the course design and implementation system, and effectively improving the teaching quality of blended classrooms.

5.3. Expanding the evaluation system and exploring diversified evaluation

By introducing diversified methods such as excellent teacher evaluation, supervisory evaluation, and third-party evaluation, the evaluation system is further enriched. With the help of teaching basic data collected by the THEOL platform, the blended teaching model of microbiology is diagnosed, urging teachers to update knowledge content, enrich teaching resources, and improve teaching effectiveness.

6. Conclusion

In the context of "golden courses," applying advanced information and network technology to actively develop "Internet + Education" is a specific requirement proposed by the Ministry of Education's "Opinions on Deepening the Reform of Undergraduate Education and Teaching to Comprehensively Improve the Quality of Talent Training." Microbiology courses are extremely important for the study and practice of life science majors. Under the new situation, how college students can use network information technology to improve teaching effectiveness and achieve diversified teaching requirements such as shaping students' values, cultivating scientific literacy, innovation awareness, and innovation abilities during the teaching process is an important issue that needs to be actively explored and urgently addressed. Therefore, it is urgent to further promote the exploration of blended teaching reform in microbiology courses using the THEOL online teaching platform. Supported by online independent learning, offline teaching activities such as answering questions, topic discussions, and knowledge expansion can be more flexible and efficient. This not only allows for the rapid and efficient transmission of textbook knowledge but also helps students establish correct lives and values, guiding them to uphold the concept of lifelong learning and achieve the main teaching goal, which is to cultivate students' comprehensive abilities and qualities [7,8]. In the process of implementing blended classrooms, students are enthusiastic about acquiring knowledge and improving their abilities to increase their future prospects. Teachers are willing to collect online teaching resources to build courses, strengthen their professional qualities, and enhance their teaching abilities, making continuous efforts to comprehensively improve teaching quality and cultivate high-quality talents.

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