Exploration of Adaptive Learning Teaching Model for Academic Postgraduates in Forest Protection Based on Digital Technology-A Case Study of the Course "Forest Microbiology"

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Abstract: With the in-depth advancement of ecological civilization construction and the national strategy for sustainable forestry development, cultivating high-level forest protection talents with innovative literacy and cutting-edge vision has become a core task of higher agricultural and forestry education. Traditional postgraduate teaching models have obvious limitations in addressing challenges such as differentiated knowledge backgrounds of students, accelerated iteration of cutting-edge knowledge, and prominent personalized research needs. Taking "Forest Microbiology", a core course in forest protection discipline, as the research carrier, this paper constructs an adaptive learning teaching model based on digital technology, and builds a trinity core framework of "learner module—knowledge unit module—evaluation and feedback module". Through a three-stage teaching process of "preliminary diagnosis and planning—mid-term inquiry and adaptation—late-stage deepening and creation", the dynamic optimization and precise adaptation of learning paths are realized. This model effectively improves postgraduates' depth of knowledge mastery, enthusiasm for scientific research exploration and independent learning ability, providing an operable practical paradigm for solving the problem of teaching students in accordance with their aptitude for academic postgraduates and promoting the innovation of smart education under the background of new agricultural sciences.

Keywords: Digital Technology; Adaptive Learning; Forest Protection; Postgraduate Education; Teaching Model

With the in-depth implementation of the ecological civilization strategy, the cultivation and development of new quality productive forces in forestry urgently need the support of high-quality and high-level innovative agricultural and forestry talents. In July 2021, the Ministry of Education and five other departments jointly issued the "Guiding Opinions on Promoting the Construction of New Educational Infrastructure to Build a High-Quality Education Support System", clearly proposing the core goal of "promoting the digital transformation, intelligent upgrading and integrated innovation of education to support the high-quality development of education". In April 2022, the Department of Degree Management and Postgraduate Education issued the "Notice on Collecting Digital Resources for Postgraduate Education", further emphasizing the importance of systematically integrating high-quality postgraduate education resources. the "Opinions of the Ministry of Education and Eight Other Departments on Accelerating the Advancement of Educational Digitization" issued in 2025 clearly requires "promoting the intelligent upgrading of curriculum systems, textbook systems and teaching systems, integrating artificial intelligence technology into all elements and the whole process of education and teaching", and "constructing new teaching organizational forms to promote the reform of learning methods".

As the core component of the terrestrial ecosystem, forests play an irreplaceable role in safeguarding national ecological security, addressing global climate change, and ensuring the supply of wood and ecological products. Forest protection science is a core discipline for ensuring the health and stability of forest ecosystems. Academic postgraduates, as the main force of future scientific research and innovation in this field, their training quality is directly related to the progress of forestry science and technology and the development of ecological protection undertakings. As a compulsory professional course for master's students in forest protection, "Forest Microbiology" systematically reveals the

"microscopic driving mechanism" of forest ecosystems. Through this course, postgraduates can deeply understand the regulatory principles and application value of material circulation, energy flow and complex life networks among soil, roots and phyllosphere in forest ecosystems, which has distinct cutting-edge and interdisciplinary characteristics.

Traditional postgraduate teaching models face many practical difficulties in local agricultural and forestry universities, and have been unable to meet the training needs of high-quality innovative talents in forest protection. the rapid development of digital technologies such as knowledge graphs, natural language processing and machine learning has provided technical possibilities for building an "adaptive learning system" that can accurately perceive students' learning status and dynamically adjust teaching content and paths. Taking the course "Forest Microbiology" as a practical case, this paper explores the digital adaptive learning teaching model for academic postgraduates in forest protection in local agricultural and forestry universities, realizes the teaching paradigm transformation from "knowledge transmission" to "competence construction", and provides practical reference and case support for the improvement of the theoretical system of smart teaching under the background of new agricultural sciences.

1. Practical Difficulties in the Cultivation of Academic Postgraduates in Forest Protection in Local Agricultural and Forestry Universities

1.1 Insufficient Teaching Adaptability

Postgraduates have diverse undergraduate professional backgrounds, covering forestry, plant protection, microbiology, biotechnology, environmental science and other fields, and there are significant differences in their knowledge reserves in prerequisite courses such as microbiology, forest pathology and molecular ecology. At the same time, academic postgraduates take the completion of high-quality dissertations as their core goal, and their research directions and interests are different. Some students focus on the development of biological control agents for forest diseases, while others focus on microbial-driven forest soil carbon and nitrogen cycle research. Traditional teaching adopts a unified syllabus, content system and progress arrangement. the "one-size-fits-all" teaching model is difficult to balance the dual needs of "making up for weaknesses" and "promoting strengths", which easily leads to a situation where students with weak foundations cannot keep up and students with surplus learning ability are "not full", thus dampening students' learning enthusiasm.

1.2 Poor Connection Between Teaching Content and Industrial Development Needs

The course "Forest Microbiology" has a strong interdisciplinary nature, and related theories, research methods and technical means are updated and iterated rapidly. Traditional teaching content is mostly limited to the static knowledge system of outdated textbooks, with insufficient attention to the pain points and difficulties in forestry production practice and emerging growth points, and insufficient coverage of cutting-edge fields such as omics technology, bioinformatics and synthetic microbial communities. Teaching content often stays at the basic level such as "specific pathogens causing specific diseases" and "nitrogen fixation function of nitrogen-fixing bacteria", and less explains in-depth content such as microbial community structure and function, microbe-host interaction mechanism, and network role in ecosystem material circulation. At the application level, there is insufficient involvement in the innovative application of microbial technology in new quality productive forces-related fields such as precision forestation, ecological restoration, carbon sink enhancement and biomass conversion, which is difficult to support postgraduates in conceiving and implementing innovative research projects.

1.3 Inadequate Integration of Teaching Methods and Innovative Competence Cultivation

Current classroom teaching forms are mostly based on teachers lecturing course content or students reporting single papers, focusing on one-way knowledge transmission and standardized replication, which suppresses students' questioning spirit and exploration desire, forming a "passive acceptance" learning ecology. Students lack complete innovative practice experience of "hypothesis-verification-trial and error", and what they acquire are mostly fragmented knowledge modules rather than

systematic thinking frameworks, making it difficult to integrate interdisciplinary knowledge to address complex practical problems. Especially for students with different research directions, there is a lack of motivation and carrier to integrate knowledge from multiple fields such as microbiology, ecology, genetics, informatics and climate science, making it difficult to establish an interdisciplinary knowledge network and macro systematic thinking.

1.4 Deviation of Teaching Evaluation from the Orientation of Core Competence Improvement

Course evaluation methods are mostly limited to final closed-book exams or standardized paper writing, mainly examining students' ability to memorize and repeat isolated knowledge points and fixed theories, rather than knowledge application, critical thinking and innovative creation abilities. This single-subject evaluation model ignores students' thinking trajectories, efforts, teamwork spirit and ability to learn from failures in the learning process, resulting in students being unable to recognize their own strengths and weaknesses through multiple channels, and there is a large gap between evaluation results and actual needs of future workplaces.

2. Connotation and Advantages of Adaptive Learning Empowered by Digital Technology

Adaptive learning is a personalized learning model that tailors learning content, paths and support services based on the unique characteristics of postgraduates such as individual knowledge reserves, learning styles and interests. Relying on digital technologies such as artificial intelligence, big data and learning analytics, this model collects and analyzes students' learning behavior data in real time, including learning duration, progress, answer situation and knowledge mastery, to accurately identify learning status and needs, and dynamically adjust the push of learning resources through real-time feedback. the system provides students with knowledge point explanations, case analyses, exercises and other content suitable for the current learning stage, and continuously optimizes learning paths according to learning feedback to ensure the efficient achievement of learning goals.

The adaptive learning system Integrates diversified learning resources such as online courses, e-books, academic papers and case libraries, which can accurately push resources based on students' needs, avoid blind search in massive information, and improve resource utilization efficiency. At the same time, the system can continuously optimize and update resources according to learning feedback to ensure that students obtain high-quality and adaptive learning content.

In recent years, adaptive learning has made remarkable progress in the global higher education field. Foreign platforms such as Knewton and Cognii have been widely used in general courses such as mathematics and languages, verifying their practical value in improving learning efficiency. Domestic universities such as Tsinghua University, Peking University, Beijing Forestry University and Nanjing Forestry University have also carried out digital teaching exploration and achieved positive results. However, due to differences in teaching resources and equipment configuration between regions and universities, existing research mainly focuses on virtual simulation experiments, smart classroom construction and online course resource development. There is a lack of in-depth development of targeted teaching models for academic postgraduate professional courses with complex knowledge systems, strong cutting-edge nature and close combination with scientific research practice.

3. Construction of Adaptive Learning Teaching Model for "Forest Microbiology"

3.1 Classroom Design Principles

Combining the characteristics of the course "Forest Microbiology" such as rich content, prominent cutting-edge and interdisciplinary nature, and aiming at the actual situation of postgraduates taking the course with diverse professional backgrounds, various research directions and hierarchical output requirements, we follow the four principles of "student-centered, data-driven, research-oriented and dynamic adaptation". We put postgraduates' personalized development needs at the core, and teaching design and activity organization all serve knowledge construction and ability improvement; we collect and analyze learning data in the whole process and from multiple dimensions to provide scientific basis for teaching decision-making and path adjustment;

we realize the seamless connection between course learning and scientific research ability cultivation, and take solving real forest microbiology problems as the core learning task; we integrate online and offline resources to build a dynamic optimization system, and adjust learning paths and resource push according to real-time learning feedback to achieve precise matching between teaching supply and learning needs.

3.2 Core Framework and Elements

Relying on the DeepSeek large model, Zhihuishu AI course platform and Xuexitong online learning platform, we construct a closed-loop system framework of "learner module—course knowledge module—tracking and evaluation module". the functions of each module are as follows:

Learner module: Through pre-course online diagnostic tests, learning style questionnaires and research interest surveys, we accurately assess students' knowledge foundations in fields such as microbial taxonomy, physiology and biochemistry, genetics, ecology and forest pathology, and clarify their research directions (such as biological control of diseases, application of mycorrhizal fungi, environmental microbial remediation, etc.) and career development intentions.

Course knowledge module: We decompose and construct knowledge graphs for the knowledge units of the course "Forest Microbiology" (such as "Identification and Pathogenic Mechanism of Forest Pathogenic Bacteria", "Symbiotic Characteristics and Application of Mycorrhizal Fungi", etc.) according to characteristics such as microbial species and application scenarios, and establish semantic associations between knowledge points. At the same time, we integrate online resources and scientific research practice cases to build a diversified and classified teaching auxiliary resource library, covering online courses, electronic resources, practice bases, micro-videos, academic papers, research datasets, virtual simulation experiments, expert lectures, etc. Under the supervision of teachers, based on the data of the learner module and knowledge graph, a personalized learning path is generated for each student. For example, for students interested in forest pathogenic bacteria research but with weak foundations, we first push micro-courses on "Structure and Function of Prokaryotic Microorganisms", then guide them to participate in virtual experiments on "Gram Staining and Molecular Identification Technology", and then push cutting-edge literatures such as "Impact of Forest Rhizosphere Microbiome on Forest Health".

Tracking and evaluation module: We carry out process evaluation by analyzing students' online activity participation, chapter quizzes, virtual experiment reports, thematic discussion contributions, etc.; at the end of the course, students are required to complete a "small-scale scientific research project" related to their personal research directions, including fund application writing, experimental scheme design, literature review and forward-looking analysis, etc., for summative evaluation.

3.3 Teaching Process Design

Based on the above framework, the teaching of the course "Forest Microbiology" is implemented in four stages:

Diagnosis and planning stage: Students complete pre-assessments and questionnaires, and teachers conduct opening guidance, interpret the model concept and rules, and initially formulate personalized learning plans.

Main adaptive learning stage: Students conduct independent learning along personalized learning paths, with interspersed online synchronous seminars. Teachers organize in-depth exchanges on common problems, core difficulties and cutting-edge hotspots, and students share their experiences in reading and researching recommended literatures.

Deepening and creation stage: As the core link of teaching, problem-oriented project-based teaching is adopted. Firstly, teachers build a "small-scale scientific research project" library based on the cutting-edge scientific research of forest microbiology and the pain points of production practice, and recommend topics and reference resources according to students' previous learning data and research interests; secondly, we strengthen the cultivation of students' "self-organization" and "self-summary" abilities. Relying on AI large models and simulation software, students complete inquiry tasks collaboratively in learning groups. Students need to integrate fragmented data to build a framework for solving ideas, and summarize and refine the inquiry process and results. Teachers act as research consultants, and students can review the content of the main learning stage according to their needs.

Summary and reflection stage: Students submit project reports and participate in defenses. the teaching process integrates flipped classroom, brainstorming and other models, focusing on the cultivation of innovative ability and problem-solving ability. Finally, a "Personalized Learning Analysis Report" is generated for each student, comprehensively presenting the learning trajectory, knowledge mastery map and ability development.

4. Evaluation of Teaching Practice

The preliminary practice of the adaptive teaching model based on digital technology in the course "Forest Microbiology" has received good feedback. Students' enthusiasm and initiative in learning participation have been significantly improved, their ability to independently use AI platforms and large model tools to solve doubts has been exercised, and their learning effects and comprehensive literacy have been comprehensively improved. Students are more willing to take the initiative to explore multiple learning paths and problem-solving schemes, and their ability to analyze and solve complex problems has been effectively enhanced.

5. Main Problems of the Model

5.1 Challenges of Technical Costs and Data Security

This study has initially built the adaptive learning framework and teaching process for the course "Forest Microbiology", but a mature and complete adaptive learning system requires continuous capital and technical investment, including system construction, hardware purchase, software update and maintenance, and technical personnel training. To address this challenge, we need to rely on the development of digital technology to promote the transformation of system construction and maintenance from heavy asset investment to an on-demand payment light asset model; reduce software development and licensing costs by adopting open-source frameworks and tools; or directly call mature AI services on cloud platforms to reduce technical thresholds and development costs. At the same time, the adaptive learning system involves the collection, storage and use of a large amount of students' personal information and learning data, so data security and privacy protection have become key issues.

5.2 Adaptation Pressure of Teachers' Role Transformation

In the adaptive learning model, teachers need to transform from traditional knowledge transmitters to learning guides and facilitators, responsible for interpreting AI learning situation analysis reports and conducting targeted interventions for complex problems, emotional care and critical thinking cultivation that the system cannot solve. This places higher requirements on teachers' teaching ability and information technology application ability. Teachers can use the time saved by the system to focus more on students' individual growth, scientific research literacy cultivation and career development planning.

5.3 Students' Poor Adaptation and Insufficient Independent Learning Ability

Some students have long been accustomed to traditional teaching models, and have difficulty adapting to the more autonomous adaptive learning method, lacking effective methods to use the system for learning. At the same time, adaptive learning has high requirements for students' independent learning ability and self-management ability, and some students have obvious shortcomings in this regard. In this regard, in the future, we need to set up enhanced guidance processes in the system for new students and students with adaptation difficulties to help them familiarize themselves with the adaptive learning model; at the same time, integrate collaborative tools to intelligently match learning groups according to learning performance and interests, encourage students to help each other solve problems and share learning resources, and make progress together in social interaction.

6. Outlook

In the future, the adaptive learning of "Forest Microbiology" will break through the limitations of a single technical tool and develop into an organic ecosystem integrating advanced and affordable technologies, empowered teachers and autonomous students. Driven by data and centered on the all-round development of people, this system will not only strive to efficiently impart forest microbiology knowledge, but also focus on cultivating forestry scientific research and practice talents who can adapt to future challenges and have continuous learning ability and innovative literacy, providing solid talent

support for the development of new quality productive forces in forestry and the construction of ecological civilization.

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