



# Application of Artificial Intelligence (AI) In Practical Teaching of Plant Tissue Culture in Forestry Education: A Case Study

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## Introduction

Digital intelligence-empowered practical education is a key element in cultivating innovative talents [1]. In forestry education, practical teaching is the core link for developing students' hands-on abilities, innovative thinking, and scientific research literacy. The advantages of AI technology, such as simulation, data mining, and intelligent interaction, are crucial to addressing the pain points of traditional practical teaching in forestry. By continuously exploring the application paths of AI technology in the reform of practical teaching in forestry, the discipline can better meet the demand for digital and intelligent skills in the new era.

## Current Situation and Challenges of Forestry Education

Forestry education encompasses plant cultivation, forest cultivation, pest control, and resource surveying. The main goal is to cultivate students' abilities in scientific inquiry, practical operation, and solving real-world forestry problems. However, in traditional forestry teaching, many universities face difficulties in practical aspects, especially plant tissue culture. First, plant tissue culture, as a core technology for asexual reproduction, variety improvement, and factory-based seedling production, requires expensive facilities such as sterile laboratories, culture racks, and media preparation equipment, as well as significant consumable costs. Many universities cannot accommodate large-scale hands-on training, forcing students to observe rather than practice. Second,

the entire process of plant tissue culture—from explant disinfection, inoculation, callus induction to differentiation, rooting, and transplanting—takes weeks or even months, making it difficult for students to track the entire process. Moreover, problems such as contamination and browning often occur, and mistakes are hard to rectify. Third, the student-to-teacher ratio in forestry programs is often high, making it difficult for instructors to provide precise guidance to each student. Finally, traditional practical teaching lacks effective evaluation of students' operational processes and standards, making it hard to accurately reflect their practical skills and innovation capabilities. These issues have hindered the quality improvement of practical teaching in forestry [2].

## Application Pathways of AI Technology in Forestry Teaching Reform

### AI-based Virtual Simulation to Enhance Hands-on Training

The primary application of AI in forestry teaching reform is to overcome resource and time-space constraints through virtual simulation, providing a low-cost, immersive, and safe practical teaching environment. Traditional plant tissue culture practice demands high sterility, consumables, lab space, and equipment, limiting hands-on opportunities. An AI-based virtual simulation platform can simulate the entire process—explant selection, disinfection, media preparation, inoculation, and environmental

control-and use AI algorithms to simulate outcomes under different operational conditions (e.g., contamination due to insufficient disinfection, abnormal differentiation due to hormone imbalance, browning due to high temperature). This “virtual practice + real validation” dual model allows students to accumulate experience and master procedures through repetition while avoiding operational risks and making more efficient use of resources. Additionally, the platform can simulate tissue culture of rare or endangered tree species that students may not encounter in real labs, broadening their practical 野 and fostering ecological awareness.

### AI Intelligent Guidance for Precision Learning

In traditional forestry teaching, it is difficult for instructors to provide precise, real-time guidance to every student, especially during plant tissue culture practice. Using AI technologies such as image recognition, voice interaction, and big data analytics, universities can establish an AI intelligent guidance system that monitors the entire learning and practice process, provides real-time feedback, and delivers precise guidance. For example, during tissue culture practice, an AI system can capture each student's movements via cameras, assess the standardization of steps (e.g., disinfection time, inoculation angle, aseptic technique), and immediately alert students via voice or text if deviations occur, while demonstrating correct procedures through images or videos. The system can also monitor culture growth, automatically identifying callus, shoot, root development, as well as abnormalities like contamination or browning, and provide data-driven solutions. Furthermore, the AI system records each student's operational data, experimental steps, and problem-solving history, building personalized learning profiles. Teachers can then identify students' weaknesses and tailor instruction accordingly.

### AI-based Data-Driven Evaluation to Highlight Comprehensive Abilities

Teaching evaluation is key to reflecting students' learning levels. Traditional evaluation methods, which rely mainly on lab reports and final outcomes, often fail to fully capture students' actual abilities. An AI-based three-dimensional data-driven evaluation system-integrating process, outcome, and innovation assessments-enables dynamic and comprehensive evaluation. For example, in plant tissue culture practice, AI quantifies operational standardization, completion of steps, and problem-solving speed; uses image recognition to objectively evaluate callus induction rate, shoot differentiation rate, and rooting rate; and scores innovative behaviours such as media optimization, procedural improvements, and experimental design innovations. Moreover, the AI system generates personalized evaluation reports for each student, highlighting strengths and weaknesses, providing targeted improvement suggestions, and offering data support for teachers to optimize teaching strategies.

### AI-enabled Integration of Teaching, Research, and Industry to Enhance Job Adaptability

Beyond the above, AI can effectively promote the integration of plant tissue culture teaching with research and production, enhancing students' scientific literacy and job competency, preparing them to meet the needs of future smart forestry. On one hand, universities can use AI to integrate cutting-edge research results and real production cases into teaching, allowing students to engage with advanced technologies and practical demands. For instance, students can analyse real-world cases of factory-based rare tree seedling cultivation or rapid propagation of superior varieties using AI, or participate in research projects optimizing tissue culture conditions using AI algorithms. On the other hand, universities can collaborate with forestry enterprises to build school-enterprise collaborative practice platforms, integrating production processes and technical standards into teaching. Students can simulate real production scenarios in virtual environments-such as large-scale media preparation, automated inoculation, and intelligent environmental control-thereby familiarizing themselves with factory-based seedling production standards. This “teaching-research-production” integration enhances teaching practicality and relevance, effectively improving students' research capabilities and job competitiveness, aligning forestry talent cultivation with the development of smart forestry.

### Conclusion

The integration of artificial intelligence offers new opportunities for the reform of forestry education. As the main base for cultivating forestry professionals, universities must actively promote the deep integration of AI technology into forestry teaching to produce high-quality talents with digital and intelligent skills, capable of adapting to the needs of smart forestry in the new era.

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### Conflict of Interest

No conflict of interest.

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