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Enhancing Medicinal Botany Education Through Comprehensive Teaching Reform from 2020 to 2023

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Abstract

This study evaluates the impact of an innovative four-year instructional strategy on the Medicinal Botany course for second-year pharmacy students at a Chinese university, covering the period from 2020 to 2023. The reform included three main components: (1) a combination of online and offline learning through digital resources and interactive activities; (2) a significant enhancement of practical experience through laboratory work, supplemented by visits to on-campus facilities and regional resources; and (3) the integration of Problem-Based Learning (PBL) to foster advanced critical thinking and problem-solving skills. Evaluation of student engagement, resource utilization, and feedback during this period revealed significant improvements in both engagement and comprehension. These findings highlight the effectiveness of a comprehensive, multifaceted pedagogical approach in enriching plant science education and bridging the gap between theoretical knowledge and practical application.

Keywords

Medicinal Botany; Teaching Reforms; Problem-Based Learning (PBL); Online and Offline Learning Integration; Practical Experience in Education; Student Engagement and Participation; Holistic Learning Approaches; Interactive Learning Activities

1. Introduction

Traditional Chinese Medicine (TCM), known for its holistic approach that emphasizes balance between body, mind, and environment, has long been a significant part of China's medical landscape (Fang et al., 2013; Hsu, 2008). As this distinctive perspective on health and disease management gains increasing recognition in integrative and complementary medicine, there is a corresponding rise in global interest in incorporating TCM principles into pharmaceutical education, particularly in the area of herbal and natural remedies (Matos et al., 2021; Liu, 2021). For pharmacy students, a strong foundation in TCM not only deepens their understanding of herbal therapeutics but also equips them to bridge the gap between traditional practices and modern pharmaceutical science. This integration is crucial in preparing pharmacists to contribute to the development, prescription, and safe use of herbal medicines, especially when used alongside conventional therapies.

To address this educational need, our pharmacy program has systematically incorporated TCM-related courses, with Medicinal Botany serving as a foundational course in the second semester of the second year. This course combines

knowledge of plant morphology, anatomy, and systematics to focus on the scientific study of medicinal plants. It is both a theoretical and practical discipline, designed to provide students with essential theories and concepts while developing their skills in identifying and classifying medicinal plants. By establishing a strong foundation, the course prepares students for advanced studies in Pharmacognosy and Natural Product Chemistry, where they will delve deeper into the identification of crude drugs and the chemical analysis of medicinal plants.

However, traditional methods of teaching Medicinal Botany, which rely heavily on lectures and rote memorization, often fail to fully engage students or promote deep learning. Limited class hours and constraints on extended fieldwork further restrict opportunities for pharmacy students to gain hands-on experience with medicinal plants. This lack of practical engagement hinders their ability to connect theoretical knowledge with real-world applications, ultimately limiting their understanding of the complexities and significance of the plants they study.

This paper proposes a comprehensive and innovative pedagogical framework that integrates online and offline learning modalities, emphasizing experiential learning through laboratory work complemented by structured visits to on-campus facilities and regional resources (Figure 1). Furthermore, the integration of Problem-Based Learning (PBL) is introduced as a central element to cultivate students' critical thinking and problem-solving skills. This multi-modal teaching strategy aims to transform the learning experience by making it more interactive, engaging, and effective. By providing diverse learning opportunities and practical experiences, this approach seeks to deepen students' understanding of Medicinal Botany and better prepare them for their future roles in the pharmaceutical and healthcare sectors.

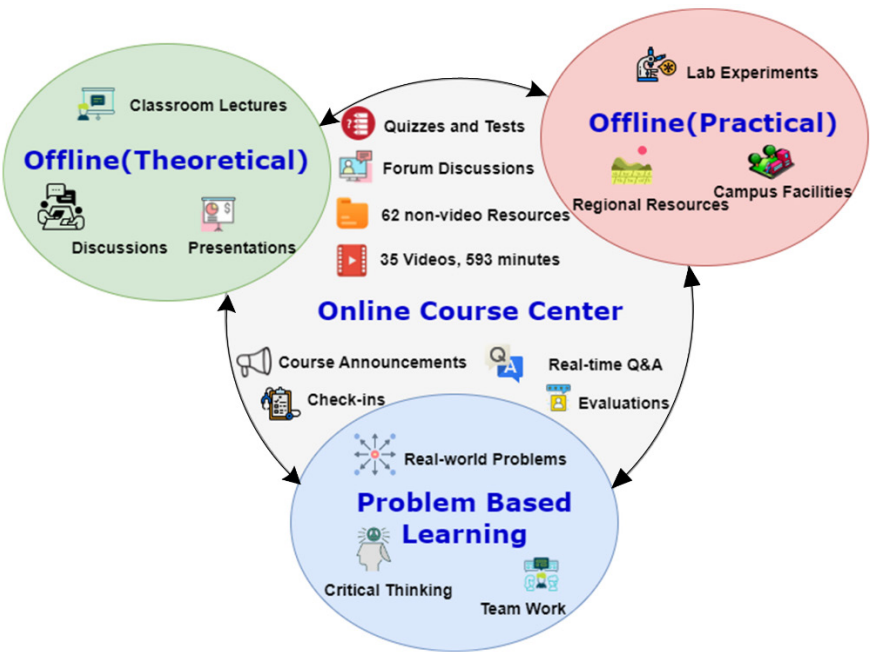

Figure 1. Integration of online and offline learning methods, practical experiences, and Problem-Based Learning (PBL) within the Medicinal Botany course.

2. Design and Implementation of Teaching Reform

2.1 Integrating Online and Offline Instructional Methods to Enhance Learning Outcomes

The integration of online and offline teaching is rapidly reshaping education, driven by the flexibility and accessibility of online platforms (Lertnattee & Wangwattana, 2017; Li et al., 2020; Yen et al., 2018). Despite its advantages, this blended learning approach presents challenges such as students struggling with self-regulation and effective technology use, teachers' reluctance to incorporate technology into traditional face-to-face instruction, and difficulties in providing adequate technological resources (Rasheed et al., 2020). We have encountered these challenges firsthand, but the pandemic has accelerated the shift toward online learning, making it a crucial part of education (Ling Koh et al., 2023; Teng & Wu, 2023; Yao et al., 2020). This shift has led to significant improvements in our online course center. We are progressively integrating online and offline teaching methods, creating a dynamic learning environment that balances theoretical knowledge with practical skills and better prepares students for future challenges.

2.1.1 Leveraging Digital Resources for Enhanced Online Learning

The online component of the Medicinal Botany course is supported by a robust digital infrastructure provided through the e-learning platform of the university. This platform offers a comprehensive array of resources designed to enhance the learning experience.

Course Videos and Learning Materials: The course includes 35 videos with a total duration of 593 minutes. These videos are integral to covering the course curriculum and key topics in depth, presenting essential theoretical concepts alongside some practical demonstrations. Additionally, the platform provides 62 non-video resources, which include lecture slides used by instructors, supplementary readings offering additional theoretical insights, and other materials that reinforce the content covered in the videos.

Exercises, Quizzes, and Unit Tests: To reinforce theoretical concepts and support self-assessment, the platform includes various assessments such as quizzes and unit tests. These assessments are complemented by a comprehensive question bank and extended reading materials, all of which facilitate in-depth study and effective exam preparation.

Interactive Tools: To actively engage students in their learning, the platform features a variety of interactive tools. These include check-ins, real-time Q&A sessions, and discussion forums, which facilitate ongoing interaction and provide immediate feedback. Course announcements are also part of these interactive features, keeping students updated with ongoing information and guidance. Additionally, online Problem-Based Learning (PBL) sessions enhance the learning experience by fostering a collaborative environment that encourages critical thinking and peer-to-peer learning.

2.1.2 Structuring Synchronized Online and Offline Learning Activities

To ensure coherence between online and offline components, pre-class activities are carefully planned and communicated to students via the online platform and social media groups (WeChat and QQ). These activities set clear expectations and help students prepare effectively. Lecture videos and PowerPoint presentations are accessible for independent study, allowing flexible and self-paced learning. Specific URLs to supplementary micro-lectures on pharmacognosy enable students to explore particular areas of interest in more depth before or after classes.

Post-class, students engage with exercises and quizzes on the e-learning platform designed to consolidate their understanding of the material covered in class. These activities are reinforced with interactive flashcards, practice questions, and summary quizzes, helping students to review and strengthen their grasp of the course content continuously. Continuous engagement is maintained through online forums and discussion threads, where students interact with peers and instructors, further solidifying their understanding of the course material outside the classroom setting.

2.1.3 Enhancing Classroom Engagement with Interactive Tools

In the classroom, interactive activities are pivotal in creating a dynamic learning environment. Because students have engaged with the material through pre-class activities as outlined in section 2.2, classroom time is used more effectively. This allows for a balanced approach where traditional lectures can cover foundational content, while additional time is dedicated to deeper exploration through Problem-Based Learning (PBL), in-depth discussions, student presentations, debates, and specimen-making, among other activities.

Additionally, attendance is recorded randomly through the e-learning platform, ensuring that students are consistently engaged and participating. Real-time Q&A sessions, where students respond to questions posed by the instructor or their peers, are conducted both in-person and through the online platform. This interaction allows for immediate feedback and clarification of concepts.

2.2 Advancing Practical Experience Through Laboratory Work Assisted by Field Studies

The intricate and visually demanding nature of Medicinal Botany necessitates a strong emphasis on practical teaching. Fieldwork is a common part of the curriculum for students studying Traditional Chinese Medicine (TCM), with many universities incorporating it into their programs, often lasting from two weeks to a month (Li et al., 2020; Tian, 2024). However, because pharmacy students typically have more courses focused on Western medicine, the hours allocated to TCM-related courses like Medicinal Botany are often compressed, limiting the opportunity for extended fieldwork. To address these constraints, our course design prioritizes laboratory-based practical teaching, complemented by multimedia resources, campus-based learning opportunities, and the utilization of local regional resources.

2.2.1 Laboratory-based Practical Teaching Supported by Online Resources

In the laboratory, students engage in detailed studies of plant morphology and anatomy, focusing on fresh plant materials for direct observation and dissection. This hands-on approach deepens their understanding of plant structures and helps them develop essential practical skills. The use of real plant specimens in lab sessions further enhances comprehension

and maintains student interest in the subject matter. To complement these laboratory activities, high-quality multimedia resources are extensively utilized in classroom lectures. These resources include detailed images, instructional videos, and documentaries that provide valuable visual and educational content. For example, students study high-resolution images and video clips of ginseng to explore its distinct morphological features.

Practical teaching is comprehensively supported by online learning resources, including instructional videos, the Lingnan Medicinal Materials premium course, and virtual labs. The Lingnan Medicinal Materials course will be further detailed in the PBL teaching section (See 2.3). Regarding the use of virtual labs, the course leverages a national-level virtual simulation platform that offers interactive modules such as pharmacognostic identification and essential oil extraction from Guang Chen Pi. These virtual labs effectively bridge the gap between theoretical knowledge and practical application, providing students with a safe and repeatable environment for hands-on learning. Additionally, students are advised to use plant identification apps and online platforms to further enhance their practical skills and connect classroom theory with real-world plant observations and applications, thereby improving overall learning outcomes.

2.2.2 Maximizing the Use of Campus Facilities and Regional Resources

The university's campus, with its diverse flora, and the dedicated Medicinal Plant Garden are integral to the practical teaching of Medicinal Botany. The campus hosts a variety of plant species that are utilized for teaching plant morphology and classification. Through guided tours and observational exercises, students enhance their skills in identifying plant features and understanding their medicinal properties. The Medicinal Plant Garden offers further opportunities for in-depth study through structured field visits. During these visits, students engage in hands-on activities such as plant identification, morphological analysis, and research projects focused on the growth and medicinal applications of the plants studied.

In addition to on-campus resources, collaborations with local institutions, such as TCM factories and herbal cultivation centers, provide students with valuable practical exposure to regional medicinal practices. These field visits, conducted once or twice per academic year, allow students to observe and participate in the cultivation, processing, and application of medicinal plants, offering insights into the practical aspects of TCM and its integration into modern healthcare.

2.3 Applying PBL to Develop Critical Thinking and Problem-solving Skills

Problem-Based Learning (PBL) is a student-centered educational approach that emphasizes solving real-world problems to enhance learning outcomes (Marra et al., 2014). In PBL, students actively engage in exploring and addressing complex issues within authentic or simulated scenarios, which fosters critical thinking, collaboration, and self-directed learning. Although PBL is widely adopted in fields such as medicine, engineering, and business, where it effectively tackles intricate practical problems, its application in Medicinal Botany and botany courses is relatively limited (Chen et al., 2021; Gonzalez-Argote & Castillo-González, 2024; Huang et al., 2020; Saraiva et al., 2024; Zabit, 2010). This is noteworthy because botany courses also place a strong emphasis on practical experience. Incorporating PBL into Medicinal Botany could offer significant benefits, allowing students to confront real-world challenges related to medicinal plants and thereby deepen their practical skills and theoretical understanding.

2.3.1 Structure and Implementation of PBL Projects

PBL projects are meticulously designed to foster both independent research and collaborative teamwork, ensuring that students actively engage with the material in a meaningful way. Students are prompted to form their own small, diverse teams, each tasked with tackling a project centered around medicinal plants. Within these self-selected groups, students are responsible for distributing tasks among themselves, ensuring that each team member contributes to the project's success. To support effective collaboration, students receive guidance on managing team dynamics and resolving any conflicts that may arise during the project. Additionally, projects are structured with specific milestones and deadlines to help students stay on track and monitor their progress.

These PBL projects are thoughtfully aligned with real-world applications, allowing students to explore scenarios such as addressing practical challenges in the cultivation, harvesting, processing, or medicinal application of Guang Chen Pi and other traditional herbs. Students are advised to utilize various resources, such as scientific literature, expert interviews, fieldwork opportunities, and online tools to address their tasks. They are guided to apply critical thinking and problem-solving skills as they navigate challenges and develop innovative solutions. Regular feedback sessions are provided to help students remain focused on their research objectives. Through this process, students gain not only a deeper understanding of medicinal plants but also valuable experience in research methodology, teamwork, and communication. The real-world relevance of the projects is emphasized through connections to industry practices and real-life scenarios.

2.3.2 Presentation and Assessment

After completing their research tasks, students are required to create PowerPoint presentations and deliver them in class to peers, instructors, and potentially industry professionals. During their presentations, students are urged to use a variety of aids to enhance their delivery and engage their audience. This can include incorporating physical samples of medicinal plants, presenting video materials, and performing demonstrations or skits related to their research. These aids help illustrate key points, make the presentation more interactive, and provide a tangible connection to the research topic.

Following the presentations, evaluations are conducted based on a set of standards. This structured rubric includes criteria such as content accuracy, depth of research, organization, innovation, the effective use of presentation aids, group dynamics, and individual contributions. While teachers may emphasize the thoroughness of the research, clarity of content, and overall presentation skills, students might focus more on how clear, engaging, and practically useful the presentation is. By incorporating feedback from both perspectives, the evaluation process ensures a comprehensive assessment, enhancing students' collaborative and presentation skills while deepening their understanding of the PBL method.

2.3.3 Blending Online and Hands-on Learning Resources in PBL

The implementation of PBL is significantly strengthened by the integration of online resources. The university's e-learning platform plays a vital role in overseeing task distribution, report submissions, peer reviews, and instructor feedback, which ensures the seamless execution of the digital components of PBL. As part of this learning experience, students are inspired to explore the premium module titled "Lingnan's Authentic Medicinal Materials" through online self-study. This module presents a series of videos that provide an in-depth exploration of key medicinal herbs, including Guang Chen P, Hua Ju Hong, Ba Ji Tian, Yang Chun Sha, and Guang Huo Xiang. These videos trace the complete lifecycle of these herbs, from cultivation and initial processing at standardized facilities to advanced processing in factories, and ultimately their distribution at specialty stores and herbal markets. Additionally, the module offers expert insights into the identification of these herbs and their applications in both medical and non-medical fields. By engaging with this module, students gain valuable real-world knowledge that directly supports their problem-solving activities.

To complement the digital learning experience, students are further advised to utilize the diverse plant resources available on and around campus, particularly the Medicinal Plant Garden and laboratory specimens. These resources provide access to live and preserved plant specimens, enabling students to conduct detailed botanical experiments and observations. Additionally, students can extend their research by visiting local specialty stores and herbal markets, where they can explore the commercial aspects of medicinal plants. This hands-on, comprehensive approach deepens their understanding of plant characteristics and practical applications, effectively connecting classroom learning with real-world contexts. Consequently, it improves the quality of their research and strengthens their problem-solving skills.

3. Teaching Effectiveness and Evaluation

A comprehensive evaluation of the teaching reforms has been conducted, covering four years of data from 2020 to 2023. This evaluation includes a detailed analysis of resource utilization metrics, student participation in quizzes and assignments, annual online interaction records, and feedback from online student evaluations, focus group discussions, and informal conversations. This multi-faceted approach provides a thorough understanding of the impact and effectiveness of the teaching reforms over the past four years.

3.1 Analysis of Online Teaching Resources, Participation, and Interaction

3.1.1 Overview of Engagement and Usage Metrics for the Online Course Platform

The utilization of the online course platform for Medicinal Botany is thoroughly detailed in Table 1, which presents key engagement metrics that highlight its importance in supporting the course's instructional activities. The Cumulative Enrollment of 537 students provides essential context for understanding the volume of interactions, indicating the total number of participants registered in the course. The Course Announcements feature, with 142 postings, has been pivotal in keeping students informed and engaged through regular updates. The extensive interaction with course materials and platform information is reflected in the Cumulative Page Views, which total 466,644. This significant figure underscores the platform's central role in facilitating access to course content. Furthermore, the Cumulative Interactions, amounting to 40,274, capture the overall level of student engagement through various interactive elements, such as discussion posts and feedback mechanisms. Collectively, these metrics demonstrate the effective use and high engagement level of the online course platform, emphasizing its critical role in the course's success.

Table 1. Summary of Online Course Platform Utilization Metrics

Metric	Quantity
Cumulative Enrollment	537
Course Announcements	142
Cumulative Page Views	466,644
Cumulative Interactions	40,274

3.1.2 Online Quiz and Assignment Participation Analysis

Table 2 provides an overview of the annual quiz and assignment participation. The data show consistently high average student engagement in quizzes and assignments across the years. In 2020, despite the relatively low number of quizzes and assignments, participation per student was nearly complete, reflecting strong initial engagement. By 2021, although the number of quizzes and assignments increased significantly, student participation per instance remained robust, indicating successful course adjustments. Despite a slight decrease in the number of quizzes and assignments in 2022 and 2023, participation remained high, illustrating the course's effectiveness in maintaining engagement. This consistency suggests that the course design effectively ensured active involvement in quizzes and assignments throughout the period.

Table 2. Annual Quiz and Assignment Participation Data

Year	Total Instances	Total Questions	Number of Participants	Enrollment
2020	9	215	79	82
2021	46	215	212	212
2022	27	215	131	132
2023	20	215	110	111

3.1.3 Trends in Annual Student Online Interaction

Table 3 illustrates the evolution of online interactions between students and faculty, offering insights into the course's online component maturation. In 2020, interactions were predominantly faculty-driven, reflecting the students' initial adjustment to the online format. By 2021, there was a significant increase in student-led discussions, indicating more active student participation. Despite a decrease in enrollment in subsequent years, the volume of interactions from engaged students remained high, demonstrating the effectiveness of online teaching methods and sustained engagement among participants.

Table 3. Trends in Annual Student Online Interaction

Year	Total Posts	Faculty Posts	Number of Participants	Enrollment
2020	2,681	2,681	0	82
2021	18,387	16,119	195	212
2022	9,456	8,052	119	132
2023	9,750	5,439	110	111

3.1.4 Analysis and Summary of Classroom Activities and Participation Metrics

The analysis of student engagement metrics from 2020 to 2023 indicates a positive trend in participation stability across various course components, with a focus on average student involvement (see Table 4).

Table 4. Annual Overview of Classroom Activities and Participation Metrics

Year	Check-ins/ Distributions	In-Class Exercises/ Distributions	PBL Tasks/ Distribution	Enrollment
2020	536/9	0	82/1	82
2021	869/21	78/4	185/1	212
2022	1267/22	228/4	112/1	132
2023	1259/23	658/14	110/1	111

Classroom Interaction: The overall engagement in classroom interactions has significantly improved. The total number of check-ins increased from 536 in 2020 to over 1200 in both 2022 and 2023. This substantial rise reflects a higher level of student interaction and suggests that the increased frequency of check-ins has led to greater utilization of online attendance tools. Although the average number of check-ins per student per distribution decreased slightly, this decrease is primarily attributed to the increased number of distributions rather than a decline in individual engagement. For in-class exercises, both the total number and the average participation per student per distribution have risen. The total number of in-class exercises increased dramatically from zero in 2020 to 658 in 2023. Additionally, the average number of in-class exercises per student per distribution rose from zero in 2020 to approximately 0.5 in 2022 and 2023. This increase indicates a substantial rise in both the frequency of exercises and overall student participation. The rise in in-class exercises also reflects the instructors' adaptation to online teaching methods, as they progressively integrated more interactive activities to enhance student engagement. This shift highlights a move towards more engaging and interactive classroom activities, underlining the instructors' efforts to make the learning experience more dynamic and effective.

PBL Participation: Participation in PBL tasks has remained high and consistent across the years. Annually, almost every student has been involved in PBL activities, demonstrating the widespread adoption and integration of this pedagogical approach. For example, in 2023, 110 out of 111 students participated in PBL tasks, resulting in a 99% participation rate. This high level of involvement reflects the effectiveness of PBL in engaging students and fostering active learning.

3.2 Student Feedback

Feedback on the course was collected through multiple channels, including online student evaluations, focus group discussions organized by the college, and informal conversations with students.

Online evaluations, gathered from 2020 to 2023, provided a quantitative measure of student satisfaction with various aspects of the course, such as content, teaching methods, and overall experience. The course center received more than 300 student evaluations during this period, with the majority of responses being overwhelmingly positive. Most students found the course engaging and appreciated the effective integration of theory and practice, particularly in the PBL sessions. Many students expressed their satisfaction by giving the course the highest possible rating, reflecting their enjoyment and the value they found in the learning experience.

Focus group discussions and informal conversations further reinforced these findings. Students consistently highlighted the engaging nature of the course, the hands-on learning opportunities, and the real-world applications provided. These discussions provided a deeper understanding of the student experience, revealing that the interactive teaching methods and PBL sessions were particularly effective in fostering collaboration and practical application of knowledge.

Comments such as "The teaching is lively and interactive, making the content accessible and enjoyable" and "The PBL sessions allowed for practical application of knowledge and effective peer collaboration" underscore the success of the course reforms. These positive evaluations demonstrate that the teaching reforms have successfully created a course that resonates well with students, blending theoretical learning with practical, real-world application.

4. Conclusion and Future Directions

In conclusion, this study has demonstrated the substantial benefits of the cohesive integration of online and offline learning methods, practical experiences, and Problem-Based Learning (PBL) within the Medicinal Botany course. These three components work synergistically, with each enhancing the effectiveness of the others. The integration of online and offline learning methods supports practical experiences by providing flexible and comprehensive access to resources, while PBL enriches both by applying theoretical knowledge to real-world challenges. This mutually reinforcing approach has significantly improved student engagement and interaction with course materials. The overwhelmingly positive feedback from students underscores their appreciation for this integrated learning strategy, which has deepened their understanding

of Medicinal Botany and better prepared them for future roles in the pharmaceutical and healthcare fields. Additionally, the reforms have enriched our methods of evaluating student learning outcomes. The use of real-time feedback, online quizzes and tests, practical performance evaluations, and comprehensive PBL assessments has provided a more nuanced and holistic view of student learning. This diverse assessment strategy ensures that students are evaluated comprehensively, capturing both their theoretical understanding and practical application skills.

Despite these successes, there are opportunities for further refinement and enhancement. Students have expressed a strong preference for interactive and applied learning experiences through PBL. Therefore, expanding and diversifying these PBL projects could greatly benefit future iterations of the course. Incorporating more complex and interdisciplinary PBL projects, which connect Medicinal Botany with fields such as pharmacology or environmental science, could offer additional layers of learning. Moreover, while the current field visits to botanical gardens and local TCM factories have been valuable, expanding these experiences to include international or more diverse regional sites could provide students with a broader perspective on global medicinal practices. This could be achieved through partnerships with international institutions or by integrating virtual field trips that offer global insights.

Looking beyond this course, the teaching reforms introduced here provide valuable lessons for broader application within the plant sciences curriculum. Integrating virtual labs and online simulations into other courses, such as Plant Morphology and Anatomy, Plant Classification, and Economic Botany, could complement traditional fieldwork and offer a more comprehensive understanding of plant sciences. Additionally, applying PBL strategies to other disciplines could enhance critical thinking and problem-solving skills across various subjects. Future research should focus on adapting these methods to different educational contexts and course objectives to maximize their effectiveness. By continually evolving these approaches, educators can significantly enhance the quality and engagement of plant sciences education, ultimately contributing to more effective and dynamic learning environments.

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