



Phytochemical screening of mint leaves (*Mentha sp.*) as an innovation in biology learning

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Abstract

Phytochemistry-based practicums have the potential to strengthen students' cognitive understanding, psychomotor skills, and affective attitudes. This study examines the effectiveness of phytochemistry testing practicums using mint leaf (*Mentha sp.*) ethanol extract on the learning outcomes, psychomotor skills, and attitudes of biology students. The research subjects consisted of 30 second-year students selected using purposive sampling, as they had already completed the basic pharmaceutical biology course. A pre-experimental one-group pretest-posttest design was applied, with instruments including a learning outcome test, observation sheets, and a response questionnaire. The phytochemical screening results confirmed the presence of flavonoids, alkaloids, saponins, tannins, and terpenoids, which provided clear and easily observable visual indicators. Statistical analysis showed a significant increase in post-test scores compared to pre-test scores ($p = 0.001$). Observations revealed good performance in laboratory skills such as procedural accuracy, work safety, and teamwork, although color interpretation required further improvement. Questionnaire responses indicated that students perceived the practicum positively, particularly in terms of motivation, relevance to everyday life, and integration of theory with practice. These findings indicate that mint leaf-based phytochemistry practicums effectively support student learning, with an average score of 80.4 in the cognitive domain (Good-Very Good), 82 in the psychomotor domain (Good), and 85 in the affective domain (Very Good). The use of local plants as a practical medium also provides a contextual, low-cost, and innovative approach to biology education, with strategic potential to improve the quality of laboratory-based learning.

Abstrak. Praktikum berbasis fitokimia berpotensi memperkuat pemahaman kognitif, keterampilan psikomotor, dan sikap afektif mahasiswa. Penelitian ini mengkaji efektivitas praktikum uji fitokimia menggunakan ekstrak etanol daun mint (*Mentha sp.*) terhadap hasil belajar, keterampilan psikomotor dan sikap mahasiswa biologi. Subjek penelitian terdiri dari 30 mahasiswa tahun kedua yang dipilih dengan teknik purposive sampling, karena telah menyelesaikan mata kuliah Biologi Farmasi Dasar. Desain penelitian yang digunakan adalah pra-eksperimental dengan rancangan one-group pretest-posttest, menggunakan instrumen berupa tes hasil belajar, lembar observasi, dan angket respon. Hasil skrining fitokimia mengonfirmasi adanya flavonoid, alkaloid, saponin, tanin, dan terpenoid yang memberikan indikator visual jelas dan dapat diamati dengan baik. Analisis statistik menunjukkan peningkatan signifikan pada nilai post-test dibandingkan pre-test ($p = 0,001$). Observasi menunjukkan keterampilan laboratorium mahasiswa berada pada kategori baik, khususnya dalam ketepatan prosedur, keselamatan kerja, dan kerja sama tim, meskipun interpretasi warna masih perlu ditingkatkan. Respon angket menunjukkan bahwa mahasiswa menilai praktikum ini secara positif, terutama dalam hal motivasi, relevansi dengan kehidupan sehari-hari, serta integrasi teori dengan praktik. Temuan ini menunjukkan bahwa praktikum fitokimia berbasis daun mint efektif mendukung pembelajaran mahasiswa dengan memperoleh rata-rata nilai 80,4 pada domain kognitif (Baik-Sangat Baik), 82 pada domain psikomotor (Baik), dan 85 pada domain afektif (Sangat Baik). Pemanfaatan tanaman lokal sebagai media praktikum juga menyediakan pendekatan kontekstual, berbiaya rendah, dan inovatif dalam pendidikan biologi, dengan potensi strategis untuk meningkatkan kualitas pembelajaran berbasis laboratorium.

A. Introduction

Biology, as a fundamental science, plays an important role in equipping students with knowledge regarding the structure, functions, and benefits of living organisms for human life. One essential aspect of biology is the understanding of plant secondary metabolites, which are natural chemical compounds produced by plants with various pharmacological benefits (Padmiswari et al., 2025). Phytochemistry, as the branch of science that studies these secondary metabolites, was chosen as the focus of this study because it not only introduces students to the chemical diversity of plants but also highlights the direct applications of these compounds in medicine, health, and industry. By studying phytochemistry, students can bridge biological concepts with chemical and pharmacological perspectives, making it a highly interdisciplinary and relevant field of study.

Traditionally, the learning of phytochemistry and secondary metabolites has been dominated by theoretical lectures, with limited opportunities for students to directly observe and test the presence of these compounds. As a result, students often find it difficult to link abstract concepts with real-life phenomena. In many cases, the learning process focused more on memorization rather than critical thinking and practical application, which led to gaps in students' understanding of how secondary metabolites function in plants and their implications for human health.

To overcome this gap, biology learning needs to be supported by applied laboratory practices so that students can connect theoretical knowledge with real phenomena in the field (Restudila et al., 2025). Laboratory-based learning through phytochemistry practicums allows students to directly observe visual changes, such as color reactions or precipitate formation, when testing for specific secondary metabolites. This not only strengthens their cognitive understanding but also develops psychomotor skills such as handling laboratory equipment and conducting procedures with accuracy, while at the same time fostering positive affective attitudes such as teamwork, curiosity, and scientific responsibility.

Biology learning in higher education, particularly for pharmacy and biology students, therefore requires the integration of theory and practice. One of the crucial competencies is the understanding of plant secondary metabolites, which are widely applied in pharmacology, healthcare, and industry. A phytochemistry-based biology practicum provides students with opportunities to link theoretical concepts with empirical phenomena in the laboratory (Prasetyo & Lestari, 2021).

Mint (*Mentha* sp.) is a widely known herbal plant containing secondary metabolites such as flavonoids, alkaloids, saponins, and tannins. These compounds exhibit various biological activities, including antioxidant, antibacterial, and anti-

inflammatory properties (Hidayati et al., 2022). Mint leaves are also commonly used in daily life as ingredients in food, beverages, traditional medicine, and cosmetics. They are known to contain flavonoids, saponins, tannins, and alkaloids, which act as antioxidants, antibacterial, and anti-inflammatory agents (Padmiswari et al., 2023). For students, the use of mint leaves in biology practicum is not only scientifically relevant but also provides a learning experience rooted in local wisdom with readily available materials. The utilization of local plants such as mint leaves as practicum materials is highly relevant since they are easily accessible while also carrying educational value in introducing the potential of local biodiversity.

Given these considerations, this research was conducted to evaluate the effectiveness of phytochemistry-based practicums using mint leaf extract as a medium for learning. It aimed to assess the impact of such practicum activities on students' cognitive, psychomotor, and affective learning domains, while also highlighting the contextual benefits of using locally available plants to enhance the quality of biology and pharmacy education.

Research in biology education emphasizes that students understand concepts more effectively when directly engaged in contextual practicum activities. However, teaching methods are still largely dominated by lectures, limiting students' opportunities to experience inquiry-based learning (Rahmawati et al., 2020). Phytochemical screening of mint leaves can serve as an innovative learning approach to enhance critical thinking skills while simultaneously providing students with basic research experience. Biology learning at the university level often remains theory-oriented, with limited laboratory activities. This condition contributes to low levels of scientific process skills and critical thinking among students (Al-hafidz et al., 2024). Therefore, innovative approaches are required to integrate theory and experimentation, one of which is through simple phytochemical screening using local plants such as mint leaves. Such innovation is expected to enhance learning motivation, conceptual understanding, and students' awareness of the biological potential of their environment.

Several studies have reported that phytochemical testing can be utilized to improve student competencies. Finne et al. (2023) found that project-based phytochemistry practicum improved students' understanding of biochemical concepts. Similarly, Nugraha et al. (2022) reported that research-based practicum using local plant materials increased motivation and laboratory skills among biology students. Although numerous studies have investigated the phytochemical benefits of herbal plants, most of them have focused on pharmacological and health aspects rather than student learning. Research specifically examining the use of mint leaves

as a medium for biology practicum is still very limited (Hudz et al., 2023). Moreover, the majority of previous studies in biology education have only assessed students' conceptual understanding without employing quantitative evaluations using pre-test and post-test methods (Sadikin, 2024). In fact, such methods are essential to determine the effectiveness of practicum in improving students' understanding and skills (Sujanem et al., 2022). This study addresses this gap by combining phytochemical testing of mint leaves with pre- and post-test questionnaire analysis to comprehensively evaluate the impact of learning.

Therefore, this research is significant as it provides empirical evidence that phytochemical screening of mint leaves is not only valuable in pharmacy but also serves as an educational innovation in biology practicum. This innovation is expected to enhance students' conceptual understanding, laboratory skills, and scientific attitudes.

B. Material and method

Research design

This study employed a mixed-method approach with a pre-experimental one-group pretest-posttest design (Teerawongpaibroj et al., 2024). This design was chosen to determine the effectiveness of the mint leaf phytochemical screening practicum in improving students' understanding by measuring learning outcomes before and after the practicum.

Research location and subjects

The study was conducted in the Laboratory of the Clinical and Community Pharmacy Study Program, Bali Institute of Technology and Health, during the even semester of the 2025 academic year. The research subjects consisted of 30 second-year students selected using purposive sampling, as they had already completed the basic pharmaceutical biology course.

Research procedure

Sample preparation and extraction

Mint leaves used as practicum materials were obtained from the Denpasar area, Bali. Fresh leaves were harvested, washed under running water to remove impurities, and dried at room temperature until a low moisture content was achieved. The dried leaves were then ground into simplicia powder. Extraction was performed using the maceration method with 70% ethanol as the solvent. A total of 200 grams of simplicia powder was soaked in 1 liter of ethanol for three days with stirring every 12 hours. The filtrate was then filtered and evaporated using a rotary evaporator to obtain a concentrated extract ready for phytochemical testing.

Phytochemical screening procedure

Phytochemical screening was carried out to identify major secondary metabolites, namely flavonoids, alkaloids, saponins, tannins, and terpenoids. Flavonoid

testing was conducted using the Shinoda method, in which magnesium metal and concentrated HCl were added to the extract solution; the appearance of a red to orange color indicated a positive result. Alkaloid testing was performed using Mayer, Wagner, and Dragendorff reagents, with positive results indicated by the formation of white, brown, or orange precipitates. Saponin testing was conducted by shaking the extract solution with distilled water, where stable foam persisting for at least 10 minutes indicated a positive result. Tannin testing was carried out by adding 1% FeCl₃ solution to the extract, with a positive result indicated by a dark blue or greenish-black coloration. Meanwhile, terpenoid testing employed the Liebermann-Burchard reagent, with the formation of a reddish-brown ring at the liquid interface indicating the presence of terpenoids.

Assessment procedures

The assessment of learning outcomes was carried out comprehensively by measuring the three learning domains, namely cognitive, psychomotor, and affective. The cognitive domain was assessed through pre-test and post-test instruments consisting of multiple-choice and short-answer questions related to phytochemistry concepts, secondary metabolites, and laboratory techniques. The comparison between pre-test and post-test results was used to determine students' conceptual improvement after the practicum. The psychomotor domain was evaluated using structured observation sheets filled out by lecturers and teaching assistants during the practicum.

The aspects observed included procedural accuracy, skill in handling equipment, compliance with laboratory safety regulations, teamwork, and the ability to interpret experimental results. Scores were then converted into percentages and categorized into fair, good, or very good. Meanwhile, the affective domain was measured using a student response questionnaire based on a Likert scale, covering indicators such as learning motivation, interest, relevance of practicum activities to daily life, cooperation, and the integration of theory with practice. The students' positive responses were subsequently classified into good or very good categories to describe the overall affective achievement.

Instruments and data collection

Data were collected using three instruments: tests, observation sheets, and questionnaires. The test consisted of 15 multiple-choice questions assessing the understanding of secondary metabolite concepts. It was administered twice, before and after the practicum, as the pre-test and post-test. Observation sheets were used to assess students' laboratory skills, including procedural accuracy, equipment handling, safety compliance, teamwork, and result interpretation. The questionnaire was used to measure

students' attitudes toward the practicum using a 5-point Likert scale, covering indicators of learning satisfaction, motivation, and the relevance of the activity to everyday life.

Data analysis techniques

Quantitative data from the pre-test and post-test scores were analyzed using a paired sample t-test with SPSS software to determine the significance of improvement in learning outcomes (Padmiswari et al., 2022). This statistical method was chosen because it is specifically designed to compare the means of two related groups, namely students' scores before and after the practicum, thereby allowing the detection of significant differences attributable to the intervention. Observational data on laboratory skills were analyzed descriptively by calculating the mean score for each indicator and classifying the results into categories of

very good, good, fair, and poor. Meanwhile, data from the student attitude questionnaire were analyzed quantitatively by calculating the percentage of responses in each category, followed by descriptive interpretation to obtain an overview of students' perceptions of the mint leaf phytochemical screening practicum.

C. Results and discussion

Phytochemical screening results

The results in Table 1 indicate that mint leaf extract contains major secondary metabolites, namely flavonoids, alkaloids, saponins, tannins, and terpenoids. Color changes and precipitate formation were clearly observed, making this practicum suitable for phytochemistry learning. Phytochemical analysis data is presented in Figure 1, Table 1 and Table 2.

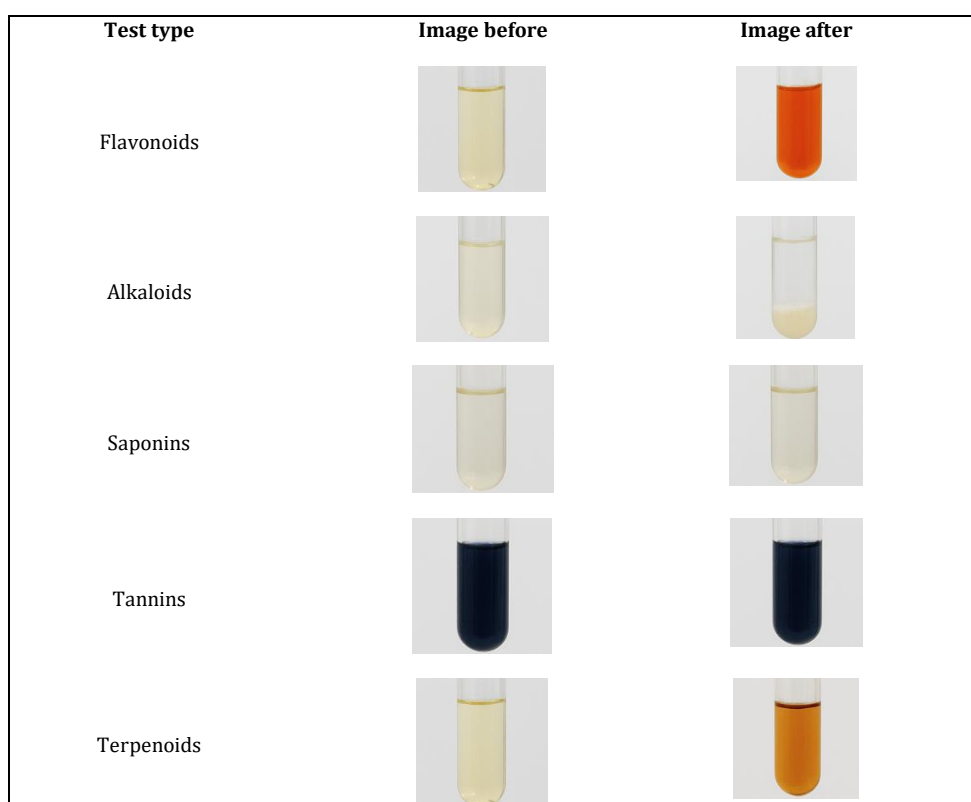


Figure 1 Phytochemical screening results color changes and precipitate formation

Table 1 Phytochemical screening results of mint leaf ethanol extract

No	Test type	Reagent	Positive control result	Mint leaf extract result
1	Flavonoids	Mg + Concentrated HCl (Shinoda)	Reddish-orange coloration	Positive (reddish-orange color)
2	Alkaloids	Mayer, Wagner, Dragendorff	White/yellow/brown precipitate	Positive (thin white to yellowish precipitate)
3	Saponins	Distilled water + shaking	Stable foam ≥ 10 minutes	Positive (stable foam for ~10 minutes)
4	Tannins	FeCl ₃ 1%	Dark blue/blackish coloration	Positive (intense dark blue-black color)
5	Terpenoids	Liebermann-Burchard	Reddish-brown ring	Positive (reddish-brown ring clearly visible)

Visual description of phytochemical tests

Table 2 presents the visual observations of phytochemical tests carried out on mint leaf ethanol extract. Each type of secondary metabolite produced

distinct and observable reactions, which varied in terms of clarity and ease of interpretation by students. The clarity levels were rated on a scale of 1 to 5, where 1 indicated very unclear and 5 indicated very clear.

Practical notes were also included to capture students' experiences and challenges during the observation

process, providing insights into the strengths and limitations of each test as a practicum activity.

Table 2 Visual observation of phytochemical tests on mint leaf extract

Compound	Visual observation	Clarity level (Score 1-5)	Practical notes
Flavonoids	Intense reddish-orange coloration	5 (very clear)	Consistently observed by all groups
Alkaloids	Thin white to yellowish precipitate	3 (moderately clear)	Some groups struggled to interpret precipitate
Saponins	Stable foam lasting ~10 minutes	4 (clear)	Results consistent, easy to observe
Tannins	Intense dark blue-black coloration	5 (very clear)	Strong and distinct color change
Terpenoids	Reddish-brown ring at the interface	4 (clear)	Intensity varied across groups

Pre-test and post-test results

Table 3 presents a comparison of students' pre-test and post-test scores to evaluate the effectiveness of the mint leaf phytochemical practicum on learning outcomes. The mean pre-test score was lower than the post-test score, indicating a marked improvement in students' conceptual understanding after participating in the practicum. Statistical analysis using a paired sample t-test revealed a significant difference ($p < 0.05$) between pre- and post-test results, confirming the positive impact of the practicum on students' cognitive achievement.

The paired sample t-test analysis showed a statistically significant improvement in students' learning outcomes after participating in the mint leaf phytochemical screening practicum. The post-test scores were considerably higher compared to the pre-test scores, indicating that the practicum effectively enhanced students' conceptual understanding. These findings confirm that the integration of practical-based activities into phytochemistry learning provides measurable benefits for cognitive achievement.

Table 3 Comparison of students' pre-test and post-test scores (n = 30)

Parameter	Pre-test (Mean $\pm$ SD)	Post-test (Mean $\pm$ SD)	p-value
Learning outcome	63.2 $\pm$ 7.8	80.4 $\pm$ 6.9	0.001*

Note: * $p < 0.05$ indicates significant difference.

Laboratory skills assessment

Table 4 presents the average scores of students' laboratory skills assessed during the mint leaf phytochemical screening practicum. The results indicate that students generally demonstrated good performance in most skill aspects, particularly in following procedures, using equipment, and

collaborating effectively in teamwork. The highest achievement was observed in laboratory safety compliance, categorized as very good, while the ability to interpret results was relatively lower, categorized as fair, suggesting an area for further improvement in practicum implementation.

Table 4 Average laboratory skill scores of students

Skill aspect	Average score (%)	Category
Accuracy in following procedures	80	Good
Skill in using equipment	78	Good
Laboratory safety compliance	89	Very good
Teamwork	83	Good
Ability to interpret results	76	Fair
Overall average	82	Good

Students demonstrated laboratory skills in the good category, with an overall average score of 82%. The highest achievement was recorded in laboratory safety compliance at 89%, which reflects students' strong awareness of safety practices during the practicum. In contrast, the lowest score was obtained in the ability to interpret results (76%), indicating the need for further guidance and reinforcement in developing students' analytical skills.

Student questionnaire results

Table 5 presents the results of the student questionnaire regarding the phytochemical screening

practicum of mint leaves. The questionnaire was designed to evaluate students' perceptions of the practicum in terms of its contribution to understanding concepts, motivation for learning, and relevance to everyday life. The responses are summarized as percentages and categorized into qualitative levels of assessment.

In general, the majority of students expressed positive perceptions of the practicum. This suggests that the mint leaf phytochemical test was not only effective in enhancing conceptual understanding but also in fostering motivation and positive attitudes toward learning.

Table 5 Students' responses to the phytochemical screening practicum of mint leaves

Indicator	Positive response (%)	Category
Practicum helped understanding concepts	87	Very good
Practicum increased learning motivation	83	Very good
Practicum relevant to daily life	85	Very good

The phytochemical screening of ethanol extract of mint leaves revealed the presence of flavonoids, alkaloids, saponins, tannins, and terpenoids. These findings are consistent with Tafrihi et al. (2021), who reported that *Mentha* sp. contains major secondary metabolites with antioxidant, antibacterial, and anti-inflammatory activities. The presence of flavonoids and tannins strongly indicates the potential of mint leaves as contextual learning media, as the visual results of the tests were clear and easily observed by students. Thus, this practicum provided concrete empirical evidence to explain the role of secondary metabolites. In addition, practical-based learning processes are effective in improving students' knowledge (cognitive domain) by reinforcing theoretical concepts through direct observation, enhancing skills (psychomotor domain) through hands-on laboratory work and the use of scientific equipment, and developing attitudes (affective domain) such as teamwork, responsibility, and appreciation of safety in the laboratory. Together, these aspects demonstrate how phytochemistry practicums serve as integrative learning experiences that support the holistic development of students.

The increase in students' average pre-test and post-test scores demonstrated the effectiveness of the practicum in enhancing conceptual understanding. Statistical analysis showed a significant difference ($p = 0.001$), suggesting that the phytochemical screening practicum successfully improved mastery of the subject matter. This result aligns with the findings of Li, B. et al. (2020), who stated that project-based practicums significantly improved students' biochemical understanding. In other words, the inquiry-based approach employed in this practicum had a real impact on student learning outcomes. Beyond cognitive aspects, students' laboratory skills also showed improvement. Observations indicated that procedural accuracy, laboratory safety, and teamwork were rated as good. This supports the findings of Khery et al. (2025), who reported that phytochemistry practicums using local plants enhanced students' laboratory skills and scientific attitudes. However, in this study, color interpretation skills were relatively lower (76%), highlighting the need for instructors to emphasize result analysis skills more strongly.

The questionnaire results revealed positive student responses, with the majority agreeing that the practicum helped them understand concepts, increased motivation, and was relevant to everyday life. This demonstrates that practicums with tangible and contextual objects such as mint leaves can

stimulate learning interest. Sudarmin et al. (2023) also confirmed that real-world experiential practicums are more effective in improving student motivation compared to purely theoretical learning. Thus, phytochemical screening using medicinal plants holds potential as an innovative strategy in biology and pharmacy education. Overall, the findings of this study confirm that phytochemical screening using local plants is valuable not only scientifically but also pedagogically. This approach integrates cognitive, psychomotor, and affective aspects simultaneously. In other words, this study fills an existing gap, namely the limited use of mint as a practicum medium for phytochemistry among clinical and community pharmacy students.

In addition to contributing to knowledge and skills, the mint leaf phytochemistry practicum also holds strategic value in linking biological concepts with community pharmacy applications. Active compounds detected, such as flavonoids and terpenoids, served as tangible examples for students of how laboratory results are related to the pharmacological benefits of plants (Fitriani et al., 2024). This finding is consistent with Hadisaputra et al. (2020), who emphasized that context-based learning experiences help students connect theory with professional practice (Ardiansyah et al., 2023).

From the perspective of knowledge (cognitive domain), practical-based learning reinforced conceptual understanding by providing direct empirical evidence that secondary metabolites such as flavonoids and tannins can be visually observed through clear color reactions. This process supported theoretical mastery of phytochemistry while simultaneously strengthening students' ability to connect abstract biological concepts with pharmacological applications (Padmiswari et al., 2025).

Regarding skills (psychomotor domain), the practicum trained students in using laboratory equipment, following standardized procedures, and interpreting experimental outcomes. The development of technical competence was evident in the laboratory skill scores, with strong performance in laboratory safety and procedural accuracy. This aligns with Jakubčínová et al. (2024), who reported that hands-on organic compound extraction experiments enhance analytical competence and scientific communication skills.

In terms of attitudes (affective domain), the practicum promoted positive scientific dispositions such as teamwork, responsibility, and an appreciation of laboratory safety protocols. Moreover, it fostered

motivation and critical thinking by requiring students to interpret and discuss results argumentatively in academic forums. This resonates with Li, M. et al. (2020), who highlighted that laboratory-based learning not only develops conceptual understanding but also builds soft skills relevant to workforce demands.

These findings suggest that phytochemistry practicums using local plants such as mint leaves effectively enhance cognitive, psychomotor, and affective domains. They serve not only as a medium for conceptual mastery but also as a platform for cultivating professional skills and attitudes that are essential for future pharmacists and biologists.

Moreover, the integration of phytochemistry practicums with local wisdom provides added value from the perspective of contextual education. The use of mint leaves as the research object demonstrated that local biological resources can serve as authentic learning media (Susanti et al., 2021). This strategy is in line with Gutiérrez-García et al. (2024), who emphasized that the use of aromatic plants in science education can strengthen ethnobotanical literacy and foster students' connection with their environment. In this way, phytochemical practicums not only improve academic performance but also instill ecological awareness and appreciation for local biodiversity. On the other hand, this study also highlights the need for digital technology integration to support laboratory activities (Hakim et al., 2020). Although the results showed significant improvements, the aspect of result interpretation remained relatively weak. According to Jongsma et al. (2024), the use of digital pre-lab modules can better prepare students for experimental procedures and enhance analytical skills. Therefore, future studies could combine direct practicums with digital pre-lab materials to strengthen students' ability to interpret experimental results.

D. Conclusion

The results of this study demonstrate that phytochemistry practicums using local plants are effective in significantly enhancing students' laboratory skills while simultaneously fostering scientific attitudes. The use of naturally available materials from the surrounding environment not only strengthens conceptual understanding of secondary metabolites and bioactive compounds but also promotes scientific process skills through direct experimental activities. Furthermore, students' engagement in practicum activities based on local contexts was proven to cultivate critical thinking, curiosity, responsibility, and awareness of local biodiversity potential. Therefore, phytochemistry practicums utilizing local plants can be recommended as an innovative learning strategy in biology education to prepare competent, character-driven, and environmentally aware future educators and scientists.

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