Bridging the generational gap: Exploring youth understanding on ethnobotanical knowledge and its integration in higher education curricula

Rinto Rinto, Retno Sri Iswari, Budi Naini Mindyarto and Sigit Saptono

Correspondence

Rinto Rinto[1,2], Retno Sri Iswari[1,3], Budi Naini Mindyarto[1,4] and Sigit Saptono[1,3]

[1]Doctoral Student, Department of Science Education, Graduate School, Universitas Negeri Semarang, Semarang City, Central Java, Indonesia.
[2]Universitas Muhammadyah Cirebon, Cirebon, West Java, Indonesia.
[3]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Semarang City, Central Java, Indonesia.
[4]Department of Physic, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Semarang City, Central Java, Indonesia

*Corresponding Author: rintogreat@gmail.com

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Research

Abstract

Background: Current ethnobotanical knowledge in Indonesia is declining among the younger generation, particularly university students. Therefore, embedding ethnobotanical knowledge in the formal education curriculum is essential to enhance young awareness of their traditional ecological knowledge. This study aims to analyze ethnobotanical knowledge in undergraduate students as a fundamental step to developing a reliable ethnobotanical learning curriculum in higher education.

Methods: This observational exploratory study involved 192 Science Education (SE) and Primary School Teacher Education (PSTE) students in Cirebon District, West Java, Indonesia. An open survey method, employing an online questionnaire, was used to obtain data on ethnobotany knowledge and cognitive competencies.

Result: The study results revealed that ethnobotany knowledge in students only reached less than 62.00 points, or moderate to low achievement. Furthermore, cognitive ability related to ethnobotanical knowledge barely got 50% across all levels, except for analytical ability ranging from 59-69%, and creating ability resulted in 0%. Most respondents discovered it challenging to use the concept of ethnobotany to identify new botanical discoveries and the application of ethnobotany in daily life. Furthermore, the respondent understands their weaknesses regarding cognitive perspective and initiate technology-based learning to overcome them.

Conclusion: Integrating technology in an ethnobotany-based curriculum can increase identification ability and explore related learning resources to make learning easier for students. Therefore, it is necessary to conduct further studies in developing learning models to increase ethnobotany knowledge through technology.

Keywords: ethnobotany, prospective teacher, traditional knowledge, young generation,

Background

The diversity of plants influences cultural life and society in diverse locations in Indonesia. The application of beneficial plants in indigenous communities is traditionally utilized by humankind, mainly for medicinal materials (Mutaqin *et al.* 2020). This knowledge summarizes the hundred years of interaction between communities (ethnicities) and native plants representing each region's characteristics, known as ethnobotany (Amboupe *et al.* 2020). The study of ethnobotany has recently evolved into a review of interpretations and associations that investigate human interrelationships to protect natural resources (Anggraini *et al.* 2018).

A recent study found that the ethnobotanical knowledge of the younger generation tended to decrease, whereas the older generation acquired more original knowledge about medicinal plants. Furthermore, the erosion of ethnobotanical knowledge has also occurred to the plant species as insecticides for agriculture (Pila and Maqueda, 2023). Socio-cultural factors such as modernization and globalization are justified in influencing traditional medicinal plant knowledge worldwide (Dapar and Alejandro 2020). Gradually, it reduces the cultivation and harvesting of medicinal plants, threatening the sustainability of potential remedies (Weckmüller *et al.* 2019a). Furthermore, ethnobotanical knowledge is tightly linked to cultural identity and heritage; losing it may intensely decrease a sense of indigenous cultural connection (Constant and Tshisikhawe 2018; Spennemann 2022). The accumulated traditional knowledge in the community about sustainable use of the environment and natural resources might fade out due to decreased ethnobotany knowledge (Dapar and Alejandro 2020; Mattalia *et al.* 2021; Alves *et al.* 2022). Losing traditional knowledge also has a significant impact on biodiversity loss (Ali 2021), as well as a lack of alternative livelihood for villagers (Kumar *et al.* 2021; N'Woueni and Gaoue 2021; Kusumawati *et al.* 2022).

The globalization and modernity era significantly decline ethnobotany knowledge globally, especially among the young generation (Beltrán-Rodríguez *et al.* 2014). It needs to be countered by proactive initiatives, particularly for undergraduate students as prospective teachers. At present, the integration of ethnobotanical knowledge into Indonesia's university curriculum is reflected in ethnobotany-related subjects, including Plant Morphology, Anatomy, and Physiology; Plant Taxonomy and Biosystematics; and Plant Ecology and Biodiversity. Also, it is widely delivered to specific majors, such as Science Education (SE), Biology, and Primary School Teacher Education (PSTE) students, who are prepared as prospective educators in the future. It is because teachers are the lead actors in the education field who deliver the importance of ethnobotanical knowledge to the young generation (van Luijk *et al.* 2021). Even though ethnobotanical knowledge is mainly used as a learning supplementation, it has varied scopes and learning objectives that must be planned comprehensively through identifying and mapping related-local potential.

On the other hand, integrating ethnobotanical knowledge into the higher education curricula implicates diverse learning objectives among different majors. Even though the subjects are identical, it may trigger different results in concept understanding, learning achievement, and outputs. For example, if the learning curriculum for SE and PSTE differs, the ethnobotanical knowledge should be assessed and developed to make it relevant to their traditional knowledge. Integrating ethnobotanical and modern knowledge in formal education can be improved by conducting early assessments to understand student needs, basic knowledge about ethnobotany, and the suitability of cognitive competence. Hence, this study aims to analyze ethnobotanical knowledge in undergraduate students as a fundamental step to developing a reliable ethnobotanical learning curriculum in higher education. This study is an essential baseline to develop an adaptable, practical, and efficient ethnobotany learning model in higher education. It is intended to help students become more aware of the ethnobotanical potential in their surroundings using a curriculum developed by considering students' basic knowledge and understanding (student-based learning).

Materials and Methods

This observational research explored students' fundamental understanding of ethnobotany and related cognitive competencies. The data collection method used in this study was an open survey using an online questionnaire through the Google Form platform. A total of 192 students from Science Education (SE) and Primary School Teacher Education (PSTE) student from Universitas Muhammadiyah Cirebon, West Java, Indonesia, were involved as respondents. Respondent's academic background, including the level of study, grade point average (GPA) scores, and participation in ethnobotany-related subjects, were identified and used for data grouping and calculation.

Development of Questionnaire

Self-assessment of ethnobotanical knowledge was conducted using an online questionnaire consisting of 38 questions developed from the minimum standard of learning competencies in ethnobotany and ethnobotany-related subjects (Table

1). The questions were then adjusted according to the cognitive levels based on Bloom's taxonomy classification (Elangovan and Sundaravel 2021) using dichotomous answers and scale following Guttman (1944)

Table 1. Developed standard competencies of ethnobotanical knowledge for the questionnaire.

Ethnobotany Related Subject	Minimum Competencies Standard
Morphology	- Recognizing the characteristics of plant morphology. (M1)
	- Gaining insight into the variations in morphological features among different species. (M2)
Anatomy	- Capable of correlating anatomical traits with the plant's adaptive capabilities. (A1)
	- Understanding the relationship between the function and structure of cells, tissues, and organs. (A2)
	- Comparing the variations in tissue and organ structures among plant species. (A3)
Physiology	- Understanding the mechanisms of plant adaptation. (P1)
	- Understanding the role of cells, tissues, and organs in plant physiological interactions. (P2)
	- Identifying potential secondary metabolites as medicine. (P3)
Taxonomy and Biosystematics	- Understanding the classification concepts of Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms. (T1)
	- Applying morphological characteristics in the taxonomic classification system of plants. (T2)
Ecology and Biodiversity	- Understanding the vital role of plant biodiversity in the surrounding environment. (E1)
	- Understanding the role of plants in ecological functions. (E1)
	- Understanding actions involved in plant conservation. (E2)
	- Understanding the concept of sustainable plant utilization in daily life, such as for health, agriculture, etc. (E3)

Several local plant species were used in generating the question because of their common function for medicinal purposes, infrastructure, and culturally related reasons. A detailed explanation of each plant species is described in Table 5. Then, the developed instrument was subsequently tested on 30 participants, consisting of fifth-semester PTSE students who had taken ethnobotany-related subjects in the previous semester. The data obtained from the trial phase was then used to calculate the validity, reliability, level of difficulty, and item discrimination power of the questionnaire.

The appropriateness of test items

Validity and reliability test

The validity of the questionnaire is indicated by the correlation of each item with the total item score and analyzed using two-tailed Bivariate Pearson analysis (Pearson Product Moment). The analysis was performed with a confidence level of 95% and a significance level (sig.) of 0.05. The total item score refers to the sum of all item values. Descriptors or questions that significantly correlate with the total score were considered appropriate items to use and included in the questionnaire. The item is valid if the value of rcalculated ≥ rtable or sig. p-value) ≤ 0.050.

The reliability of the instruments is performed by the reliability coefficient value that approaches a score of 1.00. The reliability testing of instruments was carried out using the Cronbach Alpha analysis because the research instruments were questionnaires and rating scales. The sufficient reliability of the Cronbach Alpha used in this research was considered as α-value ≥ 0.70 (Table 2). Furthermore, the items were reliable and consistently robust for application as a measurement instrument when the α-value is higher than 0.80. The questionnaire is deemed unreliable if the α-value is lower than 0.70. All validity and reliability analysis stages for the questionnaire items were conducted using SPSS var. 23.

Table 2. The outcomes from the instrument's reliability test

Cronbach's Alpha	N of Items	Interpretation
0.800	31	Very Reliable

Item difficulty index (DL)

Item difficulty analysis is a process that examines student responses to individual test items to assess the quality of those items and the test as a whole. The difficulty index (DI) was measured using formula 1:

$$P = \frac{B}{JS}$$ Formula 1

Description:

P = Item difficulty index.

B = The number of students who answered the question correctly.

JS = The total number of students who took the test.

The calculated results were interpreted according to the criteria specified in Table 3:

Table 3. Criteria for the difficulty index scores of question items

DL score	Interpretation
DL < 0,30	Hard
0,30 ≤ DL ≤ 0,70	Moderate
DL > 0,70	Easy

Item discrimination power (DP)

Item discrimination power was employed to determine how effectively the test items differentiate between students' understanding of the test. DP was calculated using Formula 2. The trial test scores were ranked from highest to lowest, and 27% of the total students were selected for the upper and lower groups (Karim *et al.* 2021).

$$DP = \frac{B_A}{J_A} - \frac{B_B}{J_B} = P_A - P_B$$ Formula 2

Description:

J = Total number of test participants.

J_A = Total number of test participants.

J_B = Total number of test participants.

B_A = Number of participants in the upper group who answered the question correctly.

B_B = Number of participants in the lower group who answered the question correctly.

$P_A = \frac{B_A}{J_A}$ = Proportion of upper group participants who answered correctly.

$P_A = \frac{B_B}{J_B}$ = Proportion of lower group participants who answered correctly.

The results of the DP calculation were interpreted following the criteria provided in Table 4.

Table 4. Criteria scores for the discrimination power items of question

DP Score	Interpretation
DP ≥ 0.70	excellent (used)
0.40 ≤ DP < 0.70	good (used)
0.20 ≤ DP < 0.40	Mediocre (used)
DP < 0.20	worse

The eligibility of each question item was determined based on four parameters: validity, reliability, DL, and DP. The items that failed to meet these criteria were removed from the questionnaire and not included in the ethnobotany knowledge assessment. After the feasibility analysis, eight items were found to be invalid, resulting in the utilization of only 30 items for evaluating ethnobotany knowledge among SE and PTSE students (Table 5).

Data Analysis Method

The data obtained from all classes were tabulated, reduced, and analyzed descriptively and quantitatively to distinguish the ethnobotanical knowledge and cognitive comprehension between SE and PTSE students. The correlation between the questionnaire scores and cognitive results, indicating the level of ethnobotany comprehension, was analyzed using Pearson’s correlation analysis. At the same time, the Mann-Whitney test was employed for the variant comparative analysis. All statistical analyses were performed using SPSS var. 23, with a confidence level of 95% and a significance level (p-value) of < 0.050. Then, the results of the statistical tests were narratively explained to describe and analyze ethnobotany knowledge

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Table 5. The structure of the questions and validation of the instrument used in the study

Question's Topics	MCS	BTL	Validity (R score)	Criteria	DL	Criteria	DP	Criteria	Reliability
1. Diversity of bamboo plants (mostly used for house structure), etc. bambu ampel (*Bambusa vulgaris*), bambu hitam (*Gigantochloa atroviolacea*), and bambu tali (*Gigantochloa apus*)	T1; E1	C	0.339	valid	0.400	moderate	0.333	mediocre	0.800 Reliable
2. Case study: An experiment on observing morphological characteristics for plant classification and biosystematics.	T2	C4	0.332	valid	0.444	moderate	0.500	good	
3. Diversity, classification, and functions of popular agroforestry plant in Indonesia: sonokeling (*Dalbergia latifolia*), secang (*Caesalpinia sappan*), and angsana (*Pterocarpus indicus*).	T1; E1	C4	0.354	valid	0.222	hard	0.250	mediocre	
4. Classifying plant species into one family using leaf shape and venation characteristics is preferred.	M2; T2	C3	0.324	valid	0.311	moderate	0.333	mediocre	
5. Morphology and flower structure in the Rutaceae family as distinguishing characters between species.	M2; T2	C2	0.306	valid	0.733	easy	0.417	good	
Question for no. 6-10. The student asked to verify a statement that was generated from the data.									
6. Effect of the soil characteristic toward sprout growth.	P1	C5	0.335	valid	0.422	moderate	0.333	mediocre	
7. Germination is easier when seeds are planted deeper into the growing medium.	P1	C5	0.342	valid	0.444	moderate	0.417	good	
8. Watering frequency increases the germination rate of *Adenium swazicum*.	P1	C5	0.494	valid	0.622	moderate	0.667	good	
9. High light intensity increases the survival rate of *Adenium swazicum* sprouts. *	P1	C5	0.109	invalid					
10. Creating a conclusion from a dendrogram/ phylogenetic graph of Gymnospermae and Angiospermae morphology.	T2	C4	0.355	valid	0.533	moderate	0.500	good	
Question for no. 11-14. The student asked to analyze plant specimen photos.									
11. *Aquilaria malaccensis* has compound leaves.	M1	C1	0.335	valid	0.422	moderate	0.333	mediocre	
12. *Aquilaria malaccensis* has zygomorphic floral symmetry.	M1	C1	0.386	valid	0.600	moderate	0.500	good	
13. *Aquilaria malaccensis* has flowers with a hypogynous flower decoration type.	M1	C1	0.372	valid	0.289	hard	0.333	mediocre	
14. *Aquilaria malaccensis* has aggregate fruit characterized by more than one carpel.	M1	C1	0.397	valid	0.822	easy	0.333	mediocre	
Question for no. 15-18. The student was asked to verify the statement generated from the data.									
15. The shoot apical meristem is a source of auxin and a sink for sugar.	A2; P2	C4	0.368	valid	0.756	easy	0.333	mediocre	

Question's Topics	MCS	BTL	Validity (R score)	Criteria	DL	Criteria	DP	Criteria	Reliability
16. Losing shoot apex causes lower expression of the BRC1 gene (a gene controlling axillary shoots' growth).	P2	C4	0.400	valid	0.733	easy	0.583	good	
17. Apart from the apex of the shoot, auxin is also produced by growing axillary buds.	A1	C4	0.401	valid	0.778	easy	0.500	good	
18. Sugar redistribution from the shoot apex to the branch provides growth energy.	A3	C4	0.316	valid	0.844	easy	0.417	good	
Question for no. 19-22 The student asked to analyze plant specimen photos.									
19. Identifying plant taxa from the morphology presented in the figure.	M1	C2	0.358	valid	0.400	moderate	0.417	good	
20. Determining the organ from the anatomical characteristics presented in the microscopic images of stem dissection.	A2	C2	0.443	valid	0.844	easy	0.417	good	
21. Identifying vascular tissue from the microscopic images of stem dissection.	A3	C2	0.446	valid	0.356	moderate	0.750	excellent	
22. Identifying plant life adaptation model from the anatomical structure.	T2	C3	0.518	valid	0.822	easy	0.583	good	
23. Analytical question: Correlating and creating a conclusion from three related premises about Gymnospermae's reproductive organ for plant grouping. *	T1	C4	-0.191	invalid					
24. Diversity of morphological characteristics of beneficial Poaceae members found in the surrounding environment.	M2; T1	C2	0.334	valid	0.778	easy	0.333	mediocre	
25. Graphical scheme of natural resources and deforestation and timber exploitation, and its effect on biodiversity and sustainable forest management	E4	C5	0.462	valid	0.400	moderate	0.583	good	
26. Determining plant species relationship based on the flower characteristics presented in a table. *	T2	C4	-0.201	invalid					
Question for no. 27-29 for analytic story problems: Students are asked to evaluate three relevant questions about the banana plant's anatomical structure, physiology, and benefits. The questions are:									
27. Secondary metabolite in banana leaves is widely used as a potential medicinal compound. *	P2; P3	C6	-0.139	invalid					
28. What is the microscopic structure of a banana plant root?	A2	C3	0.430	valid	0.844	easy	0.417	good	
29. What benefits does the banana tree bring to your daily life?	E1	C3	0.481	valid	0.844	easy	0.417	good	
30. Explained the processing of herbal medicines from Indonesian medicinal plants, such as sambiloto (*Andrographis paniculate*).	P3; E4	C4	0.326	valid	0.333	moderate	0.417	good	

Question's Topics	MCS	BTL	Validity (R score)	Criteria	DL	Criteria	DP	Criteria	Reliability
31. Explaining at least three advantages of palm trees (*Cocos nucifera*) in the community.	E4	C2	0.304	valid	0.622	moderate	0.417	good	
32. Explaining mimba (*Azadirachta indica*) leaves processing for organic insecticide.	E4	C3	0.317	valid	0.422	moderate	0.333	mediocre	
33. Analysis of teak morphology-physiology and its role in pest, drought, and climate change adaptation. *	A1; A2; P1	C6	-0.290	invalid					
34. Morphological structure comparison and the analogy between Pteridophyte and Spermatophyte.	P2; M1	C4	0.417	valid	0.867	easy	0.250	mediocre	
35. The fundamental concept for scientific naming in the binomial nomenclature system. In this question, focus on the teak plant. *	T1	C2	-0.287	invalid					
36. The destructive effect of logging on erosion and soil nutrition leaching.	E3	C4	0.338	valid	0.578	moderate	0.500	good	
37. Understanding the effect of invasive species on the plant's habitat and wildlife conservation. *	E2; E3	C4	0.059	invalid					
38. Correlation of the plant modification structure and adaptation capability: a case study of *Zingiber officinale* for herbs and traditional medicine (a knowledge from local people).	M2; A1	C5	0.337	valid	0.511	moderate	0.417	good	

Note: MCS = minimum competencies standard; BTL = Bloom's taxonomical level; DL = item difficulty level; DP = item discrimination power. The star mark (*) refers to invalid and discharged item from the questionnaire instrument.

Result and Discussion

According to the research findings, 197 respondents comprised 65 students from SE and 127 from PTSE. This respondent's number disparity was attributed to the varying number of classes in each department at the sampled university. Moreover, the respondents were mainly female students, constituting more than 73% of the total students in the SE class and over 85% of the total students in the PTSE class. The respondents represented diverse academic levels, with the oldest being three students in the fifth semester of the SE class. In contrast, the highest academic level among PTSE respondents was in the third semester (Table 6).

Table 6. The distribution of respondents based on their academic periods

Aspect	Respondents									
	Science Education (SE)					Primary School Teacher Education (PSTE)				
	M	%	F	%	Total	M	%	F	%	Total
Total	17	26.15	48	73.85	65	19	14.961	108	85.04	127
Semester										
1	9	13.85	11	16.92		6	4.72	26	20.47	
3	5	7.69	25	38.46		13	10.24	81	63.78	
5	3	4.62	12	18.46		-	-	1	0.79	
Ethnobotany related subjects										
Enrolled	3	4.62	12	18.46		12	9.45	70	55.12	
Have not enrolled	14	21.54	36	55.38		7	5.51	38	29.92	

Note: Plant morphology, Anatomy, Taxonomy, Biosystematics, Ecology

The number of respondents with more extended academic periods is unrelated to those who had taken ethnobotany-related subjects, including Plant Morphology, Anatomy, Physiology, Taxonomy and Biosystematics, and Ecology and Biodiversity. Differences in syllabus and curriculum structures in each department and faculty cause it. The ethnobotany-related subjects and ethnobotanical knowledge were first introduced in the fifth semester for SE respondents and the second semester for PTSE. The ethnobotany knowledge assessment revealed that students from both groups had a similar result; it indicates that ethnobotanical knowledge is not well-established among SE and PTSE students (Table 7).

Table 7. The outcomes of the ethnobotany knowledge assessment in both classes

Criteria	SE		PSTE	
	Value	Category	Value	Category
Ethnobotanical knowledge score				
Average	61.32 ± 2.07	Moderate	61.47 ± 2.17	Moderate
Highest	77.42		77.65	
Lowest	38.71		32.26	
Category (student)				
Low	5	7.69 %	17	13.39 %
Moderate	56	86.15 %	87	68.50 %
High	4	6.15 %	23	18.11 %
GPA				
Average	3.62 ± 0.07	High	3.62 ± 0.03	High
Highest	4.00		4.00	
Lowest	3.00		3.00	
Category				
Low	3	4.62 %	0	-
Moderate	62	95.38 %	24	18.90 %
High	-	-	103	81.10 %

This study also depicts no significant correlation between students' ethnobotanical knowledge scores and GPA. The average ethnobotanical knowledge scores for both respondent groups were below 62.00 points and categorized as a moderate category tends to low. Only 6.15% of total students in SE and approximately 18% of total respondents in PTSE achieved high scores in ethnobotanical knowledge. Furthermore, the student's GPA for the current semester was rated high, with an average score of 3.62 points.

The significant difference in knowledge scores between SE and PTSE groups indicates that the students shared a similar understanding of ethnobotanical knowledge. The research findings showed that only around 60% of the required knowledge is achieved, which is still categorized as below the minimum threshold score of knowledge students should possess. Furthermore, variant different analysis using the Mann-Whitney test reveals no significant correlation between ethnobotanical knowledge and GPA scores in both classes (Table 8).

Table 8. The results of the test for variance equality of GPA and ethnobotany knowledge scores among SE and PTSE students

	GPA	EK
Mann-Whitney U	2583.000	2896.500
Wilcoxon W	7143.000	4976.500
Z	-1.608	-.507
Asymp. Sig. (2-tailed)	.108	.612
a. Grouping Variable: kelas		

Note: Variant difference analysis using the Mann-Whitney test shown by Asymp. Sig value (2-tailed) ≤ 0.050, at a 95% confidence level.

Recent studies have shown that disruptions in ethnobotanical knowledge mostly happen due to the age gap and decreased intergenerational social transmission of knowledge (Hanazaki *et al.* 2013). Furthermore, several factors, such as modernization, promote easy medical access (Shaheen *et al.* 2023), acculturation (Aparicio *et al.* 2021), globalization and infrastructure development (Weckmüller *et al.* 2019b), insufficient multistakeholder partnerships, educational systems, and tough-minded knowledge practice (van ’t Klooster *et al.* 2019; Latulippe and Klenk 2020), have contributed to the decline in ethnobotanical knowledge among the younger generation.

Similar to the previous study, this research shows low ethnobotany knowledge may relate to the lack of practical incorporation of traditional knowledge in formal education. It is justified by the absence of a significant correlation between students' cognitive and ethnobotany scores (Table 9). This result indicates that formal education probably does not prioritize integrating traditional ecological knowledge, including ethnobotany, into the modern higher education curriculum.

Table 9. The outcomes of the correlation analysis between GPA and ethnobotany knowledge (EK) in the SE and PTSE group

		SE		PTSE	
		GPA	EK	GPA	EK
GPA	Pearson Correlation	1	.166	1	-.041
	Sig. (2-tailed)		.191		.695
	N	64	64	95	95
EK	Pearson Correlation	.166	1	-.041	1
	Sig. (2-tailed)	.191		.695	
	N	64	64	127	135

Note: significant correlation was represented by the Sig value (2-tailed) ≤ 0.050, at a 95% confidence level

The assessment findings demonstrated that the cognitive competencies of both SE and PTSE students were approximately 50% for all levels of cognitive learning, except for the sixth competence: create (C6) (Fig. 1). Cognitive competencies refer to the abilities of individuals or groups to acquire, process, and apply knowledge effectively (Salman *et al.* 2020); in this study, the cognitive competencies are related explicitly to ethnobotanical knowledge.

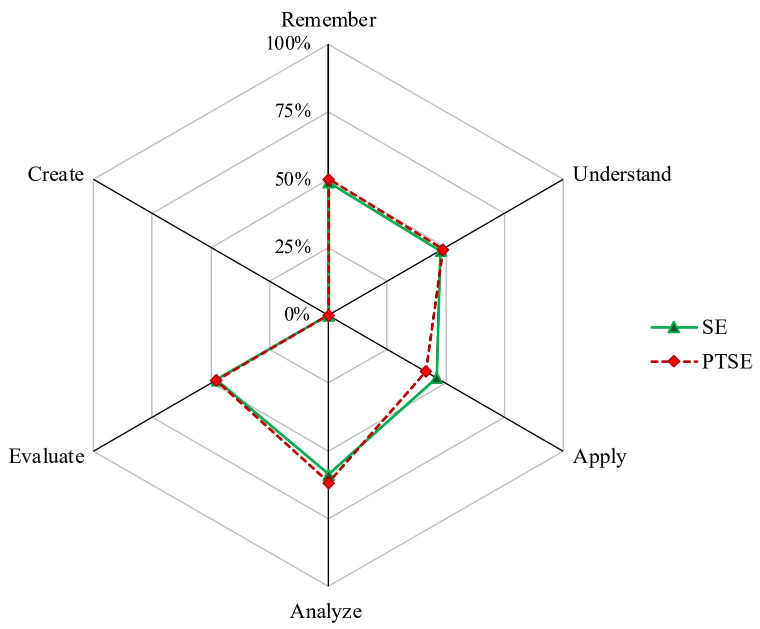

Figure 1. Distribution of ethnobotany knowledge achievement based on the hierarchy of cognitive competency levels in Bloom's taxonomy.

According to the cognitive competency hierarchy analysis, the ethnobotany-based cognitive competencies are considered as moderate to low category, with achievement scores remaining below 50%, except for the fourth competency: analysis (C4). This suggested that the cognitive development of concepts and knowledge in ethnobotany is not well-established in the sample higher education. Most respondents can recall basic ethnobotanical information-theoretically, such as plant names, traditional uses, and cultural practices. Nevertheless, students faced challenges when identifying plants and medicinal functions presented through morphological, physiological, and ecological data and photos. Further investigation is required to identify potential discrepancies between students' cognitive abilities regarding ethnobotany knowledge and their capacity to understand and interpret data.

A recent study indicated that ethnobotany is recognized as proprietary knowledge, encompassing information, data, or knowledge exclusively owned by individuals or communities in a particular location or institution (Lightner *et al.* 2021). Ethnobotanical knowledge is typically exclusive and varies based on specific regions' characteristics and natural resources. For example, certain community groups in the Philippines use rice as a medicinal plant (Cabanting and Perez 2016). Another example of ethnobotany exclusivity is using certain plants for traditional ceremonies in Balinese society in Indonesia that may not be found in other places (Ratnani *et al.* 2021). Frequently, ethnobotanical information is not widely available or accessible due to the restrictions set by the owners. It inhibits fact dissemination and reduces knowledge among younger generations, putting its valuable knowledge at risk of vanishing. Besides, the transferred knowledge played a vital role in preserving cumulative culture, including ethnobotany (Kobayashi *et al.* 2016; Salali *et al.* 2016; Lightner *et al.* 2021; Scalise Sugiyama and Reilly 2023 Feb).

This study found that respondents understood the principles and concepts that underlie ethnobotanical knowledge. However, they faced challenges in elucidating the connection between plants and their traditional uses within cultural contexts. This shortcoming could be attributed to information limitations and the transfer of ethnobiological knowledge from older generations with cultural heritage. For example, students struggled to articulate how a community's beliefs and cultural practices impact the selection and utilization of particular plants for rituals or healing purposes. This may have contributed to the drop in scores for application skills (C3).

The improvement for the fourth competency, analysis (C4), is attributed to the ability of SE and PTSE students to break down complex case study questions concerning intricate ethnobotanical information. They could elaborate on information and employ problem-solving mechanisms to explain the detailed components of ethnobotany. Respondents adeptly expound on the relationships between various plants used for cultural practices and medicinal purposes and the environmental impacts. Respondents can assess valid and reliable information from ethnobotanical knowledge sources presented in the questionnaire. However, they had no ideas to criticize and evaluate traditional practices and tended to accept the facts in the questionnaire. Nevertheless, respondents from both classes demonstrate an understanding of the challenges associated with comprehending ethnobotanical knowledge (Table 10).

Table 10. The students respond against common challenges in ethnobotany knowledge and ethnobotany-related learning.

Student ideas	SE	PTSE
Interpretation of ethnobotany	Most SE students expressed that ethnobotany was a field of study that examined the relationship between humans, culture, and the utilization of plants in various aspects of society, such as for health, religious, aesthetic, and agricultural purposes.	PTSE students described ethnobotany as a multidisciplinary field focused on the traditional use of different environments and types of plants by societies.
Identification system	1. Improving the ability to recognize plants could involve creating an instrument or app for plant identification, which included plant morphology traits linked to the internet 2. Training on plant observation, identification, and classification of valuable and uncommon species would offer advantages to the community.	Developing a classification system according to the practical benefits of plants. For instance, the student categorizes ginger, cinchona, eucalyptus, and ginseng as medicinal herbs. Meanwhile, plants like roses, jasmine, and orchids are classified as the ornamental plant group.
Plant sustainable usage	Optimally and moderately utilizing plants, forest areas, and non-timber environmental services for the well-being of society while ensuring their sustainability and preservation.	The utilization of forest plants for medicinal purposes, construction materials, and other applications should be made sustainably, taking only what is necessary to prevent depletion. This should be balanced with the conservation of the forest ecosystem to ensure the continuous growth of plants.
Conservation action	1. Applying a harvest-and-replant strategy, utilizing non-timber forest resources like coffee, palm sugar, honey, etc. 2. Initiating advocacy and information dissemination through seminars.	Offering education about plant biodiversity to instill a sense of responsibility among the populace for preserving natural resources and, subsequently, arranging inclusive conservation efforts that involve the community.

Note: Open interviews were used to collect the data.

The fact collected from the interview deduces that students fundamentally grasped the concepts of ethnobotany and actions to preserve beneficial plants. However, the problem they face, especially in learning about ethnobotany, is identifying and using strategies for potential plant utilization. In addition, the current learning models and methods, through classical discussions and not yet fully integrated into the curriculum, are considered less relevant for studying potential plants around them. Therefore, it is necessary to improve learning in terms of curriculum and learning models and methods.

Universities need to accommodate the development of ethnobotany and traditional knowledge into related subject curricula. This is an effort to develop the ability to process knowledge rooted in tradition into a scientific form, otherwise known as scientific processing ability. The ability to process science is important so that students can fully understand the application of science (Juhji and Nuangchalerm 2020) while preserving ethnobotanical knowledge. Science Process Skills are complex abilities to conduct scientific investigations in a series of learning processes involving cognitive or intellectual, manual, and social skills.

By implementing ethnobotany knowledge as the foundation of learning in formal education, it is hoped that it can develop science process skills because it involves students directly practicing knowing their cultural roots. Ethnobotanical studies provide social and natural experimental tools that promote meaningful learning and develop critical thinking skills. Creative thinking is setting, finding, and creating new, aesthetically pleasing combinations (Hardy *et al.* 2017). Creative thinking skills can be constructive based on data, information, and existing elements and as a manifestation of perceived problems, resulting in valuable solutions (Palmiero *et al.* 2020; Proctor 2020). The integration of ethnobotany knowledge in formal education is expected to form students who can respond creatively to social and environmental changes in the future without losing their cultural roots.

Ethnobotany knowledge can be integrated with modern science in various fields(Wikantika *et al.* 2022), extending to ongoing learning across different educational stages (Zidny and Eilks 2020; de Beer and Kriek 2021). Nonetheless, adopting ethnobotanical knowledge in the formal education curriculum must accommodate the needs and knowledge of community members (Georgiadis 2022; Khan *et al.* 2023). This cooperation can be built by involving local communities to identify valuable and potential plants according to their daily lives. In addition, this will undoubtedly teach students how to foster good social relations.

Several studies have also demonstrated a science curriculum model by adopting ethnobotany knowledge as one of the models, topics, and basis of analysis. For example, ethnobotanical knowledge is used as a module for studying biodiversity to improve problem-solving abilities (Fattahillah *et al.* 2023). Furthermore, studies on ethnobotany have also justified the effectiveness of ethnobotany as a learning media to improve student outcomes (Kasrina and Zukmadini 2021), literacy, and creative thinking skills (Sari *et al.* 2020). The ethnobotanical and traditional knowledge of the local community has also proven to provide basic knowledge about potential plants that can be further managed for the treatment of diseases (Ayati *et al.* 2019; Adnan *et al.* 2021; Ganapathy *et al.* 2023).

Today's young generation depends on technological developments in various aspects of life, including learning. Technology can significantly increase students' understanding and appreciation of ethnobotanical knowledge (Borokhovski *et al.* 2016). Furthermore, technology has the potential to assist students in expanding access, preservation, promotion, and collaborative action in traditional practices (Yue *et al.* 2021). This enhances the learning experience and contributes more broadly to preserving biodiversity, culture, and ecological wisdom inherent in ethnobotanical knowledge (Haeruddin *et al.* 2017). Technology-based learning developers must consider student accessibility to technology, including those in remote or disadvantaged areas. Hence, the student can take advantages from the integration of technology into the learning process. Technology creates hands-on learning in virtual simulation forms, online field trips, and fun interactive tools (Mead *et al.* 2019). Ethnobotanical knowledge combined with technology is proven to support the implementation of project-based learning and improve scientific process abilities and critical thinking processes (Syawaludin *et al.* 2019; Sumarni *et al.* 2022). Technology serves as a means of perpetual learning, encouraging collaboration among peers, experts, and indigenous communities to exchange ideas and knowledge (Mead *et al.* 2019; Wiyono *et al.* 2021). Additionally, technology applications have the great opportunity to play a vital role in conserving and recording ethnobotanical knowledge as digital archives and databases, ensuring its accessibility for future generations (Haeruddin *et al.* 2017).

Technology is envisioned to complement learning methods related to traditional knowledge rather than replace or destroy it. The use of technology is felt to be applied responsibly and ethically through collaboration with local communities and respecting cultural practices without disrupting community activities and the environment (Hamidova 2019). In addition, privacy concerns and matters associated with intellectual property and data ownership must be treated with caution to prevent the exploitation and misappropriation of natural and cultural resources.

Conclusion

Currently, the ethnobotanical knowledge among young generation, in this study are SE and PTSE student, still belongs to the moderate tends to be low, with only a small proportion having a high level of knowledge about ethnobotany. This study also found that cognitive competencies related to ethnobotanical knowledge are not well developed, with only around 50% achievement. A lack of integration of ethnobotany into the formal education curriculum and the low transmission of traditional knowledge in society may cause the low achievement of ethnobotany knowledge among university students. However, further studies are needed to identify knowledge bias with data interpretation competence.

Most students understand the meaning of ethnobotany textually but are weak in identifying and applying ethnobotany in everyday life. Furthermore, students initiated technology-based learning by identifying and exploring related learning resources to make it easier for them to learn. Therefore, it is necessary to carry out further studies in developing learning models to increase ethnobotanical knowledge through applicative technology.

Declarations

List of abbreviations:

BTL = Bloom's taxonomical level; DL = Item difficulty level; DP = Item discrimination level; EK = Ethnobotanical Knowledge; GPA = Grade Point Average; MCS = minimum competencies standard; PSTE = Primary School Teacher Education study program; SE = Science Education study program

Ethics approval and consent to participate: We did not apply for ethical approval from the national ethics commission or university level, considering that the data did not include any personal information from respondents and the questions were an evaluation of the learning process. We only asked for a review from science education experts and elementary school teachers at Universitas Negeri Semarang to assess the suitability of the questionnaire. However, we include a statement of willingness to be surveyed online which is filled in by the respondents without pressure and voluntarily.

Consent for publication: Not applicable

Competing interest: There is no competing interest in this study.

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Conflict of interest

There is no conflict of interest in this research.

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