JPII 13 (4) (2024) 700-710

Jurnal Pendidikan IPA Indonesia

https://journal.unnes.ac.id/journals/jpii

EMPOWERING STUDENTS' ETHNOMEDICINE LITERACY THROUGH AUGMENTED REALITY-ASSISTED PROJECT-BASED ETHNOBOTANY LEARNING

A. R. F. Gani[1], U. S. Hastuti*[2], S. Sulisetijono[3], F. K. Setiowati[4]

[1,2,3,4]Department of Biology, Faculty of Mathematics and Natural Sciences,
Universitas Negeri Malang, Indonesia

DOI: 10.15294/jpii.v13i4.16895

Accepted: December 5th, 2024. Approved: December 29th, 2024. Published: December 30th 2024

ABSTRACT

This research trains the students' ethnomedicine literacy by using project-based learning and augmented reality assistance and evaluating the learning effectiveness. The research method used was a non-randomized control group pretest-posttest design, and a problem-based learning model was used as a control class. This research evaluates students' ethnomedicine literacy using descriptive statistical data analysis, n-gain scores, and ANCOVA tests. The research results showed differences in ethnomedicine literacy with an ANCOVA significance value of 0.08 between the experimental and control classes. Both classes showed increased ethnomedicine literacy, but the n-gain score for the experimental class was greater than that of the control class. Students' ethnomedicine literacy is higher in the experimental class because there are learning activities that empower ethnomedicine literacy, such as students are trained to be broad-minded, have positive attitudes and behavior related to ethnomedicine studies, working on simple manufacturing projects based on student research to get closer to the environment and society, and using AR as a simulation for testing the antibacterial power of medicinal plants. This research concludes that AR-assisted project-based ethnobotany learning is proven to be able to increase students' ethnomedicine literacy. This research can be helpful as a learning design reference to empower ethnomedicine or other literacy in biology.

Keywords: augmented reality; ethnobotany learning; ethnomedicine literacy; project-based learning

INTRODUCTION

Ethnomedicine is an important topic in ethnobotany courses at the university level (Pieroni, 2006; Hiben et al., 2019). Ethnobotany learning examines the various uses of plants in local communities, such as ethnomedicine, which is related to certain plants as medicinal ingredients. This topic trains students to study health practices regarding traditional medicinal ingredients circulating in local communities (Han & Ballis, 2007; Rodrigues et al., 2020). Another thing studied in ethnobotany is the scientific study of medicinal plants, such as their secondary metabolites and antibacterial characteristics. Learning on ethnomedical topics is a complex matter that requires good literacy.

Ethnomedicine literacy is a literacy process in an ethnomedicine course. Ethnomedicine includes knowledge about traditional medicine (Sharma et al., 2022), health practices (Han & Ballis, 2007), medication, and traditional body health care (Arman et al., 2022). Ethnomedicine literacy must also include various scientific studies of plants used by local communities. These studies can include taxonomy, biochemistry, physiology, histology, and microbiological aspects of these plants (Gani et al., 2022, 2024; Hastuti et al., 2018, 2019, 2022, 2023; Ristanti et al., 2020). The scope of ethnomedicine is related to health

***Correspondence Address**
E-mail: utami.sri.fmipa@um.ac.id

sciences. Based on this information, ethnomedicine literacy becomes part of health literacy. Health literacy consists of cognitive and social skills to determine individual motivation and ability to access, understand, and use information to maintain health (Maindal et al., 2016; Rademakers et al., 2020). Therefore, ethnomedicine literacy can be formulated by referring to health literacy related to local culture.

A preliminary study on undergraduate biology students majoring in Medan who had taken ethnobotany courses showed that their ethnomedicine literacy was still not optimal. The test carried out from April to May 2023 shows that the average ethnomedicine literacy of students is 63 or in the quite good category. The knowledge aspect has the lowest score, 44.8 in the low category, while the attitude and behavior aspects have 71.1 and 73 in the good category. Examples of student answers with the lowest scores were related to the characteristics of infectious diseases. Only 16 students answered that infectious diseases start in pandemics, while 84 other students answered that all infectious diseases have high mortality rates and cause disabilities in humans.

Students' low ethnomedicine literacy is caused by their relatively low understanding of information related to health and local wisdom. Many students still have difficulty understanding and using health-related information, even though this information is essential as a basis for making decisions (Avci et al., 2019). Apart from that, some communities still have low health literacy (Gatulytė et al., 2022).

Low ethnomedical literacy is fundamental to overcome. Long-term problems with ethnomedical literacy can have an impact on society. If people have low ethnomedical literacy, various problems will occur in health and plant management. One case that can happen is the excessive harvesting of medicinal plants and the general public's lack of knowledge about medicinal plants (Chauhan, 2020). Several community groups in Indonesia have also forgotten their culture of using plants as medicinal ingredients (Gani et al., 2024). Low knowledge of medicinal plants occurs among teenagers (Azis et al., 2020), an important issue that needs to be studied more deeply.

Low ethnomedical literacy is a challenge in this era. Students' misunderstanding of health concepts and local wisdom can become a sustainability problem when students apply this misunderstanding knowledge in their daily lives. One way to solve this problem is education. Education is important for achieving sustainability goals and can empower individuals and communities to make informed decisions (Erguvan, 2024). The high school curriculum also did not teach students about health issues in the 21st century, so students do not have good health literacy (Jacque et al., 2016). This problem is the cause of the low literacy of university-level students. Therefore, it is necessary to teach ethnomedicine literacy in ethnobotany learning.

Literacy is a combination of several knowledge and skills that grow continuously. Literacy is a reading process that includes knowledge, attitudes, and behavior in everyday life (Tomczyk, 2020; Tomczyk & Fedeli, 2022). Literacy develops from various high-level skills (Levie et al., 2022). Literacy can be specifically related to the content being developed. So, ethnomedicine literacy needs to be measured and developed in ethnobotany courses. Learning must be developed based on students' knowledge, attitudes, and behavior to have good ethnomedicine literacy. Therefore, using appropriate learning models and media for this course is very important.

Ethnobotany learning must use an appropriate learning model. Ethnobotany learning can be based on problems, projects, or case studies (Paniagua-Zambrana et al., 2018; Rodrigues et al., 2020). This research uses project-based learning as a learning model for medicinal plant ethnobotany material. Project-based learning that presents problems is very suitable for ethnobotany courses because students can analyze authentic problems by conducting meaningful investigations and developing products. Students can also develop projects that can train ethnomedicine literacy.

Learning was developed based on a project-based model by Failla (Capraro et al., 2016). Learning is carried out based on the following stages: (1) introduction of materials and projects, (2) Ethnobotanical research and project design, (3) Design of products made from medicinal plants, (4) Finalization of products and designing presentations, and (5) Presentation and final evaluation. Learning is carried out by analyzing disease problems in Medan, researching medicinal plants in the surrounding community, and preparing simple and digital products. Augmented reality (AR) was used in the project introduction stage. Students used the AR to analyze the causes of diarrhea by *E. coli* bacteria and a simulation of the galangal rhizome antibacterial power test to inhibit *E. coli* growth.

Biology learning requires the help of modern multimedia tools to visualize material such as biochemistry (Haviz et al., 2024). One of the modern multimedia that can be applied in ethnobotany courses is AR. Augmented reality is a 2D or 3D technology that helps authentically virtualize objects based on specific codes (Safadel & White, 2019). Augmented reality helps students observe objects and has been proven to increase students' spatial understanding. The visualization of the plant's antibacterial power inhibits the growth of bacteria. Visualization shows the inhibition zone of bacterial growth, which appears to be a clear zone in the medium inoculated with bacterial cultures that cause diarrhea. This helps students understand the material because they do not carry out trials directly in the lab.

This research is important to solve the problems of student ethnomedicine literacy. The problem solutions designed by the researcher are to empower the students' ethnomedicine literacy into ethnobotany learning. Ethnomedicine literacy empowerment is designed by integrating each stage of project-based learning with ethnomedicine literacy indicators. This research assesses all ethnomedicine literacy aspects, such as knowledge of disease, insight regarding medicinal plants, and personal health care based on existing local wisdom. This research aims to train students' ethnomedicine literacy using augmented reality-assisted projects-based learning. This research analyzes the effectiveness of learning based on pretests and posttests and the increase in students' ethnomedicine literacy during one semester. This research is helpful as an example of a learning design that has various literacy-based learning activities.

METHODS

This research implements the learning design developed by researchers using the ASSURE model (Smaldino et al., 2011). The designed learning has been valid through expert evaluations such as biology learning, biology learning media, and ethnobotany experts (ethnobotany, ethnomedicine, and medicinal plants). The learning design has been declared practical by field practitioners (lecturers who teach ethnobotany courses). Learning has also been trialed on students who have taken ethnobotany courses in 2023. The learning products designed are lesson plans, augmented reality, handouts containing student learning activities, PowerPoint, and assessment instruments.

The population in this study consisted of three ethnobotany courses or 95 students. Participants were taken from two classes of students (58 students). Participants were taken using a purposive sampling technique, and both classes must have equal ability to be compared in the research. The equality of students' abilities was measured using a one-way ANOVA test based on their grade's average score. The results of the one-way ANOVA test show a significance value of 0.789, which means there is no significant difference in students' abilities from the two classes.

The research was carried out by applying a learning design to the students taking an ethnobotany course for one semester. The research was conducted with a non-randomized control group pretest-posttest design (Leedy & Ormrod, 2015). The control class in this research is an ethnobotany lecture with a problem-based learning model because it is a conventional model commonly used by lecturers and equivalent to project-based learning. This stage will be carried out on 29 students in the experimental class and 29 in the control class. The student participation design is explained in Table 1.

Table 1. Student participation design

Class	Treatment		
Experimental	O1	X1	O1
Control	O1	X2	O2

Notes:
The experimental class with an augmented reality-assisted project-based ethnobotany learning
The control class with problem-based learning
O1 is the ethnomedicine literacy pretest, and O2 is the ethnomedicine literacy posttest.

This research was measured using an ethnomedicine literacy test that researchers developed. Indicators of ethnomedicine literacy are (1) recognizing disease, (2) understanding the medicinal plants, and (3) having sufficient local wisdom information to manage personal health. The ethnomedicine literacy test contains 27 question items. Each indicator is measured using nine question items with details of three knowledge scale items, three attitude scale items, and three behavior scale items. The instrument has been trialed on 100 students. All items have passed the validity test requirements with a value of $\alpha = 0.05$ and passed the reliability test on each scale (knowledge: 0.705; attitude: 0.825; behavior: 0.782).

Learning effectiveness was analyzed using ethnomedicine literacy pretests and posttests. Learning effectiveness was analyzed using n-gain score and ANCOVA test (Suciati et al., 2023). Ethnomedicine literacy pretest and posttest data were analyzed using descriptive statistics for each indicator and its aspects (knowledge, attitudes, and behavior). Data were analyzed using mean values based on ethnomedicine literacy total indicators and aspects. The pretest and posttest data were also analyzed using the n-gain score to determine the increase in students' ethnomedicine literacy in each aspect and each indicator. The n-gain score data was compared to determine the level of learning effectiveness in the experimental and control classes.

The students' pretest and posttest ethnomedicine literacy data were also analyzed using the ANCOVA test to determine the differences in ethnomedicine literacy between the two classes. The ANCOVA test is carried out with the prerequisites of homogeneity and normality tests, which must be met to continue the hypothesis test (ANCOVA). The ANCOVA test was conducted by differentiating the ethnomedicine literacy posttest score moderated by the pretest score as a covariate. Next, data was analyzed on the percentage increase between students' pretest and posttest ethnomedicine literacy scores in both classes to determine the increase in each.

Additional research data is in the form of observations from observers regarding the AR-assisted project-based ethnobotany learning process of medicinal plants. The research used two observers who were education graduates and had received training before the research began. Each observer assesses the implementation of the learning and pays attention to students' responses at the lesson's opening, core, and closing. Data from the observer's observations was analyzed qualitatively to clarify student responses to the learning process that the lecturer had designed.

RESULTS AND DISCUSSION

The average of the ethnomedicine literacy pretest and posttest scores are considered for each indicator. These results were compared to see the differences in pretest and posttest scores between the experimental and control classes. The results of the pretest for each indicator are explained in Table 2, and the average posttest scores are explained in Table 3.

The students' average posttest scores were not much different, but the ethnomedicine literacy posttest for the experimental class was higher, with a difference of 4.98. Both classes showed an increase in ethnomedicine literacy scores, showing that learning is running effectively. Next, an n-gain score test was carried out to see the effectiveness score of each class.

Table 2. Pretest Scores of Students' Ethnomedicine Literacy

Aspect	Indicator	Score	
		Experimental Class	Control Class
Knowledge	Recognizing diseases	56.32	56.32
	Understanding the study of medicinal plants	41.38	43.68
	Having sufficient local wisdom information to manage personal health	59.77	70.11
Attitude	Motivation to seek information related to disease	76.09	75.86
	Motivation to seek information related to traditional medicinal plants	80.69	80.00
	Motivation to seek help for traditional medicine	70.57	70.35
Behavior	Studying the disease experienced	75.40	73.33
	Using of medicinal plants	50.57	51.49
	Having a healthy lifestyle	80.00	76.78
Mean		65.65	66.44

Table 3. Postest Scores of Students' Ethnomedicine Literacy

Aspect	Indicator	Score	
		Experimental Class	Control Class
Knowledge	Recognizing diseases	78.16	62.07
	Understanding the study of medicinal plants	80.46	50.57
	Having sufficient local wisdom information to manage personal health	86.21	78.16
Attitude	Motivation to seek information related to disease	75.40	78.62
	Motivation to seek information related to traditional medicinal plants	80.46	81.84
	Motivation to seek help for traditional medicine	74.02	74.94
Behavior	Studying the disease experienced	78.62	75.17
	Using of medicinal plants	61.38	64.59
	Having a healthy lifestyle	82.07	85.98
Mean		77.42	72.44

The n-gain test results are based on the value of the ethnomedicine literacy indicator and aspect. The n-gain test results were compared between the experimental and control classes. The results of comparing n-gain values based on indicators are explained in Figure 1, and the results of comparing n-gain values based on aspects are explained in Figure 2.

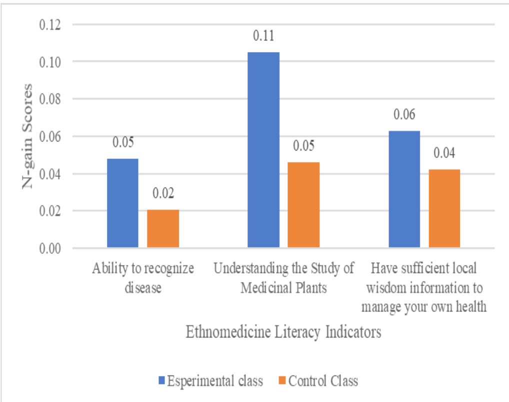

Figure 1. The Ethnomedicine Literacy N-Gain Scores Comparison Based on Indicators

The highest n-gain score based on the ethnomedicine literacy indicator in the experimental class was the indicator "understanding the study of medicinal plants" with a score of 0.11, while the control class had a score of 0.05, both in the low category. The lowest n-gain score in the experimental and control classes was proven to be the same, namely in the indicator "recognizing disease," the experimental class had a score of 0.05 while the control class had a score of 0.02. The average increase in ethnomedicine literacy for the experimental and control classes is in the low category.

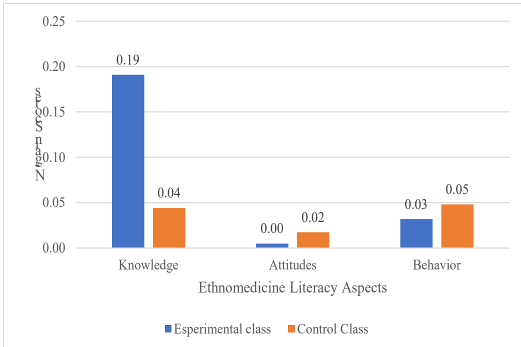

Figure 2. The Ethnomedicine Literacy N-Gain Scores Comparison Based on Indicators

The highest aspect of ethnomedicine literacy scores is knowledge. Students' knowledge increases more specifically because of the insights gained during study. Students are trained to study ethnomedicine material in every learning activity, from lesson preparation to project implementation. There are gaps in aspects of student knowledge between the experimental class and the control class, but overall, they are not much different. Therefore, an ANCOVA test was conducted to see differences in ethnomedicine literacy in each class.

The ANCOVA test was carried out to test the difference between the ethnomedicine literacy posttest scores of the experimental and control classes, and the pretest scores of each class moderated it. The results of the ANCOVA test can be seen in Table 4.

Table 4. ANCOVA Test Results

No	Test Type	Test Results	Conclusion
1	Prerequisite: Levene's Homogeneity Test	Sig: 0.552	Variance data homogeneous
2	Prerequisite: Kolmogorov-Smirnov Normality Test	Sig: 0.200	Normal data distribution
3	ANCOVA	Sig: 0.08	There are differences between the ethnomedicine literacy from experimental and control classes.

The ANCOVA test result shows the difference between the posttest scores of the experimental and control classes. The difference between the two classes is significant, but both are increasing. Therefore, the improvement percentage test is carried out to obtain an improvement score that can be compared between the pretest and posttest classes. The increase in pretest and posttest scores for both classes is shown in Table 5.

Table 5. The Percentage of Students' Ethnomedicine Literacy

Class	Pretest	Posttest	Difference	Corrected Value	Increase (%)
Project-Based Learning (Experiments)	65.65	77.42	11.78	77.57	17.94
Problem-Based Learning (Control)	66.44	72.44	6.003	72.34	9.035

The ANCOVA test results show a significant difference between the control and experimental classes. Compared with the percentage increase value and n-gain score, project-based ethnobotany learning of medicinal plants assisted by augmented reality is more effective than problem-based learning. Both learning begins by analyzing authentic problems. The problem-analyzing approach aims to examine various social phenomena around Medan. Authentic learning has been proven effective in improving students' knowledge, attitudes, and skills (Lee et al., 2022). Students are trained to get used to analyzing authentic problems while studying. Students are also trained to get used to analyzing information based on primary and secondary data related to various diseases, medicinal plants, and local wisdom to care for their health.

Student project activities are also related to ethnomedicine. Students create simple products and social media containing images and videos as solutions to disease problems that have been analyzed. This project activity trains students to get used to analyzing information related to diseases and plants with medicinal properties and how to make simplicia from medicines. Students are expected to be skilled at making and applying simple things in everyday life.

The students' investigation results produced accurate information about medicinal plant use. Students examine various literature regarding the information of active compounds with antibacterial properties in several species of plants with medicinal properties, including ginger, turmeric, and ginger. Finally, the students obtained information about the presence of antibacterial compounds, for example, flavonoids, tannins, saponins, alkaloids, and terpenoids in the medicinal plants studied. Students use this information as a reference for developing Simplicia products and disseminating them digitally. Students can be trained to create and utilize digital and traditional health information (McKinney et al., 2024). Making simplicia can train students' skills in processing plants with medicinal properties so they can be used in everyday life. Health literacy education is often trained to introduce basic skills in making a suitable product (Maybury et al., 2024). Digital product creation is also carried out to train students to produce information related to ethnomedicine that is original, accurate, and useful for society.

The first stage of project-based learning is " the introduction to material and projects." The material and projects are introduced with group presentations related to theories in Ethnobotany learning, and problems are given as triggers for implementing the project. Lectures in project-based classes are carried out as structured explanations and instructions with presentations and discussions between students and lecturers to support projects. Usually, topics follow the sequence of chapters in the curriculum and are sometimes adapted to project needs (Dolničar et al., 2017). This student activity trains them to find credible concepts by comparing sources of information. This also trains students to find information from the sources they need (Chuppa-Cornell & Zimmerer, 2017). The material in the project is introduced in groups to create an atmosphere in which students can share experiences, which becomes a source of student knowledge (McNeill, 2023).

The second stage in project-based learning is "Ethnobotanical Research and Project Design." Simple investigations into the field carry out ethnobotanical research to look for plants with medicinal properties to solve disease problems that have been studied in the first stage. Students conduct investigations by interviewing sources who are community members around the students to obtain data regarding plants with medicinal properties. This inquiry process supports information literacy as a skill for searching and finding information, advanced information search, selecting, and analyzing information sources (Encheva et al., 2023). The data obtained were analyzed in groups, after which a presentation and discussion were conducted in front of the class. Presentations and discussions from project activities support student literacy development by constructing knowledge from previously unknown concepts (Dippold et al., 2022).

The third stage of learning is "Product Design," based on the results of student investigations. This activity is carried out by collecting the available information and preparing a design for the product. Projects are micro-research that collects and organizes information (H. Yu et al., 2018). Information in the form of plans is compiled into a simple operational design that is presented to the class. Students hold discussions with peers and lecturers to exchange information by providing mutual input to produce a good project design. This is done to provide a good atmosphere for learning to use information. A good environment must support information literacy. Educators must provide facilities for project implementation, thereby training student behavior in searching for and evaluating information (Birkett & Hughes, 2013). Based on the results of discussions in class, students plan to make simple products that will be packaged well, and this product information will be distributed widely on social media.

The fourth stage is "Finalizing the product and designing the presentation." The student's final project is the final requirement in the problem-solving that has been identified, and this is a learning approach that can train students' information literacy (Santos, 2024). Students are trained to prepare simple products made from medicinal plants as a basis for the skills acquired after taking the Ethnobotany course. The important thing to do is to prepare students capable of working in the future (Molina-Torres, 2024). In addition, project-based learning is carried out to provide authentic, real, and given experiences to train student creativity (Cioc et al., 2022).

The fifth stage is "Presentation and final evaluation," which is carried out with an exhibition of student-made simplicia results and organoleptic test results. Exhibitions and organoleptic tests were carried out in class and attended by all class members, lecturers, and a team of plant laboratory assistants. The exhibition was carried out by showing simple packaging products, brochures, and social media content. Students promote the products by explaining the added value of products based on their information. Lecturers, students, and laboratory assistants provide questions that students can answer. Projects involve learning activities, including lectures, discussions, workshops, product creation, and field practice, to engage students in building critical thinking and analytical skills, and they are suitable for increasing students' literacy (Yee & Huey Shyh, 2024a). The results of the exhibition and organoleptic tests are documented by students to be analyzed and compiled into a report. Research, writing, and self-evaluation process increases students' awareness of information literacy (Crawford & Irving, 2007).

Students use AR to observe examples of aromatic ginger as a plant with medicinal properties, such as E.coli bacteria morphology and Antibacterial Power Test simulation. Students can use AR independently at home and with a group of friends in class. The Antibacterial Power Test simulation is carried out by students in groups in class and is designed as if they were doing practical work in a laboratory. AR provides interactions between physical and virtual objects that help students enrich their laboratory experience (S. Yu et al., 2023). The learning observations results show that students use AR actively. Students are interested in simulations using AR to replace work in the laboratory because time is limited. Students are trained to learn the working principles of the Antibacterial Power Test to broaden their knowledge about Ethnomedicine learning.

Augmented reality is specially designed using 2D and 3D objects. Object design is a specific model that allows laboratory simulations scientifically, but this is not always ideal and accurate (Hemme et al., 2023). Therefore, researchers continue to show the real experiment model results, which show the formation of an inhibitory zone for bacterial growth with the galangal rhizome extract effect. Apart from that, the researchers also presented real pictures of the Antibacterial Power Test process that they had carried out. This is done so that there are no student misconceptions in understanding the learning material.

AR technology can be recommended to solve problems such as students not having enough time to practice. AR can be used to teach working principles in the laboratory so that students still receive the learning well. AR must be accompanied by an original model or a picture of a laboratory object, such as a media plate in which bacteria has been inoculated and there is an inhibitory zone for the bacteria growth, which is treated with medicinal plants.

AR-assisted project-based ethnobotany learning design has increased students' ethnomedicine literacy. Learning design combines new approaches in project-based learning. Project-based learning is designed to use an emic and ethical approach to ethnomedicine research (Quinlan, 2011). The emic approach brings students closer to local communities, and the ethical approach brings students closer to studying biological aspects of local wisdom in depth.

Students' interviews with the community carried out the emic approach to find information regarding plants with medicinal properties. The information-searching of the interview process trains students to analyze and actively search for the information they need. Active learning models like this can be used to train students' communication skills (Amin et al., 2024). These communication skills are important for information exchange and building students' ethnomedicine knowledge. The information obtained by students is used to solve health problems. This problem-solving trains students to think critically to determine the solutions and final learning products. Critical thinking is critical in the biology learning process because it involves various principles, concepts, facts, and discoveries related to natural events (Danil et al., 2023).

Based on literature studies, an ethical approach is carried out by analyzing the content of plants' active compounds. The ethical approach is also carried out by simulating antibacterial power tests using AR on plants with medicinal properties that certain community groups use. Integrating biology learning with local wisdom as a problem-solving process creates an interesting situation to examine what students already have in everyday life (Leksono et al., 2023).

AR-assisted project-based ethnobotany learning of medicinal plants has proven to be a solution for increasing students' ethnomedical literacy. This learning also trains students to create simplicia and digital products. Simplicia is an ethnobotanical product that is a solution to various health problems in Medan. Learning using health cases has been proven to increase health literacy (Ha & Lopez, 2014). Apart from that, learning is carried out based on interviews with people who understand the study of medicinal plants, and this is under the integration of health literacy in learning, involving health leaders and the community (Okan et al., 2020).

Meanwhile, digital products like Instagram, which contain images, videos, and writing, are a form of disseminating information owned by students to the general public. Students are expected to be able to collect various information to solve problems through simplified products and compile new information for the general public to learn through digital content. Learning related to health literacy must examine many sources of information and highlight health practice settings (Nikolaidou & Bellander, 2020). Searching, evaluating, applying, and compiling this information becomes an activity that empowers students' ethnomedical literacy.

CONCLUSION

Augmented reality-assisted project-based ethnobotany learning has increased students' ethnomedicine literacy. Students are trained to be literate at every stage of learning. Students are trained to be insightful and have positive attitudes and behavior related to ethnomedicine. Students are trained to conduct simplicial-making projects based on student investigations to get closer to the environment and society. AR also has the benefit of helping students carry out simulation tests for the antibacterial properties of medicinal plants. Each part of the learning model is important in training students' ethnomedicine literacy. An important factor applied to empower ethnomedical literacy is applying an emic and ethical approach. An emic approach in ethnobotany learning is to deeply examine local wisdom about the plants' utility as medicine. An ethical approach is applied to study the biological aspects of medicinal plants, which are phytochemicals, antibacterial tests, and the impact of plants on the human body. If studied further, this research has long-term impacts, such as ethnomedicine literacy, which influences students' knowledge, attitudes, and behavior in using plants to maintain body health.

REFERENCES

Amin, A. M., Adiansyah, R., Mustami, M. K., Yani, A., Hujjatusnaini, N., & Ahmed, M. A. (2024). The Influence Of We-Are (Warm-Up, Exploring, Argumentation, Resume) Model Integrated With 21st-Century Skills On Prospective Biology Teachers' Communication Skills. *Jurnal*

Pendidikan IPA Indonesia, *13*(1), 12–28.

Arman, M., Chowdhury, K. A. A., Bari, M. S., Khan, M. F., Huq, M. M. A., Haque, M. A., & Capasso, R. (2022). Hepatoprotective potential of selected medicinally important herbs: evidence from ethnomedicinal, toxicological and pharmacological evaluations. *Phytochemistry Reviews*, *21*(6), 1863–1886.

Avci, G., Kordovski, V. M., & Woods, S. P. (2019). A Preliminary Study of Health Literacy in an Ethnically Diverse University Sample. *Journal of Racial and Ethnic Health Disparities*, *6*(1), 182–188.

Azis, S., Zubaidah, S., Mahanal, S., Batoro, J., & Sumitro, S. B. (2020). Local knowledge of traditional medicinal plants use and education system on their young of ammatoa kajang tribe in south sulawesi, indonesia. *Biodiversitas*, *21*(9), 3989–4002.

Birkett, M., & Hughes, A. (2013). A collaborative project to integrate information literacy skills into an undergraduate psychology course. *Psychology Learning and Teaching*, *12*(1), 96–100.

Capraro, M. M., Whitfied, J. G., Etchells, M. J., & Capraro, R. M. (2016). *A Companion to Interdisciplinary STEM Project-Based Learning*. Sense Publisher.

Chauhan, K. (2020). Role of Ethnobotany on Indian Society: A Review. *Journal of Arts, Culture, Philosophy, Religion, Language and Literature*, *4*, 109–111.

Chuppa-Cornell, K., & Zimmerer, M. (2017). The Proof is in the Project: Integrating the Framework for Information Literacy in Developmental Education Through Project-Based Learning. *Community College Journal of Research and Practice*, *41*(7), 459–461.

Cioc, C., Haughton, N., Cioc, S., & Napp, J. (2022). A Model for incorporating information literacy and collaboration in a project-based learning pedagogical exercise with application to a fluid mechanics course. *International Journal of Mechanical Engineering Education*, *50*(4), 955–977.

Crawford, J., & Irving, C. (2007). Information literacy: The link between secondary and tertiary education project and its wider implications. In *Journal of Librarianship and Information Science* (Vol. 39, Issue 1, pp. 17–26). https://doi.org/10.1177/0961000607074812

Danil, M., Corebima, A. D., Mahanal, S., & Ibrohim. (2023). The Connection Between Students' Retention And Critical Thinking Skills In Diverse Academic Skills In Biology Learning. *Jurnal Pendidikan IPA Indonesia*, *12*(2), 241–251.

Dippold, D., Heron, M., & Gravett, K. (2022). Language, literacies and learning in the disciplines: A higher education perspective. *Language Teaching*, *55*(1), 136–138.

Dolničar, D., Podgornik, B. B., & Bartol, T. (2017). A comparative study of three teaching methods on student information literacy in stand-alone credit-bearing university courses. *Journal of Information Science*, *43*(5), 601–614.

Encheva, M., Krüger, N., & Zlatkova, P. (2023). Playability of Serious Games in Information Literacy: The Findings of the European Project NAVIGATE. *International Information and Library Review*, *55*(2), 176–184.

Erguvan, I. D. (2024). Assessing the sustainability literacy of undergraduate students in a first-year writing course. *Discover Education*, *3*(1).

Gani, A. R. F., Hastuti, U. S., Sulisetijono, S., & Setiowati, F. K. (2024). Ethnobotanical study of medicinal plants among the Karo tribe in Kuala Sub-district, Langkat District, North Sumatra, Indonesia. *Biodiversitas*, *25*(7), 2960–2968.

Gani, A. R. F., Sueb, & Hastuti, U. S. (2022). Ethnoecological Studies: Environmental Management of the Local Community in Angkola Sangkunur, North Sumatra, Indonesia. *AIP Conference Proceedings*, *2659*.

Gatulytė, I., Verdiņa, V., Vārpiņa, Z., & Lublóy, Á. (2022). Level of health literacy in Latvia and Lithuania: a population-based study. *Archives of Public Health*, *80*(1).

Ha, H., & Lopez, T. (2014). Developing Health Literacy Knowledge and Skills Through Case-Based Learning. *American Journal of Pharmaceutical Education*, *1*(17).

Han, G. S., & Ballis, H. (2007). Ethnomedicine and dominant medicine in multicultural Australia: A critical realist reflection on the case of Korean-Australian immigrants in Sydney. *Journal of Ethnobiology and Ethnomedicine*, *3*, 1–14.

Hastuti, U. S., Asna, P. M. Al, & Rahmawati, D. (2018). Histologic observation, identification, and secondary metabolites analysis of endophytic fungi isolated from a medicinal plant, hedychium acuminatum Roscoe. *AIP Conference Proceedings*, *2002*.

Hastuti, U. S., Novianti, V., Rahmawati, D., Sari, R. Y., & Zahida, N. S. (2023). *Endophytic Fungi Isolated from Jasminum sambac L.: Identification, Histological Observation, and Content Analysis of Secondary Metabolites* (pp. 20–33).

Hastuti, U. S., Rahmawati, D., & Sari, R. Y. (2019). Histologic Observation, Identification and Secondary Metabolites Analysis of Endophytic Fungi Isolated from Cananga odorata (Lam.) Hook. F. & Thomson. *IOP Conference Series: Materials Science and Engineering*, *546*(2).

Hastuti, U. S., Sulisetijono, S., Thoyibah, C., Hartina Pratiwi, S., & Khotimah, K. (2022). *Histological Observation, Identification, and Secondary Metabolites Content in Endophytic Fungi of Mahogany Tree (Swietenia mahagoni Jacq).*

Haviz, M., Nasrul, E., Azis, D., Maris, I. M., & Wahyudi, F. (2024). The Use of Socio-Scintific Issues to Promote Prospective Biology Teachers' Scientific Literacy and Research Skill Development. *Jurnal Pendidikan IPA Indonesia*, *13*(2), 285–300.

Hemme, C. L., Carley, R., Norton, A., Ghumman, M., Nguyen, H., Ivone, R., Menon, J. U., Shen, J., Bertin, M., King, R., Leibovitz, E., Bergstrom, R., & Cho, B. (2023). Developing virtual and augmented reality applications for science, technology, engineering and math education. *BioTechniques*, *75*(1), 343–352.

Hiben, M. G., Louisse, J., de Haan, L. H. J., & Rietjens, I. M. C. M. (2019). Ethnomedicine and ethnobotany of Maerua subcordata (Gilg) DeWolf. *Journal of Ethnic Foods*, *6*(1).

Jacque, B., Koch-Weser, S., Faux, R., & Meiri, K. (2016). Addressing Health Literacy Challenges With a Cutting-Edge Infectious Disease Curriculum for the High School Biology Classroom. *Health Education and Behavior*, *43*(1), 43–53.

Lee, J. H., Campbell, S., Choi, M. K., & Bae, J. (2022). Authentic learning in heathcare education: A systematic review. In *Nurse Education Today* (Vol. 119). Churchill Livingstone.

Leedy, P. D., & Ormrod, J. E. (2015). *Practical Research Planning and Design* (Eleventh Edition). Pearson Education Limited.

Leksono, S. M., Kurniasih, S., Marianingsih, P., Nuryana, S., Camara, J. S., El Islami, R. A. Z., & Cahya, N. (2023). From Farm To Classroom: Tubers As Key Resources In Developing Biology Learning Media Rooted In Banten's Local Culture. *Jurnal Pendidikan IPA Indonesia*, *12*(4), 575–589.

Levie, R., Bar-on, A., Ashkenazi, O., & Dattner, E. (2022). *Developing Language and Literacy*. Springer Nature witzerland.

Maindal, H. T., Kayser, L., Norgaard, O., Bo, A., Elsworth, G. R., & Osborne, R. H. (2016). Cultural adaptation and validation of the Health Literacy Questionnaire (HLQ): robust nine-dimension Danish language confirmatory factor model. *SpringerPlus*, *5*(1).

Maybury, C., Williams, M. A., Challenger, K., Fassas, E., Galvan, S., Gelmann, D., Jung, K. S., Lu, A. Y., Wang, J., Stines, E., & Baur, C. (2024). How health literacy is taught and evaluated in dentistry, medicine, nursing, law, pharmacy, public health, and social work: a narrative review. In *Journal of Communication in Healthcare* (Vol. 17, Issue 1, pp. 51–67). Taylor and Francis Ltd.

McKinney, Z. J., Tessier, K. M., Shaheen, Z. R., Schwitzer, G., Olson, A. P. J., Scheurer, J. M., & Krohn, K. M. (2024). Empowering Third-Year Medical Students to Detect Bias and Medical Misinformation Online via Experiential Learning of "Lateral Reading," A Fact-Checker's Technique. *Teaching and Learning in Medicine*.

McNeill, E. (2023). Learning to be culturally responsive: understanding how literacy projects provide space to share past experiences. *English in Education*, *57*(3), 237–249.

Molina-Torres, M.-P. (2024). Ancient history education through project-based learning. *The Journal of Classics Teaching* , 1–6.

Nikolaidou, Z., & Bellander, T. (2020). Health literacy as knowledge construction: Learning about health by expanding objects and crossing boundaries in networked activities. In *Learning, Culture and Social Interaction* (Vol. 24). Elsevier Ltd.

Okan, O., Paakkari, L., & Dadaczynski, K. (2020). *Health literacy in schools. State of the art*. Schools for Health in Europe.

Paniagua-Zambrana, N. Y., Bussmann, R. W., Hart, R. E., Moya-Huanca, A. L., Ortiz-Soria, G., Ortiz-Vaca, M., Ortiz-Álvarez, D., Soria-Morán, J., Soria-Morán, M., Chávez, S., Chávez-Moreno, B., Chávez-Moreno, G., Roca, O., & Siripi, E. (2018). Who should conduct ethnobotanical studies? Effects of different interviewers in the case of the Chácobo Ethnobotany project, Beni, Bolivia. *Journal of Ethnobiology and Ethnomedicine*, *14*(1), 1–14.

Pieroni, A. (2006). Journal of ethnobiology and ethnomedicine - Achievements and perspectives. *Journal of Ethnobiology and Ethnomedicine*, *2*, 2–4.

Quinlan, M. B. (2011). Ethnomedicine. In *A Companion to Medical Anthropology* (pp. 381–403). Wiley-Blackwell.

Rademakers, J., Waverijn, G., Rijken, M., Osborne, R., & Heijmans, M. (2020). Towards a comprehensive, person-centred assessment of health literacy: translation, cultural adaptation and psychometric test of the Dutch Health Literacy Questionnaire. *BMC Public Health*, *20*(1), 1–12.

Ristanti, I., Diantoro, M., Wisodo, H., Hartatiek, Taufiq, A., & Hastuti, U. S. (2020). Structure, absorbance, and antibacterial activity modification by including AgNPs on Fe3O4@polyethylene glycol. *AIP Conference Proceedings*, *2234*.

Rodrigues, E., Cassas, F., Conde, B. E., Da Cruz, C., Barretto, E. H. P., Dos Santos, G., Figueira, G. M., Passero, L. F. D., Dos Santos, M. A., Gomes, M. A. S., Matta, P., Yazbek, P., Garcia, R. J. F., Braga, S., Aragaki, S., Honda, S., Sauini, T., Da Fonseca-Kruel, V. S., & Ticktin, T. (2020). Participatory ethnobotany and conservation: A methodological case study conducted with quilombola communities in Brazil's Atlantic Forest. *Journal of Ethnobiology and Ethnomedicine*, *16*(1), 1–12.

Safadel, P., & White, D. (2019). Facilitating Molecular Biology Teaching by Using Augmented Reality (AR) and Protein Data Bank (PDB). *TechTrends*, *63*(2), 188–193.

Santos, Y. T. P. (2024). Media and Information Literacy for All: An Analysis of the Content and Pedagogy in a University-Level Course. *International Information and Library Review*.

Sharma, M., Sharma, M., & Sharma, M. (2022). A comprehensive review on ethnobotanical, medicinal and nutritional potential of walnut (Juglans regia L.). *Proceedings of the Indian National Science Academy*, *88*(4), 601–616.

Smaldino, S. E., Lowther, D. L., & Russel, J. D. (2011). *Instructional Technology & Media For Learning*. Prenadamedia Group.

Suciati, S., Silvita, S., Prasetyo, O., Fauziah, M. D., Santika, K. D., Norawi, A. M., & Rahman, H. T. (2023). Problem-Based Learning Models: Their Effectiveness In Improving Creative Thinking Skills Of Students With Different Academic Skills In Science Learning. *Jurnal Pendidikan IPA Indonesia*, *12*(4), 672–683.

Tomczyk, Ł. (2020). Skills in the area of digital safety as a key component of digital literacy among teachers. *Education and Information Technologies*, *25*(1), 471–486.

Tomczyk, Ł., & Fedeli, L. (2022). *Digital Literacy for Teachers*. Springer Nature Singapore.

Yee, K. K., & Huey Shyh, T. (2024). Problem-Based Learning: Media and Information Literacy Project to Combat Misinformation for Future Communicators. *Journalism and Mass Communication Educator*, *79*(3), 340–364.

Yu, H., Abrizah, A., Rafedzi, E. R. K., & Abdullah, S. N. M. (2018). Reinforcing information literacy development through a subject-focused resource-based project. *Journal of Librarianship and Information Science*, *50*(4), 386–398.

Yu, S., Liu, Q., Ma, J., Le, H., & Ba, S. (2023). Applying Augmented reality to enhance physics laboratory experience: does learning anxiety matter? *Interactive Learning Environments*, *31*(10), 6952–6967.