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DEVELOPMENT OF A DIGITAL ETHNOBOTANY MODULE BASED ON BANYUWANGI LOCAL WISDOM TO IMPROVE THE SCIENCE LITERACY OF PRESERVICE TEACHERS

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ABSTRACT
This research aims to develop a digital teaching module for ethnobotany based on Banyuwangi local wisdom to improve the scientific literacy of preservice biology teacher students at the Universitas 17 Agustus 1945 Banyuwangi. This research uses a development research model, the ADDIE model. ADDIE is an acronym for Analyze, Design, Development, Implementation, and Evaluation. The research subjects consisted of one material expert, one media expert, biology education students taking ethnobotany courses. To see the effectiveness of learning by using the digital teaching module of ethnobotany based on Banyuwangi local wisdom for preservice teacher students, an assessment was used by giving tests before and after learning using the digital teaching module of ethnobotany. The results of the module development have been validated by material and media expert validation and show that this module is very suitable for use in learning in the ethnobotany course. The results of this module development are also quite effective in improving the scientific literacy of preservice biology teacher students when viewed from test scores with an N-Gain value of 0.56.

INTRODUCTION
798 / 5.000 Scientific literacy is a crucial component and essential skill for facing the challenges of the 21st century (Andreas, S. 2023; Fitri Y, 2018; Nasem, 2016). In the 21st century, challenges and problems relate to climate change, energy availability, food and water availability, and the spread of disease (Fananta, et al., 2017). Scientific literacy can serve as a foundation for individuals to face these challenges more critically and innovatively (Budianti, et al., 2024). Individuals with scientific literacy skills are able to use scientific knowledge, identify relevant questions, and draw conclusions based on evidence to make responsible decisions on everyday life issues (Baek, et al., 2023; Johnston JD, 2020). Scientific literacy is very important because it forms critical thinking patterns and applies scientific principles to solve real problems in the surrounding environment.

Mastery of scientific literacy is crucial for preservice biology teachers as it can help them understand biological concepts in depth and subsequently teach them effectively to students. Biology teachers play a central role in fostering students' scientific literacy as they are the primary agents in integrating scientific content into learning activities (Sadler TD, 2009; Tidemand S, 2017; Suwono H, 2017; Pratiwi SN, 2019). Teachers with scientific literacy will be able to develop critical thinking, scientific attitudes, and contextual understanding in students (Adnan et al., 2021; El Islami RAZ et al., 2020). The study results show that the scientific literacy level of preservice biology teacher students at the Universitas 17 Augustus 1945 Banyuwangi is in the low category with an average score of 30.24% uses the Test of

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Scientific Literacy Skills (TOSLS) (Muhimmatin, I and Prasetiyo, TH., 2024). This situation is certainly worrying considering that they will become biology teachers tasked with teaching science to students (Levrini, O et al., 2019). Innovative strategies are needed to improve the scientific literacy of preservice biology teachers at the Universitas 17 Agustus 1945 Banyuwangi.

Students' scientific literacy can be improved through effective classroom learning methods, one of which is in the Ethnobotany course. The ethnobotany course examines the relationship between humans and plants from a cultural perspective, thus providing space for the integration of scientific knowledge and local wisdom (Putri, SE et al., 2022). Previous research on students' scientific literacy in ethnobotany studies has shown that learning using the ethnobotany-inquiry model (Endang, SL, et al., 2024), learning using an encyclopedia of medicinal plants (Fajrin et al., 2025), and learning using e-modules based on the wisdom of the Noaulu-Maluku tribe (Nanuayo, S et al., 2023) are effective in improving students' scientific literacy because they link scientific concepts to local contexts that are close to everyday life. Other research examines the development of ethnobotany-based learning materials with local wisdom for literacy and creative thinking (Sari D et al., 2020). Research on improving the scientific literacy of preservice biology teacher students with digital modules based on Banyuwangi local wisdom has not been studied. Therefore, the development of an ethnobotany-based digital teaching module that highlights Banyuwangi's traditional cultural plants is a strategic step to improve the scientific literacy of preservice biology teacher students.

Banyuwangi is a region rich in traditions and traditional ceremonies involving various types of plants with symbolic, spiritual, and ecological values (Fattahillah N, et al., 2023; Febrianto H., 2022). Digital teaching modules present materials in a visual, interactive, and easily accessible manner, thus aligning with the characteristics of 21st-century learning (Rehman N, et al., 2024; Uma'iyah N, et al., 2023). The purpose of this study is to develop a digital ethnobotany teaching module based on Banyuwangi local wisdom to improve the scientific literacy of preservice biology teacher students at the Universitas 17 Agustus 1945 Banyuwangi. This approach not only provides contextual and meaningful learning but is also relevant to the students' socio-cultural environment.

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RESEARCH METHOD

This research uses a type of development research with the model used is ADDIE. ADDIE is an acronym for Analyze, Design, Development, Implementation, and Evaluation (Branch, R.M. 2009) (Figure 1). The stages of applying the ADDIE model in developing this digital module are as follows: (a) analyzing student needs, analyzing learning objectives, analyzing teaching materials and technological readiness; (2) designing content, required digital teaching modules, and research instruments; (3) Validation testing of materials and products to experts (expert testing), (4) implementation of teaching modules to see students' scientific literacy; (5) The final stage is a comprehensive evaluation to determine which parts need to be revised based on input and suggestions obtained from experts and the results of the implementation of the digital teaching module.

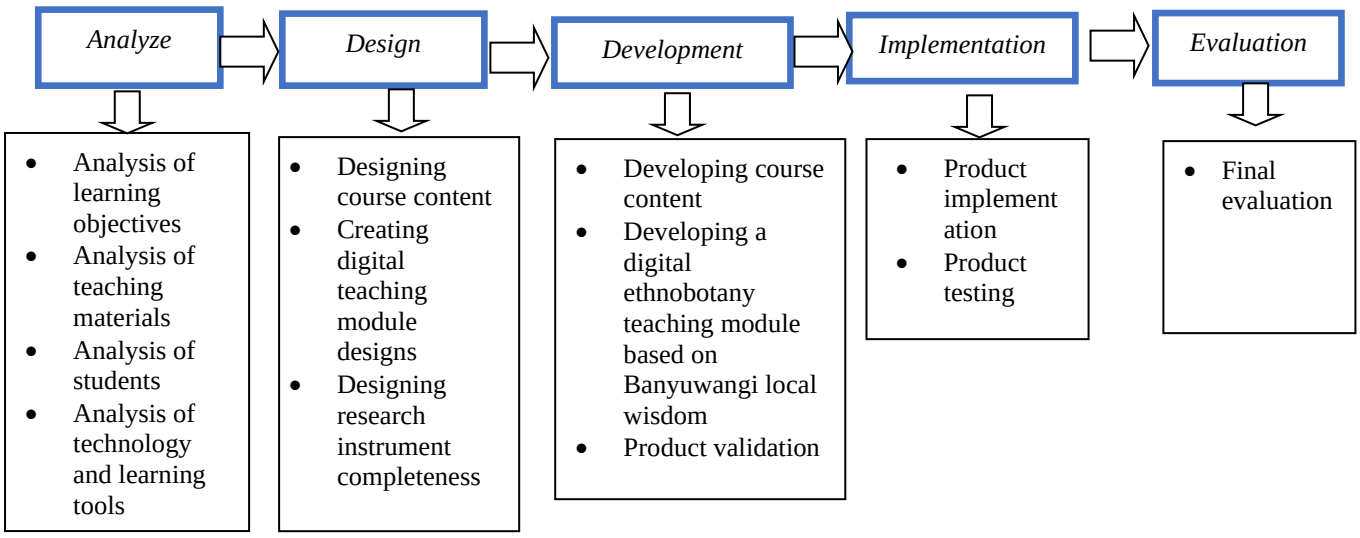

Figure 1. ADDIE Model Diagram

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The research subjects consisted of one material expert, one media expert, five biology education students who had previously taken ethnobotany courses, and eleven biology education students currently taking ethnobotany courses. The material expert was a biology education lecturer with a doctoral degree. The media expert was a lecturer with a doctoral degree in educational technology. Validation from these experts was used to assess the validity of the developed digital ethnobotany teaching module based on Banyuwangi local wisdom. Validation by biology education students who had previously taken ethnobotany courses was necessary to obtain feedback on the practicality of the developed digital ethnobotany teaching module. The tested digital teaching module was then implemented in classroom learning for the ethnobotany course. Eleven undergraduate biology education students participated in the classroom learning.

The data in this study included validation data from the digital teaching module experts (materials and media); data on the practicality of the digital teaching module, and data on the implementation results of the digital teaching module in improving the scientific literacy of prospective biology teachers. Data on the validity of the digital teaching module were obtained using a questionnaire. The questionnaire consisted of closed-ended statements and included a column for expert suggestions for improvement. Data on the implementation of the digital ethnobotany teaching module based on Banyuwangi local wisdom to determine the improvement in students' scientific literacy were obtained during the implementation of the digital teaching module in learning from the results of tests and a scientific literacy self-efficacy questionnaire.

The data analysis technique in this study was quantitative descriptive analysis. A Likert scale was used to determine the suitability of the digital teaching module. Data collected from the likert scale, derived from the questionnaire, was then processed using a percentage formula.

$$P=\frac{\sum X}{\sum Xi} \times 100\%$$

Information:
P = Percentage
∑X = Total score of respondents' answers
∑Xi = Total ideal score

The processed data using the percentage formula is then matched with the eligibility criteria as shown in Table 1.

Table 1. Criteria for the level of suitability of digital teaching modules

Equivalent	Percentage	Qualification	Category
A	90% - 100%	Very Valid	Very Eligible
B	75% - 89%	Valid	Eligible
C	65% - 74%	Quite Valid	Quite Eligible
D	55% - 64%	Less Valid	Less Eligible
E	0% - 54%	Not Valid	Not Eligible

(Sumber: Tegeh, MI. et al., 2014)

To assess the effectiveness of learning using the digital ethnobotany teaching module based on Banyuwangi local wisdom for prospective teacher students at the University of 17 August 1945 Banyuwangi, an assessment was conducted by administering tests before and after learning using the digital ethnobotany teaching module. The data obtained were then analyzed using the N-Gain formula and the results were matched with the criteria in Table 2.

$$N\text{-}Gain = \frac{\text{Post Test Score} - \text{Pre Test Score}}{\text{Maximum Score} - \text{Pre Test Score}}$$

Table 2. Interpretation Criteria for Level of Effectiveness

Percentage (%)	Level of Effectiveness
<40	Ineffective
40-55	Less Effective
56-75	Moderately Effective
>76	Effective

(Sumber: Hake, R.R, 1999)

RESULT AND DISCUSSION

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The scientific literacy skills of preservice biology teacher students can be supported by using a digital teaching module based on Banyuwangi local wisdom as a learning medium. Improving students' scientific literacy in this ethnobotany course provides them with essential 21st-century skills, such as scientific discovery approaches, exploration of local issues, strengthening critical thinking skills, and scientific literacy-based evaluation. The development of this digital ethnobotany teaching module based on Banyuwangi local wisdom was carried out in several stages.

The first stage of this research began with the analysis stage. This analysis consisted of several activities, including the objectives and teaching materials of the Ethnobotany course, the media/learning tools, and the student analysis, including the scientific literacy skills of biology education students at the Universitas 17 Agustus 1945 Banyuwangi. The results of the analysis show that so far Ethnobotany learning at the 17 Agustus 1945 Banyuwangi has not used digital-based learning media to support lectures in the Ethnobotany class, the integration of Banyuwangi local wisdom materials has not been carried out optimally in learning and the results of the analysis of the initial scientific literacy of preservice Biology teacher students at the Universitas 17Agustus 1945 Banyuwangi show that students are less able to demonstrate their scientific literacy skills. Therefore, it is necessary to develop a digital teaching module for ethnobotany based on Banyuwangi local wisdom as a strategic step to improve the scientific literacy of preservice Biology teacher students.

The next step after analysis is the design stage. At this stage, the digital teaching module is designed in accordance with the learning materials that will be used as content in the digital ethnobotany teaching module by integrating Banyuwangi local wisdom, designing the digital teaching module according to the module's structure, and developing instruments for validating the teaching module. At this stage, the content contains an introduction to ethnobotany, ethnobotany from a scientific and cultural perspective, the richness of plants and culture in Banyuwangi, as well as local Banyuwangi plants and their use in traditional ceremonies. The teaching module is designed with the characteristics that can be used by students independently, contains learning materials that integrate plants with Banyuwangi local wisdom, adapting to technological developments, namely containing text, images, illustrations, videos, animations and links that lead to research articles in Google Scholar and YouTube links. This makes it easier for students to learn ethnobotany based on Banyuwangi local wisdom. The videos in the digital teaching module are based on the relationship between plant use and the customs of the Banyuwangi people, who are the Using tribe. In keeping with its function as a learning medium, this Digital Teaching Module is used to support students' scientific literacy. It contains exercises that support students' scientific literacy skills based on the local wisdom of the Banyuwangi community.

The digital module format will accommodate scientific discovery activities, provide students with space to explore scientific issues, practice problem-solving, and use scientific literacy-based evaluation instruments, thereby improving the scientific literacy of preservice biology teachers (Humairah LP & Wahyuni S., 2024; Silvia RM, et al., 2024). The digital teaching module was developed by integrating 21st-century learning strategies, such as a scientific discovery approach, exploration of local issues, strengthening critical thinking skills, and scientific literacy-based evaluation. The scientific discovery approach using digital teaching modules has been proven effective in improving scientific literacy (Osborne J, 2014; OECD, 2021).

The development phase is the testing phase for the local wisdom-based digital teaching module that has been created. The first phase of testing is validation by subject matter and media experts using a questionnaire. Tables 3 and 4 below show the validation results by subject matter and media experts.

Table 3. Results of Material Expert Validation

Aspect	Average Value	Percentage	Qualification
Material Coverage	4,5	90	Very Valid
Material Accuracy	4,7	93,3	Very Valid
Learning Materials	4,5	90	Very Valid
Evaluation	4,5	90	Very Valid

Table 3 shows that all aspects of the teaching module scored above 4.5 (percentage ≥ 90%), categorizing it as highly valid. This means that the digital ethnobotany teaching module based on Banyuwangi local wisdom is highly suitable and can be used in teaching the Ethnobotany course. The material coverage aligns with the learning outcomes and characteristics of preservice biology teacher students. This means that the module's content not only discusses general ethnobotany concepts but also relates them to the local context of Banyuwangi. The material's accuracy is high, encompassing the suitability of indicators, final competencies, and learning strategies to learning objectives. This demonstrates that the module is not only informative but also instructional. The learning material is clearly structured, encompassing the depth, breadth, and relevance of supporting media (videos, images, illustrations). Learning evaluation is relevant to students' scientific literacy achievements. The assessment rubric and evaluation instruments are well

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integrated, although strengthening of the data analysis indicators is still needed. The module can be used directly in learning. This module has the potential to be an innovative learning resource that integrates biology, local wisdom, and scientific literacy.

Table 4. Media Expert Validation Results

Aspect	Average Value	Percentage	Qualification
Digital Module	4,5	90,9	Very Valid
Digital Module Specifications	4,6	92	Very Valid
Overall	4,6	91,2	Very Valid

The results of the data processing obtained show that (Table 4) the overall average score of the media expert validation instrument is above 4.5 (validity percentage of ≥90%). This value is in the Very Valid category. This means that the digital ethnobotany teaching module based on Banyuwangi local wisdom is considered to have met the eligibility standards as a learning medium. Several assessment aspects include: the navigation aspect is considered very clear and makes it easy for students to move between sections. The user manual is quite helpful, although it still needs to be supplemented with practical guidance in the form of a short video tutorial. The module facilities (resources & activities) are considered interesting and able to motivate students. The digital module features are quite complete, although it would be better if a discussion forum for student interaction was added. The visual media (images & videos) are appropriate, but some images need to have their resolution improved. The typography is considered very good, consistent, and easy to read. The color proportions are quite harmonious, although in some parts the text contrast needs to be improved. The audio in the video is clear, but there is still an imbalance in volume in some parts. The language used is communicative and easy for students to understand. The accuracy as a learning and independent learning medium scored high, meaning that this module is relevant for both lectures and students' independent learning.

The next trial was a practicality test conducted on students who had taken the ethnobotany course. The practicality test consisted of statements related to ease of use, effectiveness, and suitability. Table 5 below shows the results of the practicality test by students. The results of the practicality test in Table 5 show an average score above 21 with a percentage above 86.4%. This table indicates that the digital module is very practical based on student assessments, so this module can be used as a learning in the Ethnobotany course. The highest score was found in the effectiveness assessment. The lowest score was found in the ease of use assessment. These results align with the practicality test results from Erniwati et al. (2022 in Muhimmatin et al. 2025) which showed that the use of electronic modules assisted can attract students' attention.

Table 5. Practicality Result of the Digital Ethnobotany Teaching Module

Aspect	Average Value	Percentage (%)	Decision
Ease of use	21,6	86,4	Agree
Effectiveness	25	100	Strongly Agree
Suitability	22,6	90,4	Strongly Agree

The next stage was the implementation of a digital teaching module based on Banyuwangi local wisdom in the Ethnobotany course. The results of the digital teaching module's implementation on the scientific literacy of preservice biology teachers can be seen in Tables 6 and 7.

Table 6. Self-Efficacy Results of the Digital Ethnobotany Teaching Module on the Scientific Literacy of Preservice Biology Teacher Students

Aspect	Average Value	Percentage (%)	Decision
Perception of module content and design	51,9	94,3	Strongly Agree
Engagement in the learning process	55	100	Strongly Agree
Self-confidence in achieving learning outcomes	52	94,5	Strongly Agree

Table 7. Results of the Effectiveness of the Digital Teaching Module Based on Banyuwangi Local Wisdom on Scientific Literacy

Average Pre Test	Average Post Test	N Gain Score	N Gain Score %	Criteria
69	86	0,568	56,81	Quite Effective

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Table 6 show that the average student score related to their perception of the module's content and design was 51.9. This represents an achievement percentage of approximately 94.3%. This means that students assessed the digital ethnobotany module as having relevant content, easy-to-understand language, and a design that supports scientific literacy learning. Regarding engagement in the learning process, the average student score was the highest, with an achievement percentage reaching 100%. This indicates that the module was highly effective in triggering active student involvement in the learning process, such as reading, discussing, and practicing scientific literacy skills. This indicator is a key strength of the digital module's use. Regarding self-confidence in achieving learning outcomes, the average student score was approximately 94.5%. This means that students have strong self-efficacy, namely the belief that they are capable of completing assignments, understanding the material, and achieving the expected learning outcomes after using the module. Table 7 interprets that the developed module was quite effective in improving the scientific literacy of preservice teacher students, with an N-Gain Score of 56.47%. Electronic modules based on scientific literacy have been proven to improve student learning outcomes (Safitri T, et al., 2024). Furthermore, to support the understanding of today's young generation, it is necessary to integrate digital technology-based learning methods with scientific literacy (Budianti, N. M., et al., 2024). Electronic modules based on local wisdom can train students' critical thinking skills through contextual and interactive learning strategies (Sirojjuddin, et al., 2025). The richness of Banyuwangi's customs and culture can be integrated into ethnobotany teaching modules and can be used to train plant literacy and problem solving (Fatahillah et al. 2023).

The Evaluation Phase is the final stage of the development of this digital teaching module. The validation results from the material experts suggested several minor improvements, namely in the variety of ethnobotanical examples, deepening the evaluation indicators, and adding infographics based on local data. Although the validation results were very good, the material experts provided constructive input to improve the quality of the module, namely the variety of ethnobotanical examples, which are currently still dominated by several types of plants, so it is necessary to add variations of other local plants from Banyuwangi (for example, spice plants, typical fruits, and community forest plants). The deepening of the evaluation indicators, namely the scientific literacy assessment rubric, is still general, especially in the aspects of graphic analysis, data interpretation, and the preparation of evidence-based arguments. These indicators need to be clarified so that students are more focused in displaying their competencies. Infographics based on local data, namely illustrations and images, are still partly generic. It is recommended to use original documentation (field photos, local plant survey results) so that students feel closer to the learning context. The connection between sub-CPPL and learning activities, namely the need to add explicit mapping between specific learning outcomes (sub-CPL) and learning activities so that students understand the relevance of each activity. Portfolio assessment, in addition to quizzes or tests, portfolio-based assessments (reflection reports, field journals) need to be included so that students can express contextual understanding. With minor improvements, this module can be used to increase students' ecological awareness through understanding Banyuwangi's local ethnobotany, critical and analytical thinking skills can be improved through ethnobotanical data analysis tasks, 21st-century skills (digital literacy, scientific literacy, and cultural literacy) are possessed by preservice Biology teacher students at the Universitas 17 Agustus 1945 Banyuwangi. Improvements suggested by media experts are minor, namely to improve visual quality (high-resolution images). Perform audio normalization for more stable volume. Improve color contrast for readability and add interaction features (discussion forums) and offline access options.

CONCLUSION

The results of the development of a digital ethnobotany teaching module based on Banyuwangi local wisdom to improve the scientific literacy of preservice Biology teacher students have been validated by validation from material and media experts, indicating that this module is very suitable for use in learning in the ethnobotany course. This module is effective as an interactive, communicative medium, and supports the scientific literacy of preservice Biology teacher students at the Universitas 17 Agustus 1945 Banyuwangi. This digital module has the potential to be a learning medium that is not only innovative, but also sustainable, inclusive, and effective in improving students' scientific literacy. The digital ethnobotany module is very suitable for use in training students' scientific literacy. The most prominent aspect is involvement in the learning process, which means the module successfully encourages students to be active, not just passive recipients of information. Perceptions of the module's content and design, as well as students' self-confidence, are also in the very high category, indicating that overall the module meets students' learning needs in terms of content, presentation, and support for learning confidence. Thus, the digital module not only provides knowledge but also increases students' self-efficacy in scientific literacy, especially in critical thinking skills, problem solving, and active involvement

in the learning process. The results of this module development are also quite effective in improving the scientific literacy of preservice biology teacher students when viewed from test scores.

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