



Developing Plant Ethnophysiology Flashcards to Support Contextual Learning of Photosynthesis Through Local Wisdom Integration

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Abstract

Science education in the 21st century requires innovative learning media that not only strengthen students' conceptual understanding but also connect scientific knowledge with real life and cultural contexts. Integrating local wisdom into biology learning can provide meaningful learning experiences by linking abstract scientific concepts with students' surrounding environments and traditional knowledge. In this context, ethnophysiology based learning media offer opportunities to support contextual and culturally responsive science instruction. This study aimed to develop plant ethnophysiology flashcards that integrate photosynthesis concepts with local wisdom to support students' conceptual understanding, enhance learning engagement, and provide contextualized biology instruction grounded in local cultural knowledge. This study employed an educational Research and Development (R&D) approach using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model. However, the development process in this research was limited to the Analysis, Design, and Development stages. Expert validation was conducted during the Development stage to evaluate the feasibility of the flashcards in terms of learning, media design, and material content, while the Implementation and Evaluation stages will be conducted in subsequent research. The validators consisted of learning experts, media experts, and subject matter experts. Data were collected using validation sheets and analyzed using a Likert scale. The validation results showed that the overall average validity score from the learning experts, media experts, and material experts was in the very valid category. Therefore, the flashcards were categorized as highly valid and suitable for use in biology learning. These findings indicate that plant ethnophysiology flashcards have strong potential as contextual learning media for strengthening students' understanding of photosynthesis, increasing learning engagement, and fostering appreciation of local cultural knowledge.

Keywords: ADDIE; flashcard; local wisdom; photosynthesis; plant ethnophysiology

INTRODUCTION

Biology learning in higher education is required not only to convey theoretical scientific concepts but also to connect science to students' real life contexts. This approach aligns with the demands of the Independent Learning Curriculum and the 21st century learning paradigm, which emphasizes meaningful, contextual, and local wisdom based learning. One fundamental topic in biology studies is photosynthesis, which is at the core of plant physiological processes and fundamental to understanding energy flow in ecosystems, food security, and global climate change (Gagnidze, 2018; Bragaswangga *et al.*, 2019; Akbar *et al.*, 2021). However, in practice, photosynthesis is often taught abstractly through a rote approach, lacking a direct connection to students' everyday experiences (Jančaříková & Jančařík, 2022; Giawa, 2023). This contributes to low interest in learning, weak active engagement in the learning process, and a lack of in-depth and applicable conceptual understanding (Alfi & Bakar, 2021; Nafiati, 2021; Pratama *et al.*, 2024).

When students fail to see the relevance of the concepts they learn to their local lives, the potential for contextual scientific literacy is hampered.

Therefore, a learning strategy is needed to bridge modern biology concepts with students' local cultural and environmental realities. One potential approach is integrating photosynthesis concepts with traditional community knowledge through plant ethnophysiology-based learning media. This approach not only strengthens scientific understanding but also promotes awareness of the importance of preserving local culture and ecosystems (Kusum *et al.*, 2023; Ramadani, 2025). The integration of local wisdom into science learning plays an important role in creating meaningful learning experiences. Through an ethnoscience approach, particularly plant ethnophysiology, concepts such as photosynthesis can be understood through examples of local plant utilization in community life, including agricultural practices and the traditional use of forest resources (Sukiastini, 2024; Septina, 2025). These practices contain biological knowledge related to photosynthesis, respiration, transpiration, and physiological adaptation. When students recognize the connection between scientific theories and cultural traditions, learning becomes more contextual and meaningful, with the potential to enhance learning motivation (Utami *et al.*, 2021; Jabnabillah & Margina, 2022; Mailidarni & Djafar, 2025).

However, the integration of local wisdom into biology learning has not been widely implemented in schools and higher education, primarily due to the limited availability of instructional media that effectively connect scientific concepts with local knowledge (Maigoro *et al.*, 2017; Nurhasnah *et al.*, 2022; Mailidarni & Djafar, 2025). This condition highlights the need for innovative and contextual learning media that can bridge scientific knowledge with students' cultural experiences. Several studies have reported that ethnoscience based learning media significantly improve students' conceptual understanding, learning motivation, and scientific literacy. For example, Ramadani (2025) found that teaching materials integrated with local wisdom enhanced students' critical thinking skills, while Shofa & Murtono (2021) reported that visual learning media such as flashcards increased students' engagement and retention of science concepts. Lin *et al.* (2018) demonstrated that visual verbal learning tools improve memory performance and conceptual recall in science learning contexts.

Flashcards, as concise visual learning media, have been shown to strengthen visual verbal connections and promote active learning (Lengari & Agustika, 2020; Solissa *et al.*, 2023). When designed using local plant illustrations and ethnobotanical narratives, flashcards can support contextual learning by linking abstract biological processes with students' everyday experiences. Contextual visual media significantly improved students' understanding of complex biological concepts, integrating ethnoscience into physiology learning increases students' learning motivation and environmental awareness (Paldy *et al.*, 2025; Septina, 2025). Despite these positive findings, there remains a lack of learning media specifically designed to integrate photosynthesis concepts with plant ethnophysiology in the local context of Riau Malay and other regions in Sumatra, particularly for prospective biology teacher students (Ramadha & Zuhaida, 2021; Arsyaf *et al.*, 2022). Most existing media focus primarily on conceptual content without explicitly incorporating local ecological knowledge. This gap indicates the need for innovative learning media that combine scientific accuracy with cultural relevance to support meaningful biology learning.

Developing plant ethnophysiology flashcards for photosynthesis, therefore, represents a strategic effort to strengthen students' conceptual understanding, learning engagement, and environmental awareness while promoting culturally responsive science education. Considering the importance of contextual learning media, this study aims to develop plant ethnophysiology flashcards designed to support students' conceptual understanding, enhance learning engagement, and promote environmental awareness through the integration of local wisdom. In addition, this study seeks to determine the validity of the developed media through assessments by subject matter experts, media experts, and learning experts. The validity results serve as an initial indicator of the media's feasibility before wider classroom implementation. Therefore, this study aimed to develop plant ethnophysiology flashcards that integrate photosynthesis concepts with local wisdom to support students' conceptual understanding, enhance learning engagement, and provide contextualized biology instruction grounded in local cultural knowledge.

METHOD

The research employed an educational R&D approach using the ADDIE model in Biology Education Study Program, Riau Islamic University (Allen, 2006; Branch, 2009). The ADDIE model was selected because it provides a systematic and structured framework for developing instructional media. Its flexibility allows researchers to adapt the development process to research needs and constraints while maintaining product quality and validity (Nurfitri *et al.*, 2022; Szabo, 2022; Yulia & Sutrisno, 2024). This study was limited to the first three ADDIE stages: Analysis, Design, and Development. Expert validation was conducted during the development stage to assess the feasibility of the flashcards in terms of learning, media design, and content. The implementation and evaluation stages will be addressed in future studies to examine practicality and effectiveness. The ADDIE stages are presented in Figure 1.

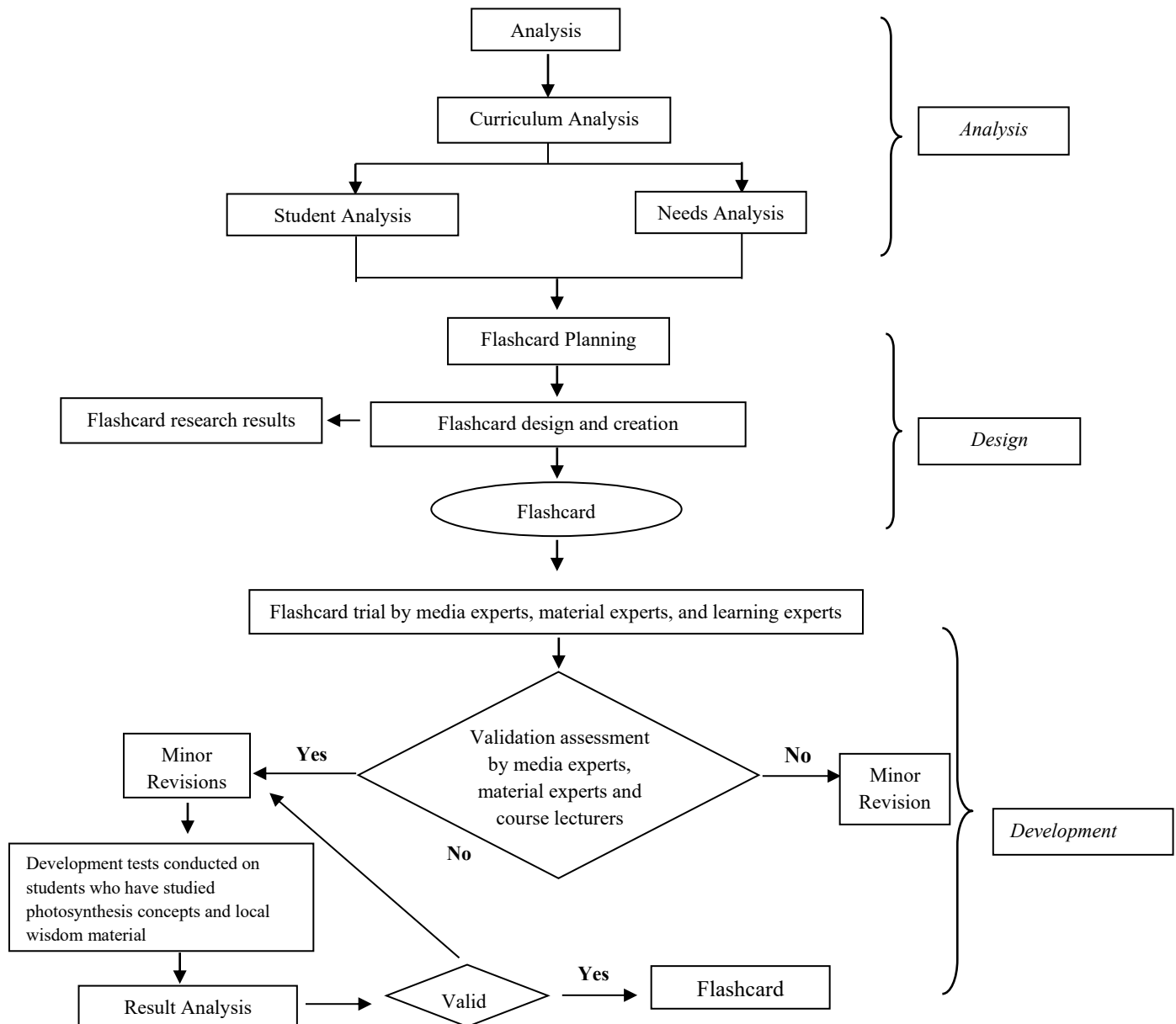


Figure 1. ADDIE stages (*Analysis to Development*) (Molenda, 2015; Mellisa & Yanda, 2019)

This study was conducted at the development stage of the ADDIE model, focusing on expert validation of the developed flashcards. The validation process involved three experts, consisting of one media expert, one learning expert, and one material expert. All validators were university lecturers specializing in biology education and instructional media development. A validation sheet was used as the research instrument to evaluate the feasibility of the product in terms of content, media design, and learning aspects. The collected data were analyzed using a Likert scale. The validity percentage was determined by dividing the total score obtained from expert assessments by the maximum possible score and multiplying the result by 100. In this calculation, the validity score (V) reflects the level of product validity, the total score obtained (TSe) represents the accumulated scores assigned by the validators, and the maximum expected score (TSh) refers to the highest possible score that could be achieved (Akbar, 2015).

After the results of each validation test were obtained, the validity of the product was determined by comparing the percentage scores from expert, teacher, and student assessments with predefined validity criteria. Products achieving a validity score of 85.01%–100% were considered very valid and suitable for use without revision. Scores of 70.01%–85.00% indicated that the product was quite valid and could be used with minor revisions. Scores ranging from 50.01% to 70.00% were categorized as less valid and required major revisions, whereas scores of 1.00%–50.00% were classified as invalid and unsuitable for use without substantial improvement (Mellisa & Saputri, 2023). These criteria were used to determine the overall feasibility of the developed flashcards before proceeding to the implementation stage. In addition, the validation results provided feedback regarding aspects of the product that required improvement, particularly in terms of content accuracy, media design, and instructional suitability. The suggestions and comments provided by the validators served as the basis for revising and refining the product to ensure its quality and effectiveness for learning.

RESULTS AND DISCUSSION

This study produced plant ethnophysiology flashcards integrating photosynthesis concepts with local wisdom. The developed flashcards contain information on local plant species, photosynthesis processes, ethnobotanical knowledge, and guiding questions to support students' conceptual understanding. To evaluate the feasibility of the product, expert validation was conducted involving learning, media, and material experts. The validation results are presented in Figure 2.

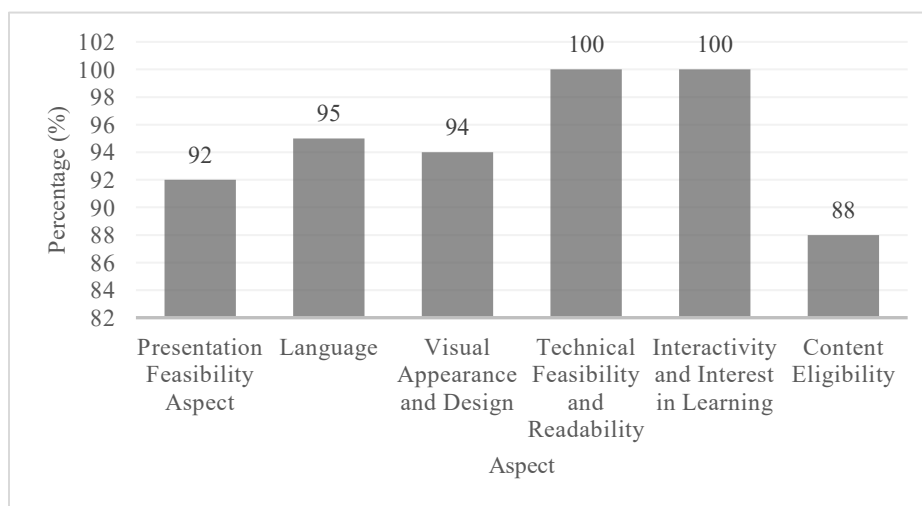


Figure 2. Summary of expert validation results for the developed flashcards

The integration of local wisdom into learning media is important as it helps contextualize scientific concepts and enhances students' meaningful learning experiences (Mashudi, 2021; Roesmawati *et al.*, 2022; Suanda *et al.*, 2024). In this study, the developed flashcards were designed to connect photosynthesis

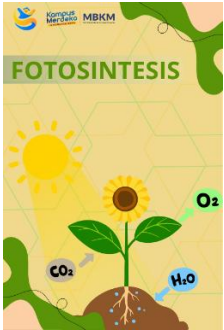
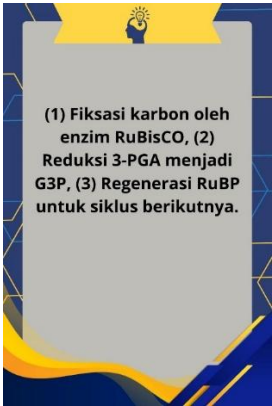
concepts with ethnobotanical knowledge derived from local plant species, allowing students to relate biological concepts to their real-life environment. In addition, supplementary cards were included to present course learning outcomes, as well as a cover card that introduces the learning objectives and scope of the material. The overall design emphasized simplicity, readability, and visual balance, using appropriate typography and color schemes to enhance visual comfort and instructional clarity, in line with multimedia learning principles that highlight coherence, signaling, and visual effectiveness (Lin *et al.*, 2018; Arsyaf *et al.*, 2022; Paldy *et al.*, 2025). Therefore, the integration of ethnobotanical elements into the flashcards was intended not only to support the learning of photosynthesis concepts but also to promote the preservation and appreciation of local wisdom among students.

This study was conducted up to the development stage of the ADDIE model, focusing on expert validation and product revision. Expert validation involved three university lecturers with expertise in biology education and instructional media, consisting of one learning expert, one media expert, and one material expert. The validation process was conducted to evaluate the feasibility of the developed flashcards in terms of presentation quality, language clarity, visual design, technical feasibility, interactivity, and content accuracy, which are commonly used criteria in instructional media evaluation (Sugiharni, 2018; Astuti *et al.*, 2021; Maisyura *et al.*, 2021). Each expert assessed the product using a structured validation sheet based on a Likert scale, which was then converted into percentage scores to determine the level of validity of the developed media. Furthermore, the expert validation process served as an essential quality assurance mechanism in the development of the instructional media. The recommendations and suggestions provided by the validators contributed to the optimization of both the pedagogical and technical aspects of the flashcards.

The validation results indicated that the developed flashcards were categorized as very valid, with an overall average score of 93%. Learning experts provided an average score of 93%, suggesting that the presentation structure and language used in the flashcards were appropriate and clear for supporting biology learning. Media experts gave the highest score of 98%, indicating that the flashcards had strong visual appearance, good readability, technical feasibility, and engaging interactivity. Meanwhile, material experts assigned a score of 88%, confirming that the content was conceptually accurate and relevant to the learning objectives, although minor improvements were suggested to further enrich the depth of the material. These findings demonstrate that the developed flashcards meet the established criteria for instructional quality and are suitable for implementation in biology learning activities. The consistently high validation scores across all expert groups indicate that the product successfully integrates content accuracy, pedagogical appropriateness, and effective media design.

Based on these findings, the developed flashcards can be considered feasible for use as learning media in biology education, particularly in supporting students' understanding of photosynthesis through a contextual approach. The high validation scores from all expert groups indicate that the product meets essential criteria of instructional media, including pedagogical appropriateness, visual clarity, and scientific accuracy. Although categorized as very valid, the material expert's feedback highlighted the need for refinement in certain content aspects to enhance conceptual depth and completeness. Revisions were subsequently carried out based on suggestions and comments from the experts. These revisions included improvements in content accuracy, enhancement of visual layout, and clarification of instructional elements to ensure better readability and learning flow. The revision process reflects the iterative nature of educational Research and Development, in which products are continuously improved through systematic expert evaluation. A summary of the revision outcomes based on expert validation is presented in Table 1 below.

Table 1. Summary of flashcard revisions based on expert validation

Validator	Comment	Before	After
Media Expert	It is necessary to increase the color contrast so that the text is easier to read, it is best to avoid colors that are too bright which can tire the eyes.		
Material Expert	It's best to make one card for the cover.	Not available	
	In general, only text/narration is displayed, no images are displayed on the flashcards.		
Learning Expert	Add one card for CPL, CPMK, and Sub CPMK achieved in this medium.	Not available	

The validation results obtained from learning experts (93%) indicate that the developed flashcards demonstrate strong pedagogical feasibility, particularly in terms of presentation structure and language clarity. A systematic organization of content and the use of communicative language are essential in reducing cognitive load and supporting meaningful learning, especially when addressing abstract biological concepts such as photosynthesis. Clear instructional flow enables students to integrate new information with prior knowledge more effectively, thereby facilitating deeper conceptual understanding. These findings are in line with previous studies showing that well-structured multimedia learning materials, along with clear language and organized content, significantly enhance students' comprehension, retention, and conceptual thinking abilities (Fahrizal *et al.*, 2025; Handoyo & Kamal, 2025).

Media expert validation achieved the highest score (98%), demonstrating that the flashcards' visual design effectively supports learning. High ratings for illustrations, layout, typography, and readability indicate strong visual literacy support, while the integration of verbal and visual information helps learners develop clearer and stronger mental representations (Yunus & Fransisca, 2020; Mellisa *et al.*, 2023; Al Qalbi *et al.*, 2025). The integration of photosynthesis explanations and images of local plant species helps students understand abstract concepts more easily, while increasing engagement and motivation. This finding aligns with studies demonstrating the effectiveness of visual media in improving biology learning (Arsyaf *et al.*, 2022; Kusum *et al.*, 2023; Solissa *et al.*, 2023). Therefore, the high validation score from media experts suggests that the flashcards not only meet technical and aesthetic standards but also have strong potential to enhance the overall quality of the learning process.

Material expert validation achieved a score of 88%, confirming that the scientific content and integration of local wisdom are conceptually accurate and aligned with learning objectives, although further enrichment was recommended. This result suggests that while the flashcards adequately represent photosynthesis concepts within an ethnophysiological framework, expanding physiological explanations and incorporating a wider range of local plant species could strengthen content depth. The high overall validity score (93%) demonstrates that the flashcards meet essential criteria for contextual biology learning. The dominance of the media aspect underscores the importance of visual representation in facilitating efficient cognitive processing of complex concepts. Attractive illustrations, coherent layouts, and concise explanations contribute to learners' ability to construct meaning from instructional content. Therefore, refinement of content diversity represents an important direction for future development, particularly to better balance scientific rigor with cultural relevance and to enhance students' conceptual understanding through culturally grounded visual media (Supit *et al.*, 2023; Ramadani, 2025; Wahidin, 2025).

Moreover, the strong ratings for learning and language aspects indicate that the flashcards are pedagogically accessible and supportive of conceptual integration. The inclusion of ethnobotanical narratives connects scientific explanations with students' everyday cultural experiences, thereby reinforcing the ethnoscience approach in biology education. Although the material aspect received the lowest score among the evaluated components, it still falls within the very valid category. Expert feedback highlighted opportunities to enhance ecological representation by increasing the diversity of local plant examples, which is considered important for strengthening students' understanding of biodiversity and ecological context. Overall, embedding local wisdom and expanding biological diversity in learning materials can promote cognitive engagement, affective involvement, and ecological literacy, enabling students to perceive science as relevant to their lived environments (Lin *et al.*, 2018; Lestari & Rahmita, 2025; Nurkanti *et al.*, 2026).

The revision process further illustrates the importance of expert involvement in educational product development. Improvements in visual contrast enhanced readability, while the addition of learning outcome cards strengthened alignment between instructional media and curricular objectives. These iterative refinements reflect core principles of educational research and development, which emphasize continuous evaluation and revision rather than one step product finalization (Szabo, 2022; Mellisa *et al.*, 2023). Since this study was limited to expert validation at the development stage of the ADDIE model, the findings represent media feasibility rather than instructional effectiveness. Nevertheless, the validated flashcards demonstrate strong potential as contextual learning tools capable of supporting students' conceptual understanding, learning engagement, and environmental awareness through the integration of local wisdom.

Therefore, future research should implement the flashcards in classroom settings to evaluate their impact on students' conceptual mastery, motivation, and ecological literacy, as effectiveness testing is a crucial stage in determining the practical value of instructional products (Arsyaf *et al.*, 2022; Solissa *et al.*, 2023; Paldy *et al.*, 2025).

This study contributes to ethnoscience-based instructional design by demonstrating that ethnophysiological representations can bridge abstract biological concepts and students' socio cultural experiences. By integrating photosynthesis concepts with local plant knowledge, the flashcards support constructivist learning, enhance conceptual understanding, and foster engagement and ecological awareness. The novelty of this study lies in the development of ethnophysiology-based flashcards that combine physiological processes with local wisdom, an approach rarely explored in biology learning media. Unlike conventional flashcards focused on memorization, the developed media incorporates cultural narratives and regional plant characteristics to promote contextual learning. The study also provides expert-based validity evidence and offers a practical framework for developing culturally responsive and scientifically accurate learning media.

CONCLUSION

This study developed plant ethnophysiology flashcards integrating photosynthesis concepts with local wisdom as contextual biology learning media. Expert validation by learning, media, and material lecturers resulted in an overall validity score of 93% (very valid), with the highest score in the media aspect (98%), followed by learning and language (93%) and material content (88%). These findings indicate that the flashcards meet key criteria of visual quality, pedagogical appropriateness, readability, and conceptual accuracy. By linking scientific concepts with students' socio-cultural experiences, the media supports meaningful learning and environmental awareness. Although limited to expert validation, the flashcards show strong potential as culturally responsive learning tools that enhance conceptual understanding, engagement, and ecological literacy. Furthermore, the product supports the implementation of Indonesia's Independent Learning Curriculum by promoting contextual, student centered learning that integrates local wisdom and biodiversity education. Future studies should examine its impact on students' conceptual mastery, motivation, and contextual scientific literacy through classroom implementation.

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