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The basis for designing BUSAKA Pteridophytes as a cotribution to citizen science in local biodiversity

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Abstract

The conservation of Pteridophyta presents ongoing challenges that call for educational institutions to strengthen students' critical thinking and data literacy skills. However, conventional learning media have proven insufficient in supporting meaningful understanding of this complex topic, creating a gap between instructional intent and student outcomes. This study aimed to analyze the learning media needs of both teachers and students as an empirical foundation for developing innovative instructional solutions. A descriptive qualitative method was employed,.data were collected through needs assessment instruments and analyzed to identify patterns in media use, student comprehension, and instructional preferences. The findings revealed a notable gap between teachers' perceptions of their media as engaging and students' actual conceptual understanding, which remained suboptimal. Students expressed a strong need for dynamic, interactive visual media to improve concept retention, comprehension, and learning motivation. These results indicate an urgent need for a pocket book featuring rich, meaningful visualizations as a practical and accessible instructional solution. This study provides a robust empirical foundation for future media development efforts aimed at significantly enhancing student engagement and conceptual mastery in biodiversity.

Abstrak. *Tantangan konservasi Pteridophyta menuntut peran aktif lembaga pendidikan dalam membangun kapasitas berpikir kritis dan literasi data siswa. Namun, media pembelajaran konvensional terbukti belum mampu mendukung pemahaman yang bermakna pada topik yang kompleks ini, sehingga menciptakan kesenjangan antara tujuan pembelajaran dan capaian siswa secara nyata. Penelitian ini bertujuan menganalisis kebutuhan media pembelajaran dari sudut pandang guru dan siswa sebagai landasan empiris bagi pengembangan solusi instruksional yang inovatif. Metode yang digunakan adalah deskriptif kualitatif, data dikumpulkan melalui instrumen analisis kebutuhan dan dianalisis untuk mengidentifikasi pola penggunaan media, tingkat pemahaman siswa, dan preferensi pembelajaran. Hasil penelitian mengungkapkan kesenjangan yang signifikan antara persepsi guru mengenai daya tarik media yang mereka gunakan dengan pemahaman konseptual siswa yang masih belum optimal. Siswa sangat membutuhkan media visual yang dinamis dan interaktif guna meningkatkan pemahaman konsep, retensi materi, dan motivasi belajar. Temuan ini menunjukkan adanya kebutuhan mendesak untuk mengembangkan buku saku dengan visualisasi yang kaya dan bermakna sebagai solusi pembelajaran yang praktis dan mudah diakses. Penelitian ini menyediakan landasan empiris yang kuat bagi upaya pengembangan media di masa mendatang yang bertujuan meningkatkan keterlibatan dan penguasaan konseptual siswa dalam pembelajaran keanekaragaman hayati secara signifikan.*

A. Introduction

Indonesia is rich in biodiversity, both in flora and fauna, including pteridophytes. Pteridophytes are vascular plants that reproduce using spores, and one of the characteristic is their leaf arrangement, which resembles wings or feathers. Pteridophytes are a part of the flora whose existence is rarely recognized. The population of pteridophytes experienced a decline from 2015 to 2019, especially in the ex-situ area of the Purwodadi Botanical Garden (Renjana, 2019). This finding is significant because pteridophytes play a complex role in ecosystems, including being important for erosion prevention and soil stabilization in various ecosystems, contributing significantly to environmental sustainability. In addition, pteridophytes can colonize habitats disturbed by natural forces such as tectonic activity, wind, water, and fire, as well as by human activities (Brock et al., 2016; Irawati et al., 2012; Afifah et al., 2023). The people of Kalimantan utilize pteridophytes for both food and medicinal purposes, such as "*Kelakai*" in South and Central Kalimantan and "*Piyai*" in North Kalimantan, which are used as vegetables and traditional medicine, especially to increase blood and breast milk, and to heal wounds and skin diseases (Kurdiansyah et al., 2024).

The challenges of Pteridophytes conservation are essentially a shared responsibility that involves multidisciplinary synergy between universities and communities. Educational institutions also play a role in developing capacity through critical thinking training in analyzing conservation issues, data literacy for biodiversity information management, and adequate field skills including species identification, as conservation efforts are a shared responsibility (Hadisiswoyo et al., 2025; Helida et al., 2019). Society has a role in implementing conservation programs based on local wisdom which will enhance the character of sustainable conservation (Yasir et al., 2024). Efforts to maintain ecosystem stability aimed at conserving Pteridophytes require integration between academic science and practical conservation knowledge within the community. Synergistic collaboration helps in making decisions based on the implementation of scientific data. In this framework, the development of educational media serves a critical function in advancing biodiversity literacy, solidifying conceptual understanding, and cultivating conservation awareness. As evidenced by various studies, biodiversity literacy is fundamentally interconnected with cognitive knowledge, environmental awareness, and practical conservation behaviors (Aminullah et al., 2025).

Due to limited instructional time in biology curricula, pteridophytes are predominantly taught as supplementary material confined to the classroom. To compensate for the lack of practical field experience, previous research has primarily focused on developing indoor instructional media, such as E-modules and textbook booklets (Abrori & Adhani, 2017; Nurhasmayanti et al., 2023). Existing media rarely engage students in authentic scientific activities, such as the observation, identification, and collection of biodiversity data. In contrast, BUSAKA integrates a citizen science approach with Augmented Reality (AR) technology to foster active student engagement as data collectors in real-world environments. Furthermore, conventional media are generally limited to delivering theoretical content and lack integration with localized citizen science programs. Consequently, BUSAKA is designed to bridge the gap between theoretical knowledge and direct field exploration, enabling students to act as observers and data collectors of flora within their immediate surroundings

A primary constraint in teaching Pteridophyta is the limited time allocation, as this topic is frequently subsumed under general biodiversity lessons. Consequently, a significant gap in students' conceptual mastery emerges. This issue is further compounded by the suboptimal integration of complex botanical theories with field exploration, creating a distinct pedagogical disconnect. Without adequate skills in field identification and ecological analysis, students struggle to comprehend Pteridophyta contextually, which ultimately dampens their interest and motivation for field-based studies.

This situation highlights the urgent need for instructional frameworks that harmoniously bridge theory and practice. Since field activities constitute the core of biology and conservation education, the learning paradigm must shift from mere knowledge transfer to the cultivation of applied competencies relevant to real-world conservation. This pedagogical approach, which deeply roots the learning process within the physical and local environment shared by teachers and students, aligns precisely with the tenets of Place-Based Education (PBE) (Yemini et al., 2025)

In response to these challenges, citizen science offers a transformative approach by shifting students from passive consumers to active producers of scientific data through direct involvement in the scientific process (Somerwill & Wehn, 2022). This approach allows learners to act as young researchers who contribute to the real-world collection of biodiversity data. To facilitate this activity, Augmented Reality (AR) technology emerges as a promising medium with the ability to interactively visualize complex digital information over real-world objects. Conceptually, AR enhances citizen science frameworks through the visual representation of local species. The integration of AR enables students to actively observe, identify, and document data. The use of AR in citizen science has previously been implemented based on science projects, which has the potential to be adapted by other scientific disciplines (Berger & Gerke, 2023; Buditjahjanto & Irfansyah, 2023) Before developing innovative learning media, a critical step is to

comprehensively understand user needs. This research aims to analyze the needs of students and teachers as a basis for developing the citizen science-based BUSAKA AR Pteridophytes media. The research will identify the gap between expected competencies and actual abilities, obstacles in field learning, and the level of user readiness to adopt augmented reality technology. The results of this needs analysis will serve as an empirical foundation for designing relevant media and a theoretical contribution in the form of a framework for integrating citizen science into the conservation of Indonesian biodiversity.

B. Material and method

This research is part of a research and development study using the ADDIE method, but focuses on the Analysis stage which aims to gather information about the expected product specifications for biology learning, particularly pteridophytes, in the surrounding environment. The research aims to identify the various causes of the performance gap among users, particularly from the perspectives of teachers and students.

This study employs a descriptive qualitative research design utilizing a purposive sampling technique. The sample comprised 20 Biology teachers from the Banjarmasin and Banjarbaru regions. These teachers were selected based on the criterion of having 3–10 years of teaching experience as educational media users, ensuring they possessed substantial practical expertise in lesson planning and classroom management. Additionally, the sample included 17 eleventh-grade science students (Class XI MIA) from SMA Sabilal Muhtadin, SMK ISFI, and SMAN 3 Banjarmasin during the 2024/2025 academic year. These schools were selected to represent students from both general academic (SMA) and vocational (SMK) secondary institutions. Data was obtained through surveys and interviews. The survey was conducted with teachers and students through questionnaires. Subsequently, the interviews conducted by the researcher were a combination of structured and unstructured approaches to delve deeper into the results of the survey administered to teachers and students. As for the teacher and student instruments, they are shown in (Table 1).

Table 1 Items asked in the busaka development basis for teachers and students

No	Aspect
1	Learning media commonly used in teaching
2	Opinions on the use of media in teaching
3	Teachers' opinions on the media already used in teaching
4	Teachers' opinions on the use of pocketbooks as a learning aid for Biology
5	Teachers write down what should be used if other media are to be developed.
6	Teachers write down what should be included in the media if they are to be developed.
7	Teachers write down various aspects highlighted in media development
8	Students' opinions on the various pteridophytes found in the surrounding area through pocketbooks
9	Students' opinions on the appeal of using pocketbooks that include interesting facts about pteridophytes.
10	Students' opinions on visual learning in pteridophyte studies
11	Students' opinions on biological concepts conveyed through images and stories compared to regular text
12	Students find it easier to understand the material compared to verbal explanations.
13	Students' opinions on pocketbooks used in biology lessons, especially for topics that require visualization of pteridophytes
14	Students' opinions on learning motivation if the pocketbook are equipped with interactive features, such as augmented reality

Tabel 2 Summarof teacher perspectives on existing media and pocket book developme

Existing media	Teacher's perspective on student difficulties	Key considerations for pocket book development
The printed textbook is too thick, and the language is overly formal and academic	Students find it difficult to identify the core content of the material, and their average scores and perceived understanding are relatively low.	The material should be deconstructed into concise, sharply focused summaries, complemented by a mini glossary and expressed in more accessible, semi-casual language.
The media is insufficiently visual and is dominated by black-and-white text.	Students become bored quickly, and their concentration tends to decline after approximately fifteen minutes of reading.	Colored visuals, visual icons or markers, and simple character-based illustrations should be integrated to clarify abstract concepts and sustain engagement.
The existing media is not practical to carry (heavy printed books or resources that require a laptop to access).	Learning activities mainly occur only when the teacher initiates them in class, with limited independent study outside formal lesson time.	The pocket book should have dimensions suitable for being carried in a pocket or small bag, or be designed with an optimized vertical layout for smartphone use, so that it can be read flexibly at any time.

Unstructured interviews were conducted to obtain the necessary additional data. Then, a survey was conducted using questionnaires as the basis for developing BUSAKA. This study employed a descriptive design complemented by supporting quantitative data. Accordingly, the data analysis procedures were organized into two main components based on the types of data collected. Quantitative data obtained from the closed-ended questionnaires completed by teachers and students were analyzed using descriptive percentage statistics to identify the overall response trends within each group. The analysis focused on determining the proportion of respondents selecting each response category, which served as the basis for describing perceptions toward the learning media under investigation. Mathematically, the percentage for the i-th response category (P_i)was calculated using the Formula 1.

$$P_i = \frac{f_i}{N} \times 100\% \text{.....Formula 1}$$

Note:
$P_i$denotes the percentage for the i-th response category,
$f_i$represents the frequency or number of respondents selecting the i-th category, and
Nrefers to the total number of respondents in the respective group.

The resulting percentages for each category were subsequently interpreted descriptively based on predetermined interval criteria, thereby enabling a clear characterization of response tendencies (e.g., very positive, positive, less positive, or negative).

C. Results and discussion

The research was conducted to analyze the need for an Augmented Reality-based Pocket Book, as seen in Figures 1 to 12. Based on the results of the needs analysis, it was found that various media will be developed regarding pteridophytes. The use of Augmented Reality-based Pocket Book development on pteridophytes.

Teachers perspective

Based on the data collected, it is known that the teachers who filled out the questionnaire have varying teaching experiences, with 40% having taught for over 3 years, while the remaining 60% have taught for less than 3 years. The composition of respondents is 75% female teachers and 25% male teachers. This indicates that the input comes from relevant stakeholders in the learning process.The results of the questionnaire are presented in Figures 1 to 4.

Based on Figure 1, it is known that the media used are conventional media and presentations like PowerPoint (35%), followed by textbooks (20%) and learning videos (20%). Based on the results of interviews, respondents use a combination of media such as (1) teachers who use a combination of textbooks, student worksheets, images, and learning videos, (2) choosing to take students to the school environment to see various pteridophytes, although the number is limited, and (3) using textbooks, videos, student worksheets, interactive quiz websites, and the school environment in this learning. Using PowerPoint is common in areas that affect teachers, although many things need to be considered as a reflection of students' needs (Chávez Herting et al., 2023).

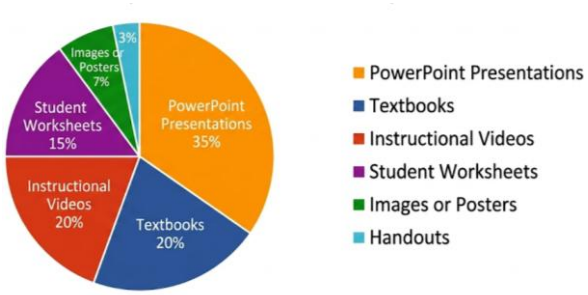

Figure 1 Learning media commonly used in teaching

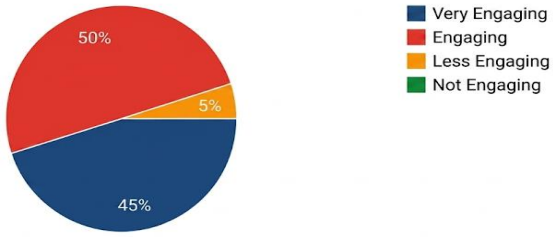

Figure 2 Teachers' opinions on the use of media commonly used

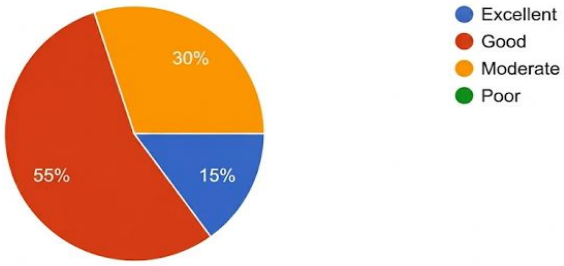

Figure 3
Teachers' opinion on students' understanding using commonly used media

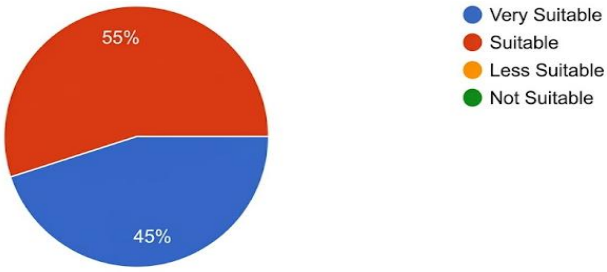

Figure 4 Teachers' opinions on the use of pocketbooks in learning

This is reinforced in Figure 2, where the majority of teachers believe the media used falls into the category of considering the current media interesting (50%) or very interesting (45%). However,

based on interviews conducted with Biology teachers, it was found that only 2 teachers mentioned direct experience with the environment to learn about pteridophytes directly as part of citizen science, namely teaching participants more about the project's focus and scientific processes (C., 2019; Vohland et al., 2021). Based on Figure 3, the interest in learning media shows that the majority of respondents are aware that the media is considered interesting, but the resulting level of student understanding is not optimal. Most respondents (55%) rated student understanding at the Good level and 30% at the Sufficient level. Only 15% felt that student understanding was Very Good, which concludes that there is a gap between teachers' perception of the media's attractiveness for improving student understanding and its enjoyment for students. Fun learning implies a series of learning experiences that are active, personally satisfying, and successful (Sundaram & Ramesh, 2022).

Next, interviews were conducted regarding various obstacles to teaching pteridophytes, including a lack of suitable media for precise and detailed visualization, and the use of image sources that do not yet reflect the diversity familiar to the students. Various media can be explored as learning resources in handling learning (Indriany & Chastanti, 2022)

Based on the information gathered, teacher 1 believes that there is a lack of interest and enthusiasm for material without practical work, and a lack of interesting learning media variation to accompany biology lessons. Teacher 2 respondents, on the other hand, believe in choosing story topics relevant to students and using interesting illustrations, which aligns with teacher 3's response that if digital media were to be developed, more attention should be given to making the images and text as attractive and non-boring as possible to keep students engaged in continuous reading.

Based on Figure 4, four respondents agreed that a pocketbook could be used in Biology learning. The teacher added the expected features for media development that are found in the pocketbook, as shown in Figure 5

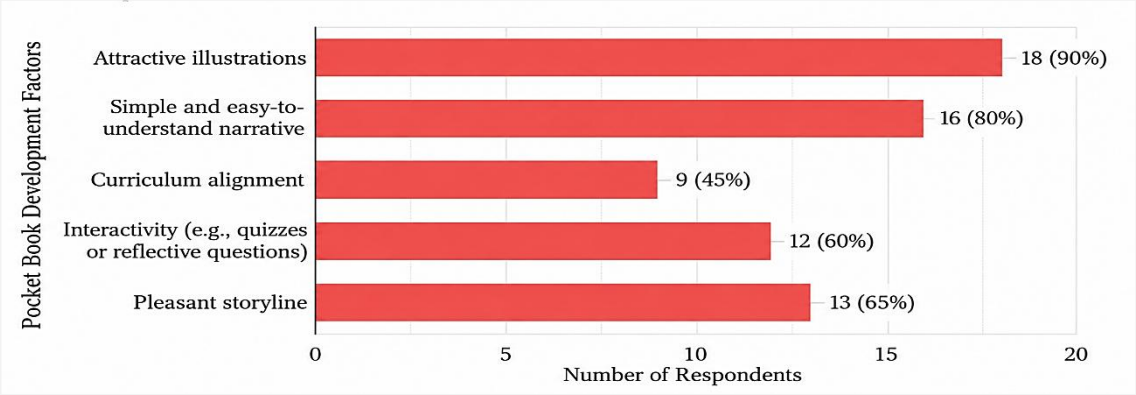

Figure 5 Important factors on pocketbooks development

Based on the data, respondents expect media that is interactive, uses easy-to-understand language, has a storyline close to everyday life, and is able to attract students' interest in reading. The pocketbook should display clarity and an appealing appearance to the reader, ensuring a clear flow of language (Dharmono et al., 2023; Putra et al., 2023)

The data collected above indicates that the development of an augmented reality-based pteridophyte pocketbook must have advantages over the media previously used by teachers and can support citizen science-based student learning. The following points are noteworthy: (1) the main priority is to use attractive and high-quality illustrations suitable for the target students; (2) the practicality of the book size, as it will be carried by students and teachers into the surrounding environment; (3) the use of AR is expected to visualize the content in a modern and detailed manner, even down to the spore parts of pteridophytes; (4) there are reflective questions that students can use for learning outside of using the pocketbook, but still in accordance with curriculum equirements. The development of various learning products is expected to result in a needs analysis that aligns with the products desired by users (Harun et al., 2024; Rahmi et al., 2023).

Based on the interview findings with the teacher respondent, information regarding the instructional media employed and the teacher's perspectives on the difficulties encountered by students is summarized in (Table 2).

These findings reveal a critical disconnect between the perceived attractiveness of currently utilized media and its actual pedagogical efficacy. Such a disparity highlights the necessity of developing future instructional media that prioritizes a learner-centered framework over a traditionally restrictive, content-centered design.

Other perspectives emphasize teachers' demands for instructional tools that offer detailed, accurate visualizations combined with interactive technologies like Augmented Reality (AR). Utilizing AR

serves as a strategic effort to reify abstract subject matter, optimize student retention, foster an engaging learning environment, facilitate self-paced repetition, and leverage robust multimedia capabilities." (Diki et al., 2022; Yapici & Karakoyun, 2021). "Furthermore, the pocketbook's concise and portable nature makes it an ideal tool for independent learning and citizen science. This compact format enables students and the public to bring into the field, supporting independent biodiversity identification.

Students perspective

The students come from various high schools in the city of Banjarmasin, such as Sabilal Muhtadin High School, ISFI Vocational School, and Banjarmasin 3 State High School. Based on the questionnaire distributed, students overall had a positive response to the development of an Augmented Reality-based pocketbook, as shown in Figures 6-12.

Based on the results from Figure 6, it can be concluded that students chose to use visual media as a key part of the main context in the development of the pteridophyte pocketbook. From this statement, a book is needed with specifications that must focus on clear and accurate visualization. This is supported by Figure 7, which shows that respondents agree and strongly agree with the use of pocket books.

In Figure 8. The use of visual media falls under the category of digital media usage, which will provide input that BUSAKA will help meet students' needs. Consistently, the majority of students agree and strongly agree that it facilitates and accelerates understanding of pteridophyte material. because it's presented through images rather than plain text. Increased motivation and engagement will help students in learning (Amintarti et al., 2019).

Descriptive data also highlights the positive impact of using pocket book media, which can contain interesting and easy-to-understand images and explanations, making it highly suitable for learning using pocket books. Based on interviews with respondents, it was found that one student stated, "Learning is more enthusiastic when the material is presented through pocket books," which aligns with another student who believes that using pocket books can contain interesting and easy-to-understand images and explanations, making them highly suitable for learning using pocket books.

This shows that visually appealing media not only serves as an aid to understanding but also as a trigger for engagement. When learning is perceived as "fun" and "creative," students tend to be more proactive and motivated to delve deeper into the material. This is important because the use of visuals is a representation of using the senses and is aided by relevant tools (Utami et al., 2021). Next, Figures 10 to 12 will explore various things included in the Augmented Reality-based pocketbook.

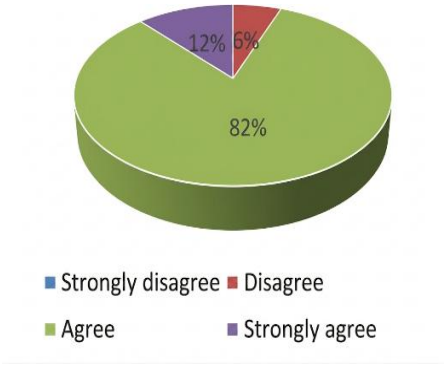

Figure 6
Students remember biology concept more easily if using pictures.

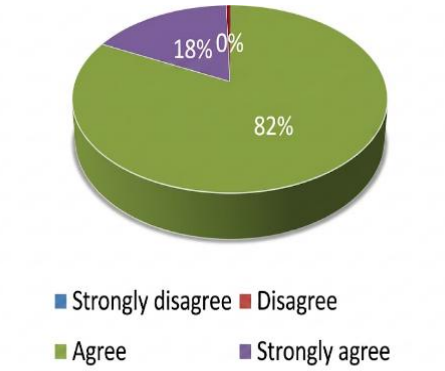

Figure 7
Students are interested using pockebooks because of the interesting visual

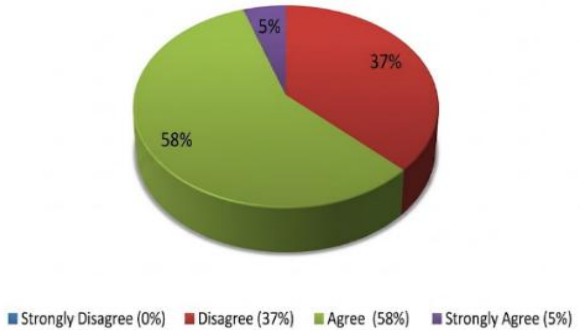

Figure 8
Visual-based media usage help students to understand the material rather than verbal explanation

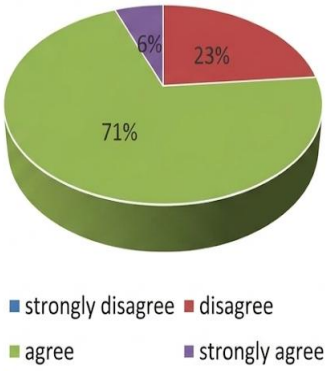

Figure 9
Students' interest on using pocketbooks about pteridophytes

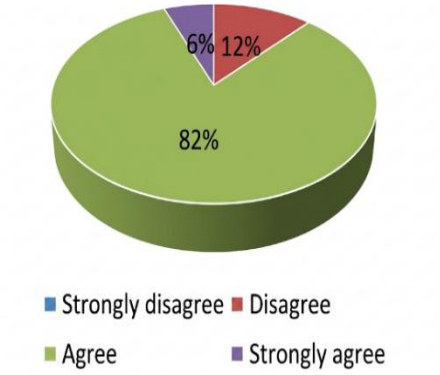

Figure 10
Pocketbooks describe about characteristics, habitat, role of pteridophytes

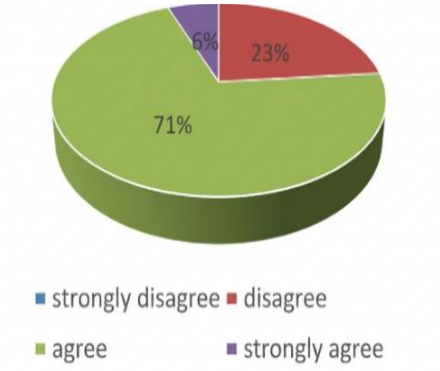

Figure 11
Students are motivated to learn when the pocketbooks include interactive feature, such as reflective questions

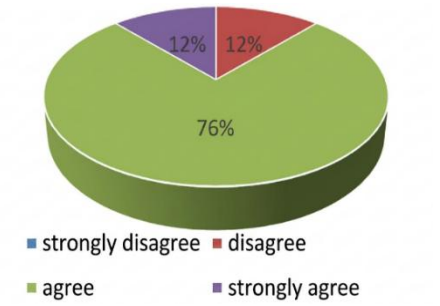

Figure 12
Students will have a better understanding when the pocketbooks include real-life illustrations

As shown in Figure 11, students agreed to use a pocket equipped with interactive features such as reflective questions. This aligns with the teachers' opinions, who also expressed the same sentiment. Therefore, BUSAKA will be developed to include interactive features such as quizzes or augmented reality. This is consistent with Figure 12. That students expect real-life illustrations. Digital media like pocket books aim to clarify and overcome limitations of space, time, energy, and sensory abilities, including visual, auditory, and kinesthetic capabilities.

Based on this description, users hope to find content that includes a discussion of morphology, detailing characteristics such as spores, sporophyll leaves, tropophyll leaves, and the root systems found in pteridophytes, along with detailed illustrations of spore and sporangium shapes for specific species. The habitat and specific roles of pteridophytes in their environment are also expected to be covered.

These user expectations complement previous relevant studies that have successfully developed various Pteridophyte learning media. Prior research has focused on practical and interactive formats, such as Pteridophyte Smart Cards integrated with QR codes, STEM-based Herbariums and Field Guide Books for macro-identification and local-potential Booklets for pterydophytes (Efendi et al., 2023; Nisa et al., 2021; Mualimaturrochmah et al.,, 2020; Siregar, 2021). While these earlier developments are highly effective and practical for general field identification and basic morphological understanding, this current study addresses a critical, unfulfilled gap.

Unlike previous media that predominantly feature general, macro-level real images, this proposed book specifically targets the demand for micro-morphological visualizations particularly detailed spore and sporangium with a deepen into the specific ecological roles of pteridophytes in their localized habitats. By accommodating these specific user expectations, this development directly impacts the research problem by elevating the learning material from a basic identification tool to a comprehensive taxonomic and ecological resource.

Theoretically, this approach draws on the Cognitive Theory of Multimedia Learning (Mayer, 2014), which holds that targeted, high-fidelity visualizations of complex micro-structures such as sporangia can effectively reduce cognitive load by presenting information in a form the brain more readily processes. When students are exposed to detailed visual representations of microscopic botanical features, they are better equipped to construct accurate mental models, which in turn supports deeper retention and comprehension of abstract biological concepts.

Further analysis of the qualitative input shows that students did not stop at using static visuals. There were inputs such as using interactive detailed visuals, as stated by respondent student 3: "Learning became easier to understand in a unique way, so I was interested in this." This aligns with the opinion of student respondent 4, who stated that learning needs to use detailed visuals because they are less interested and proficient. Additionally, classroom learning only makes students know statements without understanding why or how the process works. The mapping of the relationships between teacher obstacles, student interests, and media development solutions is presented in Table 3, illustrating how each field challenge is mechanically addressed by the product features.

Table 3 Triangulation matrix of field needs and ar pocketbook product features

Key aspect	Teachers' real obstacles (survey data)	Students' reality & interest	Solutive features added to the product
Engagement & learning motivation	Learning tends to be one-way; students quickly become bored and lack enthusiasm if the material is not accompanied by direct hands-on or practical activities.	Possess a very high empirical interest in learning media in the form of Biology Digital Comics. Students are fatigued by dense text.	Packaging taxonomic content into a creative storyline to build affective engagement and trigger internal motivation.
Visual representation of material	Conventional media (PPT/2D Images) are inadequate for visualizing the complex macro-micro morphological structures of biological objects.	Experience a high cognitive load (overload) when attempting to construct mental models of abstract objects.	AR Technology Integration with object projection features embedded to clarify morphological details dynamically.
Context & material relevance	Existing media are too general (global/national) and do not yet reflect the local biodiversity where the students reside.	Difficulty connecting the material with real life because the species examples in textbooks feel foreign and distanced from their daily lives.	Local Biodiversity Exploration designed with the setting of regional characteristic ecosystems to foster environmental literacy and ecological awareness.
Spatial flexibility	Require a concise, information-rich, and practical self-study reference medium to support learning beyond classroom hours.	Require a flexible (portable), digitally-based, and non-monotonous independent learning medium to be used at any time.	Handheld Pocketbook Design: Consolidating comics and AR within a lightweight digital application on smartphones, functioning as a dynamic field guide for citizen science.

Overall, this descriptive analysis concludes that students are not only open to, but actively desire learning media that utilizes visual and interactive technology. This need is not based solely on a desire for entertainment, but rather on a pragmatic goal: to understand difficult subject matter in an easier, faster, and more in-depth way. This result provides very strong justification for the development of learning media such as Augmented Reality-based pocketbooks, which directly address all identified needs.

D. Conclusion

This research concludes that there are critical pedagogical and structural gaps in the utilization of Biology learning resources, particularly regarding the mismatched perceptions between educators and students. Conventional two-dimensional media employed by teachers fall short of supporting students' conceptual mastery due to limited visualization, text-dense formats, and a lack of integration with local biodiversity. Conversely, the needs analysis reveals that students possess strong preferences and high intrinsic motivation for narrative-based visual media, which is considered effective in strengthening memory retention and improving learning efficiency. These findings demonstrate a paradigm shift in educational resources, moving from passive-textual classroom environments toward active, environment-based exploration supported by Augmented Reality (AR). Within the scope of this needs analysis, the conceptualization of an AR-based pocketbook named BUSAKA is proposed to support citizen science practices and autonomous ecological exploration in students' immediate surroundings. The practical implication of this study highlights the necessity of advancing BUSAKA through further development to ensure its validity and usability in educational settings.

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